Flight Safety DIGEST

SEPTEMBER 2003–FEBRUARY 2004

Waterproof Flight Operations

■ A comprehensive guide for corporate, fractional, on-demand and commuter operators conducting overwater flights

Airline Data Included

Flight Safety Digest

Vol. 22, No. 9–12 and Vol. 23, No. 1–2
September 2003–February 2004
US$240.00 (nonmembers)

In This Issue

Waterproof Flight Operations

A comprehensive guide for corporate, fractional, on-demand and commuter operators conducting overwater flights

Ditching

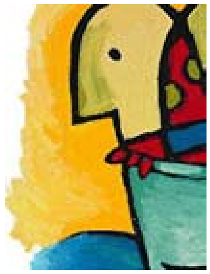
3

Search and Rescue

111

Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 910 member organizations in more than 142 countries.

Survival



149

Equipment and Training

233

Regulations and Recommendations

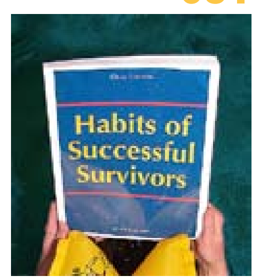
387

Aviation Statistics

469

References

631



The work on this extraordinary *Flight Safety Digest* was begun in 2001 by the Flight Safety Foundation (FSF) publications staff in response to queries from corporate aviation managers who were initiating overwater flights. They wanted additional guidance about how to ditch their aircraft, how to select life rafts, how to use the required equipment and what might be expected from search-and-rescue resources in various parts of the world.

The publications staff learned quickly that in-depth practical information was not readily available for corporate, fractional, air-taxi and commuter operators, and that air carrier operators had resources and requirements that were not readily transferable to the other sectors. Moreover, what information was available presumed the unlikelihood of ditchings; therefore, practical information about surviving a ditching was minimal, leaving room for myths and misconceptions.

Roger Rozelle, FSF director of publications, a pilot with overwater experience and a licensed merchant mariner with offshore experience, led his staff, whose senior editors are pilots, in assembling this issue. They studied the literature on ditching and post-ditching survival, helped conduct an in-the-water life raft evaluation, visited survival-equipment manufacturers, and examined safety-related equipment. They interviewed specialists in safety, survival and training; manufacturers of aircraft and equipment; regulatory authorities; and many others. As information was gathered, new questions arose, topics were explored in greater depth, page count multiplied and the scheduled publication date became a moving target. To ignore any of the many interconnecting parts of the subject would have failed to give the most affected aircraft operators the information that they needed.

Surrounding overwater operations are scheduled changes in requirements for emergency locator transmitters, which are essential in the worldwide search-and-rescue system; a trend to reduce the requirements for overwater survival equipment based on the proven reliability of turbine engines (although the role of human factors cannot be overlooked); accidents involving fare-paying passengers during near-shore operations in nonturbine-powered airplanes; the utility of long-range corporate jets that supports growth in overwater operations; and the dependence of the offshore-energy industry on helicopters, which has resulted in considerable overwater experience to share with other sectors.

As the data were crunched, the publications staff recognized that other water-contact accidents involved evacuation and survival issues paralleling those in ditchings. Moreover, they learned that while such accidents are relatively uncommon, ditching remains a risk — even for modern airline jets — and is not a relic of an earlier era.

Among ditchings that have been conducted in recent years are the following: A Boeing 737 was ditched in a river in Indonesia after both engines flamed out in heavy rain and hail during a scheduled flight with 54 passengers; one flight attendant was killed. A businessman-pilot ditched his CitationJet off the northwest U.S. coast after an apparent pitch-trim problem; the two people aboard survived. A Falcon 20 was ditched in a U.S. river during a cargo flight when both engines flamed out on an instrument approach; both pilots survived. Intake icing caused both of a Shorts 360's turboprop engines to fail during an overwater departure for a scheduled mail flight in Scotland; both pilots died. Another Shorts 360 had a dual-engine flameout on approach to an airport on the coast of Libya during an unscheduled passenger flight; 22 of the 41 occupants were killed. The pilot of a Cessna 402C was unable to maintain altitude after a power loss from one engine during a commuter flight to the Bahamas; two of the nine passengers were killed. A similar accident involved a Piper Chieftain during an on-demand sightseeing flight in Hawaii; one of the eight passengers drowned. All seven occupants were killed after a dual-engine failure occurred on a Chieftain during a scheduled flight in Australia.

There were several close calls, too. For example, an Airbus A330, with 291 passengers, was on a chartered flight from Canada to Portugal when an apparent fuel leak resulted in both engines flaming out; the crew *glided* the airplane 85 nautical miles (157 kilometers) to a landing in the Azores. A chartered Douglas DC-9 was on a flight to Mexico when a navigational problem took the airplane far off course in the Gulf of Mexico; the crew diverted toward the nearest suitable airport and *glided* the final 23 nautical miles (43 kilometers) to a forced landing on a road near the airport; four of the 40 passengers received minor injuries during the evacuation.

The unthinkable happens.

The publications staff came to realize that the sea is the great equalizer: Whether the survivors arrive from a ditched aircraft or from an abandoned ship, once in the water, their survival issues are universal.

The sheer volume of what has been written would tax the confines of a book (although this issue will be available as a printed book by special order from our Internet site <www.flightsafety.org>). Presenting the information on compact disc proved most practical and allowed liberal use of color in a fresh design. A built-in search engine enables navigation of nearly 700 pages packed with facts, and links connect to a variety of relevant Internet sites.

Valuable safety information is here for all our members.

Stuart Matthews
President and CEO
Flight Safety Foundation

Ditching

■ Ditching

The Unthinkable Happens

If you believe that ditching a transport category airplane is a thing of the past, read on.

—FSF EDITORIAL STAFF

Ebb tide reveals a Shorts 360 that broke up during a ditching on rough water and sank rapidly.

Data show that the probability is low that the crew of a turbine-powered business airplane will have to ditch — that is, to deliberately conduct an emergency landing on water. Nevertheless, as the following examples indicate, the risk of ditching is not absent in a transoceanic journey or a flight close to shore (see "Rationalize the Risk of Ditching: It Won't Happen to Me," page 5).

On July 22, 2003, a Cessna CitationJet was being flown on autopilot through 16,000 feet after departing from Sidney, British Columbia, Canada, for a private flight to Boise, Idaho, U.S., when an uncommanded change of pitch attitude — to about 45 degrees nose-down — occurred. A preliminary report by the U.S. National Transportation Safety Board (NTSB) said that the pilot disconnected the autopilot, moved the throttle levers to idle and attempted to retrim the airplane.

"He reported that the [elevator] trim indicator was in the full-forward (nose-down) position and that neither the manual [trim actuator] nor the electric

The occupants, who had not donned life vests, were rescued from the water by boaters.

trim actuator would respond to his inputs," the report said. "After numerous configuration changes and unsuccessful attempts to regain full pitch control, the pilot elected to ditch the airplane."

The pilot told investigators that the wings were level and airspeed was approximately 100 knots when he ditched the airplane. The CitationJet struck the water about 900 feet (275 meters) from shore in Penn Cove, Coupeville, Washington, U.S. The pilot and his passenger were not injured, and they exited through the main cabin door.[1] The airplane sank within 10 minutes in 60 feet (18 meters) of water. The occupants, who had not donned life vests, were rescued from the water by boaters.

Engine Failure Cripples Piston Twin

U.S. regulations governing commuter and on-demand operations require that a multi-engine airplane flown over water with passengers aboard must be able to climb at least 50 feet per minute (fpm) at 1,000 feet above the surface with the critical engine inoperative.[2] As the following example indicates, however, a catastrophic engine failure might render an airplane incapable of meeting the single-engine climb performance figures in the airplane flight manual (AFM).

On July 13, 2003, a Cessna 402C operated as Flight 502 by Air Sunshine on a commuter flight from Fort Lauderdale, Florida, U.S., to Treasure Cay, Abaco Island, Bahamas, was at 3,500 feet and about 20 nautical miles (37 kilometers) from the destination when the pilot observed oil leaking from the right engine, heard a "pop" and observed engine parts exiting through the top of the cowling.

The pilot said that although he feathered the propeller on the right engine and increased left-engine power to full, he was not able to maintain altitude. With landing gear and flaps retracted, the airplane descended about 200 fpm to 300 fpm until it struck the water approximately six nautical miles (11 kilometers) west of Treasure Cay Airport (which is approximately 162 nautical miles [300 kilometers] east-northeast of Fort Lauderdale). The ditching occurred at 1530 local time, about 65 minutes after departure.

"Just before impact with the water, [the pilot] raised the nose," the NTSB preliminary report said. "The airplane skipped over the water and came to rest."

The pilot received a minor injury when his head struck the windshield on impact, but none of the nine passengers was injured during the ditching.[3] The pilot exited through the left cockpit window and opened the cabin door. All the passengers exited through the cabin door before the airplane sank in 15 feet to 30 feet (five meters to nine meters) of water about 45 seconds after impact. The airplane was equipped with life vests for all the occupants, but only four of the occupants had donned life vests. There was no life raft aboard the airplane; regulations did not require that a life raft be aboard the airplane during the accident flight.[4]

The flight had been conducted under visual flight rules (VFR), and the pilot was not in radio contact with air traffic control (ATC). Nevertheless, he declared mayday, a distress condition, and his radio transmission was heard by the pilot of another Air Sunshine aircraft that was airborne at the time. The pilot relayed the message to ATC. The Miami (Florida) Air Route Traffic Control Center notified the U.S. Coast Guard at 1541.

The U.S. Coast Guard launched three aircraft: an HU-25 (military version of the Dassault Falcon 20) and an HH-65 Dolphin (Eurocopter Dauphin) from Air Station Miami; and an HH-60 Jayhawk (Sikorsky S-70B) from Andros Island, the Bahama Islands.[5]

"The Falcon was launched for its speed and because it could deploy life rafts," said Petty Officer Carleen Drummond of the public affairs office for the U.S. Coast Guard Seventh District in Miami.[6] "The Falcon crew provided communication with the helicopters and the civilian aircraft, and tracked the rescue process. The use of two helicopters was based on the number of survivors in the water and the need for more assets to recover them faster."

The Falcon and the Dolphin were launched at 1555. The Falcon arrived at the ditching site at 1605, and the Dolphin arrived about 1657. The Jayhawk arrived at the ditching site at 1702. The Air Sunshine pilot who had relayed the mayday call to ATC remained at the site until the U.S. Coast Guard aircraft arrived.

Continued on page 7

Rationalize the Risk of Ditching: It Won't Happen to Me

Risk management might appear to be an obscure academic process, but it is exercised by everyone, every day on an intuitive and informal level. An example is walking across a road. A cautious person might wait until the road is clear of traffic before crossing. A person willing to take more risk might wait only until a suitable interval occurs between vehicles. A daredevil might set off across the road with little regard for the oncoming traffic, rationalizing that because he has the right-of-way, drivers will take the necessary actions to avoid striking him.

Formal risk management includes realistic analysis of both the likelihood of a hazardous event and the consequences of the event, followed by action to eliminate or reduce to an acceptable level the likelihood of the event or its consequences. Errors in risk management can be introduced by inadequate analysis of an event's likelihood or consequences, and by rationalization — basing one's actions on seemingly credible but fallacious principles.

Rationalization in risk management can be present at all levels of program management. For example, before the space shuttle *Columbia* accident, the U.S. National Aeronautics and Space Administration (NASA) knew that the shedding of insulation on external fuel tanks was a recurring problem during launches; however, NASA underestimated the consequences of debris striking the orbiter.[1] Accident investigators said that space shuttle program managers "rationalized the danger [of] strikes on the orbiter's thermal-protection system" and "treated [the problem] as a maintenance issue rather than a fatal flaw." The *Columbia* accident report said that among the causes of the accident was NASA's "reliance on past success as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements)."[2]

Analysis Begins at the Bottom or the Top

Formal risk management involves the use of two traditional methods of analysis. One method is a "bottom-up" analysis of a fault and its consequences; the other method is a "top-down" analysis of an event and the underlying events that are required for the top-level event to occur.

The bottom-up method often is called a *failure modes and effects analysis*. A common application involves the identification of possible failures of an aircraft-system component and the evaluation of the results of those faults on the behavior of the system to which the component belongs. An example would be an analysis of how the failure of a hydraulic pump would affect a flight control system. The analysis would show whether the pump failure would lead to loss of functionality of the flight control system and what that loss would mean for the safe conduct of the flight. Calculating the probability of a pump failure would complete the risk assessment.

The bottom-up method also is used to analyze the consequences of an operational error — for example, incorrect operation of a flight control system component.

The top-down method is called *fault tree analysis*. This method begins with the identification of a specific event (top-level event) and continues with the identification of other events (sub-events) that had to have occurred. Generally, the top-level event is caused by the combined results or effects of two or more sub-events. A common application of the top-down method is the analysis of aircraft accidents and incidents.

The adequacy of either risk-analysis method is only as good as the ability of the analyst to identify the failure event or the top-level event. An unknown, unidentified or unanticipated event can thwart effective risk management.

When both the likelihood and the consequences of an event have been identified, action to manage the risk can begin. Either the likelihood or the consequences — or both — can be the target of risk management, which includes the following actions:

- Remove the hazard;
- Protect from the hazard; or,
- Contain the hazard.

If the hazard is removed, the risk associated with the hazard is removed as well. This is the most effective action, but it is often the most difficult action to accomplish. Action to protect from the hazard if it occurs requires the development of mechanisms to minimize consequences if the hazard is encountered. Containing the hazard involves actions to localize the effects of the hazard. This is often the least effective action, but it is the action that most easily is implemented.

Examples can be derived from the *Columbia* accident report, which recommended that NASA take the following actions:

- Eliminate shedding of insulation from external fuel tanks [i.e., remove the hazard];

- Increase the orbiter's ability to sustain debris damage [protect from the hazard]; and,

- Develop the capability to inspect the orbiter and make emergency repairs — or, if repairs cannot be made, increase the orbiter's ability to re-enter the atmosphere with minor leading-edge damage [contain the hazard].

Likelihood of Ditching Is Not Negligible

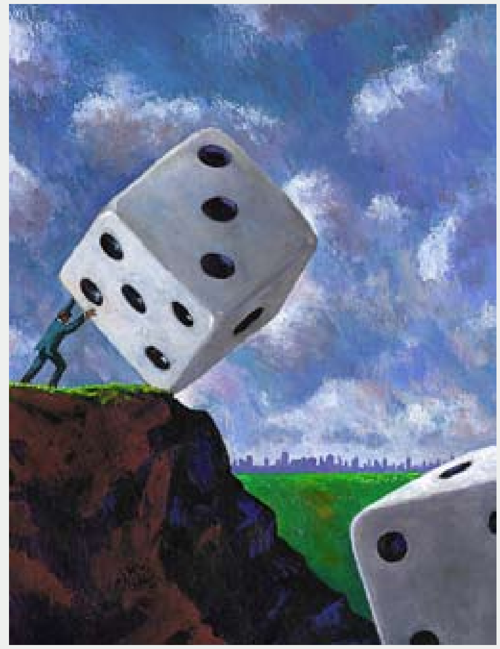
Applying the principles of formal risk management to overwater operations begins with the understanding that the likelihood of having to ditch a multi-engine turbine airplane is very small — *but not negligible* (see "The Unthinkable Happens," page 3) — and that the potential consequences are significant. The analysis indicates that action is required to reduce the risk. Possible actions include the following:

- The hazards could be removed (eliminated) simply by not flying over water. This would be an impractical action for many operators;

- The hazards could be protected against by aircraft design features, proper maintenance of those design features and operational procedures that minimize the likelihood of failures that would lead to a ditching; or,

- The hazards could be contained with adequate emergency equipment and survival equipment — and with crew training and passenger preparation to properly use the equipment.

In summary, the essence of risk management is to understand both the likelihood and the consequences of an event and to develop prevention strategies or intervention strategies to eliminate, protect from or contain the hazards resulting from that event. Nevertheless, the risk management process is only as good as the thoroughness of the analysis and the ability of the analyst to anticipate and identify the hazards. There must be some reserve capability to handle unknown and unanticipated problems. In the overwater-operations example, risk management would include considerations such as life raft flotation redundancy and repair capabilities should a leak develop, and evacuation training that accounts for the possible incapacitation of a crewmember.



Effective risk management is the foundation of a strong safety culture. Nevertheless, the foundation can be weakened by complacency and rationalization. The space shuttle example shows that any organization can fool itself: The *Columbia* accident report said that although NASA believed that it had a strong safety culture, it had in fact become "reactive, complacent and dominated by unjustified optimism."

Obviously, preventing accidents and incidents is preferable to dealing with the consequences. Successful accident prevention is difficult. Hazards rarely can be eliminated. Therefore, success is achieved by a significant reduction of the events that initially brought attention to the hazard. Success often is temporary, however. Without continued attention to the hazard, after some period of time, the events often begin to reoccur. Accident prevention typically is cyclical — when you get good at it, the need for it seems to disappear — for a while. ■

— Earl F. Weener, Ph.D., FSF Fellow

[FSF editorial note: After earning a bachelor's degree, a master's degree and a doctorate in aerospace engineering at the University of Michigan, Earl F. Weener was employed for 24 years by Boeing Commercial Airplanes in various design, engineering and safety positions. He retired from Boeing in 1999 as chief engineer of airplane safety technology development. Weener was chairman of the FSF Controlled Flight Into Terrain (CFIT) Steering Committee and is co-chairman, with FSF Executive Vice President Robert Vandel, of the FSF Ground Accident Prevention (GAP) program.]

Notes

1. Columbia Accident Investigation Board (CAIB). *CAIB Report*. Volume I. August 2003.

2. The *CAIB Report* said that 82 seconds after launch on Jan. 16, 2003, space shuttle *Columbia* was at 65,820 feet and traveling at Mach 2.46 when a slab of insulating foam weighing less than two pounds (one kilogram) was shed from the external fuel tank and struck the inboard leading edge of the orbiter's left wing, causing a breach in the wing's thermal-protection system. Soon after the orbiter re-entered the Earth's atmosphere on Feb. 1, 2003, the breach allowed superheated air to penetrate the wing's leading-edge insulation and melt the aluminum spar. The orbiter then broke up, killing all seven astronauts.

One passenger died before the U.S. Coast Guard aircraft arrived; her body was recovered by a Bahamian police officer who had commandeered a small powerboat to travel to the accident site.

Drummond said that the Falcon crew saw two groups of survivors in the water, about 900 feet (275 meters) apart. The crew dropped two life rafts, and survivors from one group boarded one of the life rafts.

"The other group was just treading water," Drummond said. "The main thing that helped was that our Falcon crew was able to locate the scene [quickly] and then provided navigation coordinates to direct the helicopters to the survivors. One rescue swimmer was deployed from each helicopter."

The rescue swimmer from the Dolphin helped the four survivors in the life raft to be hoisted aboard the helicopter. The rescue was completed in less than 10 minutes. The helicopter then took the four survivors to Freeport, Bahamas.

The crew of the Jayhawk rescued the five survivors who were in the water. Three of the survivors — a child, an infant and the pilot — required medical attention. The rescue swimmer administered cardiopulmonary resuscitation to the infant. The injured child died in a Freeport hospital. Preliminary information from NTSB and the U.S. Coast Guard did not indicate the causes of death of the child or of the woman who died before the rescuers arrived.

"We are relieved that we were able to successfully locate and recover eight survivors, thanks to the quick notifications by the FAA [U.S. Federal Aviation Administration] and the [pilot of the Air Sunshine] aircraft reporting the mayday call," said Cmdr. Gerald Dean, chief of search and rescue (SAR) for the U.S. Coast Guard Seventh District.[7]

During the initial response to the SAR alert, the U.S. Coast Guard asked the Bahamas Air Sea Rescue Association (BASRA), a nonprofit rescue sub-center of the Seventh Coast Guard District, to identify and brief available SAR resources. A BASRA representative made a telephone call to ask the nearest police authorities — on Moore's Island, approximately 27 nautical miles (50 kilometers) south of the ditching site — to send a boat, said Chris Lloyd, BASRA operations manager.[8] The west side of Abaco Island, the closest shore to the ditching site, is a barren, swampy area with few people and no direct roads from the east side of the island.

"We told them that the [local SAR] response time would be quite a while," Lloyd said. "No [commercial] fishing boats were in the area north of us because the lobster season had not started. One police officer [the one who retrieved the dead passenger's body] responded by commandeering a civilian boat and going to the scene. I do not know if more than one boat responded; we did not launch any other boats. If it had been lobster season, there would not have been a boat available at Moore's Island. But with islands everywhere, rescuers usually can find someone to provide a boat."

BASRA, which is not unlike other organizations in small countries around the world that have been instrumental in rescuing occupants of downed aircraft and maritime vessels in distress, considers all aircraft water-contact accidents to be SAR cases that require the most rapid response possible. Paid employees of BASRA are on duty from 0900 to 1700 seven days a week in a SAR control room in Nassau, Bahamas. Trained volunteers answer emergency calls from their homes at other times, and they can initiate a SAR response from anywhere in the Bahama Islands.

"In a ditching, everyone responds with no questions asked — unlike a boat running out of fuel, for example," Lloyd said. "There is never anything good about an airplane going down."

"In a ditching, everyone responds with no questions asked."

Dual Flameouts Lead to Ditching in River

A dual-engine failure led to the ditching of a Falcon 20 in the Mississippi River on the evening of April 8, 2003. The crew was conducting a cargo flight from Del Rio, Texas, U.S., and had received vectors from ATC for the instrument landing system (ILS) approach to Runway 30R at Lambert–St. Louis (Missouri, U.S.) International Airport. Preliminary information from NTSB indicated that the tower controller cleared the crew to land; because of deteriorating weather conditions and a developing traffic situation, however, the controller later told the crew to fly the airplane to 3,000 feet and to establish radio communication with approach control.[9]

While being vectored for another approach, the crew several times asked the approach controller how far from the airport they were being taken. When the Falcon was on base leg, the crew told the controller that they had a "fuel limitation." The controller issued a vector to the final approach course and cleared the crew to conduct the ILS approach to Runway 30R.

"After being switched to the tower frequency, the flight crew declared an emergency," the preliminary report said. "The crew reported to the tower controller that they 'lost the [left] engine.'"

The right engine then flamed out, and the crew ditched the airplane. Both pilots received serious injuries. Weather conditions at the time of the accident included a 1,000-foot overcast and seven statute miles (11 kilometers) visibility.

"The airplane was recovered [the next day] in two parts," the preliminary report said. "The aft fuselage structure, including the tail surfaces and engines, was separated at the trailing edge of the wing [and] remained attached to the forward fuselage by cables, wiring and plumbing.

"The fuel tanks were drained, and a large amount of water was drained from each wing tank. No measurable quantity of fuel was recovered during the draining process."

'We're Out of Fuel'

Another recent ditching involved a 1940s-vintage airliner that was landed in a bay during a maintenance-check/crew-proficiency flight on March 28, 2002. The airplane was a Boeing Stratoliner that had been restored for the U.S. National Air and Space Museum by The Boeing Co. and a group of volunteers working with Boeing.[10]

In its final report on the accident, NTSB said that the flight crew planned to fly the airplane from Seattle, Washington, U.S., to Everett, Washington, about 20 minutes away, where they would conduct

landings and takeoffs, then refuel the airplane, swap crew positions and fly back to Seattle.[11]

After a full-stop landing at Everett, the captain told the crew that they would conduct two takeoffs and landings at the airport before refueling. On takeoff, however, the crew observed a momentary overspeed of the propeller on the no. 3 (right, inboard) engine and elected to fly the airplane back to Seattle.

On approach over the bay, the crew observed an indication that the left-main landing gear was not down and locked. They rejected the approach and circled over Elliott Bay while the landing gear was extended manually, a procedure that required seven minutes to complete.

During the second approach, the Stratoliner was about six nautical miles (11 kilometers) from the runway when the crew observed a decrease in fuel pressure in the no. 3 engine. Selection of the fuel-boost pump did not restore normal fuel pressure, and a power loss occurred in the engine.

The no. 4 (right, outboard) engine's low-fuel-pressure warning light then illuminated, and the captain told the flight engineer to select another fuel tank.

"There is no other tank," the flight engineer said. "We're out of fuel."

The captain moved the throttles forward and called for the no. 3 engine to be shut down and the propeller feathered.

Continued on page 12

Lessons From Another Era

Training and experience were the keys to improving the survival rate of airmen who were involved in ditchings during World War II, said a unique report issued by the U.S. Air Force in 1955.[1]

Ditchings were frequent during the war, when combat action took place over water, crews of airplanes damaged during combat over land often nursed their airplanes toward the sea to avoid capture by the enemy, and transport airplanes and combat airplanes crossed the Atlantic Ocean on the average of one every 13 minutes and crossed the Pacific Ocean on the average of one every 90 minutes.

The report said that 4,000 to 5,000 ditchings occurred during World War II. Analysis of 2,500 case histories indicated that ditchings from 1943 to 1945 were caused by the following factors:

- Combat damage — 45 percent;
- Engine failure or other mechanical failure — 19 percent;
- Fuel exhaustion — 17 percent;
- Navigational error — 7 percent;
- Instrument failure — 4 percent;
- Radio failure — 3 percent;
- Weather — 3 percent; and,
- Miscellaneous (e.g., "turbulence, collision, lightning") — 2 percent.

Often, flight crews had to choose between ditching or bailing out.

"Most fliers preferred to take their chances with a hopelessly damaged aircraft rather than hit the silk," the report said.

Among the few conditions that made bailing out more attractive than ditching were insufficient time to regain control of the

Known as a 'bad ditcher,' the Consolidated B-24 Liberator bomber did not have safety belts for all 10 crewmembers, and a bulkhead tended to collapse on impact.

airplane, fire, hung bombs, low surface visibility, fuel exhaustion, and "when the ditching characteristics of the aircraft were known to be bad."

The ditch/bail decision confronted the pilots of 16 Chance-Vought F-4U Corsairs that ran out of fuel during a training mission over the Atlantic Ocean. [The Corsair has a 41-foot (13-meter) wingspan; is 33.3 feet (10.2 meters) long and 16 feet (five meters) high; and has a 2,000-horsepower (1,492-kilowatt) radial piston engine and a maximum takeoff weight (MTOW) of 14,000 pounds (6,450 kilograms).]

"Although the F-4U was rated a good ditcher and floated long enough to permit an unhurried exit, it rarely gave time to inflate the life raft and to step into it dry from the wing," the report said. "[Nevertheless,] all of the 14 pilots who chose to ditch were rescued. The only man lost was one of the two who chose to bail."

Most fighters, however, were not "good ditchers."

"The floating time of single-place aircraft was always short; usually, they sank almost at once," the report said. "Under the best of sea conditions, fighter aircraft hit hard, frequently slewed, cartwheeled on one wing or nosed over while the pilot hung upside down, helpless until he could release his safety belt and swim upward."

The Boeing B-17 Flying Fortress [65,500 pounds (29,711 kilograms) MTOW] was known as a good ditcher. Three-quarters of the 112 B-17s ditched during the war floated for more than one minute; half floated for more than five minutes, said the report.

The Consolidated B-24 Liberator [71,200 pounds (32,296 kilograms) MTOW], North American B-25 Mitchell [35,000 pounds (15,876 kilograms)] and the Martin B-26 Marauder [38,200 pounds (17,328 kilograms)] were known as bad ditchers. In 41 ditchings of B-24s during the war, 140 of the 400 occupants (35 percent) either were killed on impact or drowned when the airplanes sank.

Airman's safety equipment included a life raft, a kit to mend bullet holes, a sea bucket, a life vest and a dye sack.

"The B-25 and B-26 were feared for their high landing speeds and their tendency to sink rapidly when ditched," the report said.

One pilot described a ditching as follows (the airplane was not identified in the report):

> *Just before we hit, I rang the alarm. I never heard that bell. There was an ear-splitting racket as the tail of the fuselage smacked the top of a wave, then a grinding, grating, thunderous crash when the nose hit one of those mountains of sea full-force. The whole cockpit seemed to explode. Abruptly, the tumult ended, and there was nothing but the gurgle of water. It had been like riding an eggshell into a concrete wall, then dropping to earth, a sodden mass of waste.*

Ditching drills were conducted, but ditchings seldom went as planned.

"In preparation for ditching, [the] pilot and copilot fastened safety belts and shoulder harnesses to avoid crashing into the instrument board or through the [windshield]," the report said. "Loose articles that might become projectiles in the sudden stop were thrown out. Extra bombs or gas were jettisoned, and all exits were opened. The crew braced themselves to resist the shock of impact and the dragging deceleration forces. … Plans provided for each man to leave through an assigned exit and for each to take a preassigned part of survival gear.

"Perfection in this orderly procedure was rarely achieved because of physical injuries received in ditching, structural damage to the aircraft on impact, fire or explosion on landing, high swamping seas and attendant disorganization and panic. Large planes often flooded quickly when they ditched. The in-rushing water either covered the equipment laid out for salvage or, as in B-25s and B-26s, washed it into the tail, where it could not be recovered. … Equipment stored in the wings or fuselage and released on ditching was often all that the crew had."

A common factor in ditchings conducted in various climates and weather conditions was that survivors emerged from the aircraft injured and dazed.

"Usually, the water revived them, but all felt exhausted and found that their limbs were slow to respond," the report said. "Men in the water before boarding life rafts were especially attracted to the wing and tail surfaces, which provided the only visible handholds to keep from drifting away. This practice was dangerous in any but the calmest sea, for the violent slapping of the wings and tail of large aircraft in a heavy sea often knocked men unconscious and upset life rafts."

Although most aircraft broke up on impact and sank quickly, many survivors were able to exit and swim free.

"Men were sometimes trapped in the fuselage, but unless they were completely immobile or held in the wreckage, they could swim surfaceward through any exit before the aircraft had sunk too far," the report said. "Time and again, crewmembers, even though poor swimmers, were able to shoot upward from depths of 30 [feet] to 40 feet simply by inflating the life vest. They had to be careful to avoid jagged metal that might rip, pierce or snag clothing or equipment."

When the war began, pilots generally did not know how to ditch their airplanes.

"Conflicting theories confused the problem of ditching, chiefly because of lack of knowledge of how each type of aircraft should be handled in ditching," the report said. "No one could be sure how long each airplane would float or whether the sinking hulk would suck men down [with it]. Above all, men did not know what *not* to do."

Training and experience — in ditching procedures and in search-and-rescue procedures — improved substantially the number of aircrew who survived ditchings and were rescued during the war. For example, only 6 percent of U.S. fliers who ditched during the first half of 1942 were rescued, but of the 2,130 U.S. fliers who ditched from March 1943 through March 1944, 1,169 fliers (55 percent) were rescued.

"The improvement in American rescue figures was largely due to training and practice," the report said.

The report said that although improved airplane performance and more direct routings after the war reduced substantially the time required to cross oceans, the risk of ditching remained.

"The likelihood of a forced descent at sea must be reckoned as a hazard on all overwater flights," the report said. ■

– FSF Editorial Staff

Note

1. Llano, George Albert. *Airmen Against the Sea*. Arctic, Desert, Tropic Information Center (ADTIC), Research Studies Institute, U.S. Air Force. ADTIC Publication G-104. 1955. The preface said that the report was "the fourth in a series of ADTIC studies to determine how military personnel survived under emergency conditions in various parts of the world." The series included *999 Survived* (Southwest Pacific tropics), *Sun, Sand and Survival* (African deserts) and *Down in the North* (Arctic). Most of the information in *Airmen Against the Sea* was obtained from records of the U.S. Air Force and U.S. Navy; the publication also includes information from records of the air forces of Australia, Britain, Canada, Germany and New Zealand. The report is based on information gathered from airmen who survived ditching or bailing out of airplanes, mostly during World War II and to a lesser extent during the Korean War and the early 1950s. "The most valuable and informative material was found in the firsthand accounts written by the survivors themselves," the report said.

Crewmembers check their 'Mae West' inflatable life vests before flight.

Some passengers shouted and some prayed.

"When the throttles were pushed forward, multiple engine surges occurred," the report said. "Then, the surging stopped, and it appeared that the remaining engines had also lost power. The airplane was rapidly losing altitude, and the captain decided to ditch."

The airplane remained afloat after striking the water, and the crew evacuated. None of the four occupants received serious injuries. The airplane was substantially damaged.

"They were quickly picked up by rescue boats," the report said. "The airplane was subsequently towed to shallower water … before it partially sank in the water just offshore."

NTSB said that the probable cause of the accident was "loss of all engine power due to fuel exhaustion that resulted from the flight crew's failure to accurately determine on-board fuel during the preflight inspection."

Rain, Hail Strangle a Boeing

Loss of all engine power set the stage for the ditching of a Boeing 737-300 on Jan. 16, 2002. Airclaims said that the airplane, operated by Garuda Indonesia, was flown through heavy rain and hail during descent from about 32,000 feet to 23,000 feet, inbound to Yogyakarta, Jawa, Indonesia.[12] Both engines flamed out, and the crew was unable to restart them. The crew also was unable to start the auxiliary power unit (APU), and a loss of all electrical power occurred.

The airplane broke out of the clouds at about 8,000 feet. The crew ditched the airplane on the Bengawan Solo River about 14 nautical miles (26 kilometers) from the destination. A flight attendant seated in the rear cabin was killed when the rear section of the fuselage tore away on impact. Five passengers were seriously injured; eight crewmembers and 54 passengers received minor injuries or no injuries. The airplane came to rest in shallow water near the riverbank. The survivors were helped to shore by local villagers.

Fuel Leak Turns A330 Into a Glider

A fuel leak caused the flight crew of an Airbus A330 to narrowly avoid a ditching in the Atlantic Ocean on Aug. 24, 2001.

The airplane was more than four hours into a charter flight from Toronto, Canada, to Lisbon, Portugal, and about 39,000 feet above the water when the crew observed an imbalance of fuel in the left main tank and the right main tank. They opened the crossfeed valve to balance the fuel.

The crew then observed that fuel quantity was lower than it should have been. They told ATC that they were diverting the flight to Lajes Field, a U.S. Air Force base on Terceira Island in the Portuguese Azores. Soon thereafter, they declared an emergency.

The airplane had been aloft about five hours when the right engine flamed out. About 13 minutes later, the left engine flamed out. At this time, the airplane was at 34,000 feet and about 85 nautical miles (157 kilometers) from Lajes Field. The crew told ATC that they might have to ditch the airplane.

The cabin crew prepared the passengers for a ditching. Media reports said that some passengers shouted and some passengers prayed during the descent.

The airplane reached land, and the crew conducted a "dead-stick" landing at Lajes Field in visual meteorological conditions just before dawn. The landing gear reportedly was damaged during the hard, fast landing. Of the 306 occupants, nine occupants received minor injuries during an emergency evacuation conducted after the crew brought the airplane to a stop on the runway.

At press time, Portuguese authorities had not issued their final report on the accident.[13] A preliminary report by NTSB said that the problem began with a fuel leak and was made worse by the open crossfeed valve.

"Both engines lost power as a result of fuel starvation," the preliminary report said. "There had been a leak in the fuel system near the right engine [causing the fuel imbalance], and an open crossfeed valve allowed fuel to be lost from both wing tanks."

Media reports said that Portuguese investigators found a crack in the low-pressure fuel line on the right engine that might have been caused by contact with an adjacent hydraulic line.[14,15] The fuel line had been replaced by the operator, Air Transat, in compliance with Rolls-Royce Service Bulletin 29-C625, but a matching hydraulic line required by the service bulletin had not been installed. Both the fuel line and the hydraulic line in the accident airplane's left engine had been replaced in compliance with the service bulletin.

Intake Contamination Precedes Ditching in Scotland

On Feb. 27, 2001, a Shorts 360 was ditched in the Firth of Forth after a power loss occurred in both engines after departure from Edinburgh (Scotland) Airport for a scheduled mail-delivery flight to Belfast, Northern Ireland.

The accident report by the U.K. Air Accidents Investigation Branch said that the twin-turboprop airplane had been parked, facing into the wind, for 17 hours without engine-intake plugs installed.[16] During this time, weather conditions included strong surface winds, light-to-moderate snow and freezing temperatures.

"Tests showed that conditions were ideal for a large buildup of ice, snow or slush to occur in both [engine-intake] plenum chambers, where it would not have been readily visible to the crew during a normal preflight inspection," the report said.

The airplane was at about 2,200 feet after takeoff when the commander [captain] told the first officer to engage all anti-icing systems. Four seconds after the engine-anti-icing vanes were engaged, both engines flamed out.

"Interaction between the moving vanes and the residual ice, snow or slush contamination in both intake systems is … the most likely cause of the engine failures," the report said.

The report said that there were no recommended procedures for rapid relight of the engines. The commander turned the airplane toward the coastline, began a descent and reduced airspeed to 110 knots. The crew did not extend the flaps.

"The rate of descent stabilized at 2,800 feet per minute, and [the commander] realized that the aircraft would have to be ditched in the water," the report said. "As the aircraft descended close to the water surface, the commander gradually increased the pitch attitude of the aircraft and correspondingly reduced the speed.

"The aircraft impacted the water in a 6.8-degree nose-up attitude at an airspeed of 86 knots. … It came to rest on the sea bottom in a nose-down attitude with the forward section of the fuselage submerged, 65 meters [213 feet] offshore, in a water depth of about six meters [20 feet]."

The airplane was destroyed, and both pilots drowned.

Low Flight Leaves Little Time for Preparation

A Piper Chieftain was being flown 1,000 feet over the Pacific during a VFR sightseeing flight off the coast of Hawaii, U.S., on Aug. 25, 2000, when a loss of power occurred in the right engine. After attempting unsuccessfully to restore power, the pilot secured the engine and feathered the propeller, the NTSB report said.[17] The pilot told the eight passengers that he would land the airplane at Hilo (Hawaii) International Airport, which was 23 nautical miles (43 kilometers) away.

The pilot declared an emergency when he found that he was not able to maintain altitude with full power from the left engine. When it was obvious that the airplane would not reach land, he told the passengers to don their life vests and to assume the "crash position."

The passengers were wearing headsets to listen to the pilot's tour narration over the public-address (PA) system. Some passengers donned their life vests over their headsets.

The airplane was 250 feet above the water and five nautical miles (nine kilometers) from the airport when the pilot reduced airspeed, while maintaining full power on the left engine, and extended full flaps. The landing gear remained retracted.

"[The pilot] felt the tail of the airplane touch the water, followed by a jolt that momentarily stunned him," the report said. "When he fully regained his senses, the water in the cockpit was already chest high."

The passengers who had donned their life vests over their headsets momentarily became entangled and had to unplug the headset jacks before they could move from their seats. Water pressure on the overwing emergency exit prevented its use. The pilot and seven passengers exited through the pilot door and the main cabin door. (The pilot, from outside the airplane, and a passenger inside the airplane worked together to open the main cabin door.)

Several passengers inflated their life vests after the airplane struck the water. One passenger made no apparent attempt to exit the airplane; she remained in the cabin and drowned.

"[Her husband] indicated that she 'was not a swimmer' [and was frightened]," the report said. "Once he exited the airplane, he looked back and saw her sitting still, with her seat belt still fastened and her life vest inflated."

Another passenger, who had inflated her life vest in the airplane, said that the pressure of the water entering the cabin was "enormous" and that the front exit was under water by the time she reached it. She momentarily became trapped in the exit but "wiggled free."

The airplane descended below the surface within 60 seconds of impact and sank in 80 feet (24 meters) of water. Four passengers were rescued by a fire-department helicopter that arrived 15 minutes later; the other occupants were rescued by a

The front exit was under water by the time she reached it.

fire-department boat soon thereafter. The survivors received minor injuries, including skin burns from contact with fuel that leaked from the airplane. Several occupants were nauseated by the ingestion of salt water and fuel.

NTSB said that the probable cause of the accident was "deterioration and failure of the oil-filter-converter-plate gasket [in the right reciprocating engine], which resulted in a loss of engine power and a subsequent in-flight fire."

Five passengers completed NTSB questionnaires after the accident. All said that the pilot's preflight briefing was valuable to them. Only one passenger said that he read the safety-instruction card, which helped him locate the nearest emergency exit (the main cabin door) after the airplane struck the water.

One passenger told investigators that the pilot's safety instructions immediately before the ditching were not thorough.

"He thought that the pilot should have spent the last five minutes (before they hit the ocean) giving the passengers detailed safety instructions instead of talking to the control tower and flying the airplane," the report said.

Powerless on a Dark, Moonless Night

At 1856 local time on May 31, 2000, the pilot of a Whyalla Airlines Piper Chieftain — en route on a scheduled flight from Adelaide to Whyalla in South Australia — radioed that the airplane was 35 nautical miles (65 kilometers) from the destination and that he was beginning descent from 6,000 feet.[18] Five minutes later, he declared mayday, a distress condition, and told Adelaide Flight Information Service that both reciprocating engines had failed and that he would have to ditch the airplane with seven passengers aboard. He then reported that the airplane was 15 nautical miles (28 kilometers) from the shore of Spencer Gulf.

The Australian Transport Safety Bureau (ATSB) said, in its final report on the accident, that fatigue cracking caused the crankshaft in the left engine to fracture. The pilot feathered the left propeller and increased power on the right engine. Soon thereafter, the right engine overheated, and a portion of a cylinder head and piston melted. The right propeller was not feathered. ATSB did not determine whether the right engine was producing power when the airplane struck the water.

The crew of another aircraft heard an emergency locator transmitter (ELT) signal for 10 seconds to 20 seconds soon after the accident pilot's last radio transmission. The next morning, SAR personnel found the bodies of two passengers and airplane debris floating near the last position reported by the pilot. Several days later, the wreckage of the airplane with the bodies of the pilot and four passengers inside was found on the seabed. The body of one passenger was not found.

No life vests, life rafts or other flotation devices were aboard the airplane.

The pilot and five passengers had drowned, and one passenger had died from multiple injuries.

"Four of the passengers suffered injuries that may have affected their ability to egress from the aircraft and/or survive in the water for any length of time," the report said. "One passenger … and the pilot suffered no major physical injuries [on impact]."

Personnel involved in the search for the airplane on the night of the accident said that cloud bases were from 2,000 feet to 2,500 feet, with patches of cloud below. A mariner involved in the search said that the waves were 1.6 feet to 3.3 feet (0.5 meter to 1.0 meter) high.

"Crews commented that there was a light southerly wind with no turbulence," the report said. "They also indicated that it was a particularly dark night with no moon."

The airplane was in a shallow nose-down attitude when it struck the water; airspeed was not determined. The right wing separated, and both engines were torn from the wings.

"Contact with the water caused disintegration of the nose section and the cockpit area," the report said. "Rapid and forceful ingress of water is considered to have further aggravated the initial impact damage and contributed to rapid sinking."

The passenger seats had seat belts but no shoulder harnesses. No life vests, life rafts or other flotation devices were aboard the airplane. Australian regulations did not require this equipment in multi-engine airplanes with fewer than 10 passenger seats that are flown within 50 nautical miles (93 kilometers) of land.

"Almost all ditchings recorded on the ATSB incident/accident database involved aircraft operating within 50 nautical miles from land," the report said. "Furthermore, many of those ditchings involved multi-engine aircraft. Although [regulations] did not require those aircraft to carry life jackets, past experience and research data indicate that life jackets significantly enhance survivability.

"It is highly likely that the chances of survival for the occupants would have been enhanced if the passenger seats had been fitted with upper body restraints and if the aircraft had been carrying life jackets or individual flotation devices."

The report said that data indicate that at least 13 other Chieftains and Piper Navajos (from which the Chieftain was derived) were ditched from 1984 through 2001. One ditching (discussed previously in this article) involved fatalities.

"Available records worldwide of previous Piper Chieftain engine-failure/ditching events illustrate that, in most instances, successful night ditchings occurred in better visibility and weather conditions than those confronting the pilot of [the Whyalla Airlines Chieftain]," the report said. "The relatively minor injuries suffered by the occupants of the aircraft indicated that the pilot demonstrated a high level of skill in ditching the aircraft."

Off-course Excursion Results in Close Call for DC-9

Preliminary information from NTSB and from Airclaims indicates that on the afternoon of May 14, 1996, loss of power from both engines of an Allegro Airlines Douglas DC-9 occurred during a charter flight over the Gulf of Mexico from Orlando, Florida, U.S., to Cancun, Mexico.

Airclaims said that the airplane was about 190 nautical miles (352 kilometers) from Cancun when the crew experienced a navigational problem.[19] About 60 minutes later, ATC told the crew that the airplane was 300 nautical miles (556 kilometers) off course and that the nearest airport was in Tampico, Mexico, 220 nautical miles (407 kilometers) west.

The crew diverted the flight to Tampico, which is on the east coast of Mexico. The airplane was about 65 nautical miles (120 kilometers) from Tampico when the left engine flamed out. About 23 nautical miles (43 kilometers) from the airport, the right engine flamed out. Airclaims said that the airplane's fuel supply had been exhausted.

The NTSB preliminary report said, "The pilot elected to continue the approach and attempt to land at the Tampico airport. The airplane was reported to have landed on a road, short of the airport. During the landing roll, the nose landing gear collapsed, resulting in structural damage to the airframe."

Four passengers received minor injuries during the emergency evacuation; 36 passengers and the four crewmembers received no injuries.

Four Bizjets Ditched In 1964–2002

Research on accidents involving aircraft typically used in corporate/business operations identified four jet airplanes that were ditched between 1964 and 2002.[20] Fuel exhaustion specifically was cited in three accidents, of which two apparently were precipitated by navigational errors by the crew.

Following are some available details about the accidents:

- On Oct. 12, 1973, a Hawker Siddeley 125 of Mexican registry was destroyed when it was ditched off the coast of Acapulco, Mexico. (No other information was available.)

- On Jan. 14, 1976, a North American Sabreliner 40 of U.S. registry was ditched in the South Atlantic after fuel exhaustion during a government ferry flight from Ascension Island, which is off the west coast of Africa, to Recife, Brazil. One occupant was killed; two occupants received no injuries or minor injuries. The crew had written an incorrect course on a navigational chart.

- On Jan. 24, 1982, a Falcon 10 of U.S. registry was ditched in a swamp in South America after fuel exhaustion during a corporate flight from Houston, Texas, U.S. None of the five occupants was injured; the airplane was substantially damaged and was recovered. While programming the airplane's inertial navigation system, the crew had entered incorrectly the coordinates for a navigational fix, designating the latitude/longitude coordinates for the fix as north, rather than south.

- On Oct. 11, 1987, a Falcon 20D of Spanish registry was ditched about 45 nautical miles (83 kilometers) from Keflavik, Iceland. The crew had requested Flight Level (FL) 350 (approximately 35,000 feet) as the cruising altitude for the unscheduled commercial flight to Keflavik from Gander, Newfoundland, Canada. The flight plan included an estimate of three hours 15 minutes en route, with fuel sufficient for four hours 30 minutes of flight. ATC assigned FL 290 as the cruise altitude because of eastbound traffic at higher altitudes. At 1815 coordinated universal time (UTC) — about three hours after departure — the crew declared an emergency and told ATC that the airplane was "low on fuel." The passengers donned life vests, and one of the passengers, a maintenance technician, positioned the life raft near an emergency overwing exit, fastened the life raft to the base of a seat and moved all loose items into the lavatory. At 1842 UTC, the crew told ATC that both engines had flamed out. At 1852 UTC, the crew ditched the Falcon in "fairly heavy seas" near a ship. The airplane touched down at about 90 knots. After the airplane came to rest on the water, the two pilots and four passengers boarded a life raft deployed over the front of the left wing. The report said that they had "little trouble" getting into the life raft (water temperature was 40 degrees Fahrenheit [four degrees Celsius]). An Icelandic Coast Guard airplane and a rescue helicopter were overhead when the Falcon struck the water. The helicopter crew deployed a sling and rescue swimmers but aborted the pick-up attempt because of the rough sea conditions. The survivors were taken aboard the ship at 2040 UTC.

The crew had written an incorrect course on a navigational chart.

Passengers Near Panic After Ditching Warning

After being told that a ditching was imminent during a 1983 flight, many passengers said that the apprehension that resulted from the flight attendants' lack of information about what was happening was the most difficult part of the emergency.

They were among 162 passengers aboard an Eastern Air Lines Lockheed L-1011 that was en route from Miami to Nassau, Bahamas, May 5, 1983. The NTSB report said that the airplane was about 50 nautical miles (93 kilometers) from Nassau when the crew shut down the no. 2 engine because of a low-oil-pressure indication and turned back to Miami because of deteriorating weather conditions at Nassau.[21]

A few moments later, the low-oil-pressure lights for the other two engines illuminated, and the crew observed that the oil-quantity indications for all three engines were zero. When the crew told ATC about the indications, they said, "We believe [them] to be faulty indications since the chance of all three engines having zero oil pressure and zero [oil] quantity is almost nil."

The airplane was about 80 nautical miles (148 kilometers) from Miami when the no. 3 engine failed. The flight engineer called the senior flight attendant to the cockpit, told her to prepare the cabin for a ditching and then closed the cockpit door. The senior flight attendant received no information about the nature of the emergency or how much time was available before ditching.

Five minutes after the no. 3 engine failed, the no. 1 engine failed. The airplane was in a glide with all three engines silent.

The flight attendants were instructing passengers how to don their life vests when the flight engineer announced on the PA system that "ditching is imminent." The senior flight attendant believed that this announcement meant that the airplane was about to strike the water, and she told the passengers to assume the brace position.

"Generally, the passengers were close to panic, especially after the flight engineer said that ditching was imminent," the report said. "Some passengers screamed throughout the emergency. However, only a few passengers were unable to respond to instruction from the flight attendants;

these passengers were assisted by other passengers and the flight attendants.

"One flight attendant said that of the 15 persons in her section, one passenger was incapable of functioning and three or four others were close to uncontrolled panic because they were nonswimmers and had had problems with their life vests."

Some passengers had difficulty retrieving their life vests from storage compartments under their seats. Some passengers could not open the plastic packages in which the life vests were stored.

"Many passengers had difficulty donning their life vests while seated with their lap belts fastened," the report said. "Some flight attendants reported that they had to assist passengers into their life vests after the passengers had become 'tangled' in the vests. At least two flight attendants stood on seats to again demonstrate donning of the life vest, a technique which passengers said was helpful."

(The flight attendants told investigators that they had demonstrated donning life vests during the predeparture briefing but that "as usual, many passengers did not watch the demonstration." A postaccident survey found that 46 passengers [28 percent] had read the safety-briefing card before takeoff.)

Although they were told not to inflate their life vests inside the cabin, some passengers inflated their life vests. One passenger explained to investigators that he did not want to wait until he was in the water to discover that the life vest would not inflate.

Ten minutes after telling the passengers to brace for impact, the senior flight attendant looked out a window and observed the city of Miami.

"She opened the cockpit door, and the flight engineer told her to prepare for a normal landing," the report said. "Simultaneously, the captain made the same announcement to the passengers."

Some passengers could not open the plastic packages in which the life vests were stored.

The crew had been able to restart the no. 2 engine. After the airplane was landed at Miami International Airport, an inspection revealed that master chip detectors had been installed in all three engines without oil seals, causing oil to leak from the engines.

Inadequate Crew Coordination Lessens Chances for Survival

Visibility was about two statute miles (three kilometers) on the afternoon of May 2, 1970, when the crew of a DC-9, en route from New York, New York, U.S., conducted an nondirectional beacon (NDB) approach to the airport at St. Maarten, Netherlands Antilles. The NTSB accident report said that the crew observed the runway too late to conduct a landing and turned left to position the airplane for a visual approach.[22]

The airplane was not aligned properly with the runway on the first visual approach and was too high and too close to be landed on the runway during the second approach. The crew abandoned their attempt to land at St. Maarten and headed for their filed alternate, St. Thomas, U.S. Virgin Islands. A low-fuel-quantity indication then compelled the captain to divert to St. Croix,U.S. Virgin Islands, which was closer.

The captain flew the airplane to a lower altitude to establish visual contact with the sea. He called the purser to the cockpit (the PA system was inoperative, a fact discovered by the crew before departure) and told him that they were low on fuel and to prepare the cabin for ditching.

There was no further communication between the flight crew and cabin crew before the airplane struck the water 10 minutes later. The captain said that he flashed the "fasten-seat-belt/no-smoking" sign before impact.

The report said that the captain demonstrated exceptional airmanship in ditching the airplane under extremely adverse conditions.

"The captain leveled off momentarily at 500 feet and positioned the aircraft over an established swell system," the report said. "He then descended in 100-foot increments, pausing momentarily to improve his depth perception. At approximately 20 feet, he lowered 15 degrees flaps and allowed the airspeed to decrease.

"When the low-fuel-pressure lights flickered, he selected full flaps. Shortly after this, the engines flamed out, and he flew the aircraft onto the water at approximately 90 knots while maintaining the aircraft body angle at five degrees to six degrees nose-up."

The airplane remained "essentially intact" after impact. Nevertheless, of the 63 occupants, 23 were killed, including two infants and a flight attendant. The report provided no details on the causes of death.

"The probability of survival would have been increased substantially if there had been better crew coordination prior to and during the ditching," the report said.

The purser, flight attendants and several passengers were standing, and some passengers did not have their seat belts fastened when the airplane struck the water. Some passengers had not donned life vests.

None of the airplane's five 25-person life rafts was deployed. Four crewmembers were removing galley equipment that had spilled onto a life raft when the life raft inflated, momentarily pinning the first officer to the galley bulkhead.

The airplane floated about 10 minutes, then sank in 5,000 feet (1,525 meters) of water and was not recovered.

The navigator found an escape slide floating on the water and inflated the slide. Many of the occupants clung to the slide until they were rescued.

Rescue aircraft dropped four life rafts to the survivors.

"[Two life rafts] fell too far away to be reached," the report said. "The captain swam to [the third] raft, and the navigator reached the [fourth raft], but neither was able to maneuver his raft back to the main group."

U.S. military helicopters began recovering the survivors 1.5 hours after the airplane was ditched. Recovery was completed in an hour, in weather conditions that included an overcast at 400 feet to 500 feet and visibility less than 0.4 statute mile (0.6 kilometer) in rain.

NTSB said that the probable cause of the accident was "fuel exhaustion, which resulted from continued, unsuccessful attempts to land at St. Maarten until insufficient fuel remained to reach an alternate airport."

The U.S. Coast Guard, which is responsible for SAR operations off the coasts of the United States and in several large oceanic SAR regions, said that of 337 SAR cases — that is, responses to civil aircraft in distress — recorded during fiscal years 2000, 2001 and 2002, 50 (15 percent) were categorized as ditchings.[23] Among the aircraft involved in the ditchings were 29 private/recreational aircraft, 10 commercial passenger aircraft, three seaplanes, two cargo aircraft and six "other" aircraft. ■

The bottom line, in our opinion ...

- ***It happens* — and not only to small general aviation airplanes. Recent ditchings have involved piston-powered twins carrying fare-paying passengers, business jets, a vintage airliner on a test flight and a modern airliner on a revenue flight.**

- **Fuel exhaustion is not the only cause. Transport category airplanes have splashed down after an apparent flight-control problem and after flameouts from intake icing, rain and hail.**

- **Regulations are no substitute for common sense. Australian authorities found that almost all ditchings have been conducted within 50 nautical miles (93 kilometers) of shore, where life vests are not required aboard commercial multi-engine airplanes with fewer than 10 passenger seats.**

- **Lack of preparation is deadly. One pilot exhibited exceptional airmanship while ditching a jet transport in adverse conditions; yet, the people in the cabin did not know what was happening, and many died.**

- **The count is down, but the risk remains. Almost 50 years ago, a study of 4,000 to 5,000 ditchings conducted during World War II taught us that "the likelihood of a forced descent at sea must be reckoned as a hazard on all overwater flights."**

- **Believing that a ditching can't happen or won't happen is not supported by data.**

Notes

1. Hogenson, Dennis; investigator-in-charge, U.S. National Transportation Safety Board (NTSB). Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Aug. 18, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

2. U.S. Federal Aviation Administration (FAA). Federal Aviation Regulations (FARs) Part 135, *Operating Requirements: Commuter and On-demand Operations and Rules Governing Persons On Board Such Aircraft*. Subpart C, *Aircraft and Equipment*. Part 135.183, “Performance requirements: Land aircraft operated over water.”

3. Yurman, Alan; investigator-in-charge, NTSB. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Aug. 12, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

4. FAA. FARs Part 135. Subpart C. Part 135.167, “Emergency equipment: Extended overwater operations.” The regulation requires life rafts and other emergency equipment to be carried on airplanes flown more than 50 nautical miles (93 kilometers) from the nearest shoreline. Yurman said that the accident flight was not conducted more than 50 nautical miles from shore.

5. Dean, Gerald. “Coast Guard Rescues 9 from Bahamas Plane Crash.” News release 07-04, issued July 13, 2003, by Seventh Coast Guard District. U.S. Coast Guard, U.S. Department of Homeland Security.

6. Drummond, Carleen. Telephone interviews by Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 17, 2003, and July 25, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

7. Dean.

8. Lloyd, Chris. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 21, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

9. Brannen, John; investigator-in-charge, NTSB. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. April 23, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

10. Golkin, Peter; media relations manager, U.S. National Air and Space Museum. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Aug. 18, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

11. NTSB. Report no. SEA02FA060. See also: FSF Editorial Staff. “Fuel-quantity Miscalculation Cited in Ditching of Boeing Stratoliner.” *Accident Prevention* Volume 60 (August 2003).

12. Airclaims. *World Aircraft Accident Summary*. (Supplement 130): A02:2.

13. Stoss, Nick; acting director of air investigations, Transportation Safety Board of Canada. E-mail communications with Lacagnina, Mark. Alexandria, Virginia, U.S. April 16, 2003, and Sept. 5, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

14. Fiorino, Frances. “A330 Overwater Flameout Raises ETOPS Issues.” *Aviation Week & Space Technology* Volume 155 (Sept. 3, 2001): 34–36.

15. Dornheim, Michael A. “A330 Fuel System: How It Works and Pilot Choices.” *Aviation Week & Space Technology* Volume 155 (Sept. 3, 2001): 36–37.

16. U.K. Air Accidents Investigation Branch. *Aircraft Accident Report No. 2/2003 (EW/C2001/2/6): Shorts SD3-60, G-BNMT, near Edinburgh Airport on 27 February 2001*. See also: FSF Editorial Staff. “Engine-intake Icing Sets Stage for Ditching of Shorts 360 During Cargo Flight.” *Accident Prevention* Volume 60 (September 2003).

17. NTSB. Report no. LAX00FA310.

18. Australian Transport Safety Bureau. Aviation Safety Report 200002157: *Piper PA31-350 Chieftain VH-MZK, Spencer Gulf SA, 31 May 2000*. See also: FSF Editorial Staff. “Loss of Engine Power Sets Stage for Ditching on a Moonless Night.” *Accident Prevention* Volume 61 (January 2004).

19. Airclaims. *World Aircraft Accident Summary*. (Issue 131): A96:16.

20. Robert E. Breiling Associates. *Business Turbine Aircraft Accidents Involving Intentional In-water Ditching, 1964–2003*. A special report prepared for Flight Safety Foundation. February 2003.

21. NTSB. *Accident Report: Eastern Air Lines, Inc., Lockheed L-1011, N334EA, Miami International Airport, Miami, Florida, May 5, 1983*. NTSB/AAR-84/04. March 9, 1984.

22. NTSB. *Aircraft Accident Report: Overseas National Airways, Inc., Douglas DC-9, N935F, Operating as Antilliaanse Luchtvaart Maatschappij Flight 980, Near St. Croix, Virgin Islands, May 2, 1970*. NTSB-AAR-71-8. March 31, 1971.

23. Schaefer, Richard; SAR planning team leader, Office of Search and Rescue, U.S. Coast Guard. E-mail communications with Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 16, 2003, and Sept. 5, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

Prepare to Ditch

When the unthinkable happens, surviving a ditching will require knowledge, preparation and skill. Early recognition of a problem, prompt notification of air traffic control and careful preparation of passengers are essential.

— FSF EDITORIAL STAFF

Cruising at 41,000 feet over the ocean in a corporate jet, the last thought on the flight crew's mind might be that their airplane could be in that cold blue water, rather than at the intended destination — which, in some of today's long-range corporate/business airplanes, could be several thousand miles away. Should *something* happen to make a ditching probable, there will be scarce time for contemplation; action will be required (see "The Unthinkable Happens," page 3).

In an emergency, the best action is planned action, and having a plan goes far beyond knowing where to find the airplane's ditching checklist.

"You must have a plan," said Lt. Andy Miller, Lockheed P-3 Orion pilot training officer at the U.S. Naval Air Station in Jacksonville, Florida, U.S.[1] "That is the hardest thing for us to teach. We can teach the actual ditching techniques — that's just piloting skills. The hardest part is getting the message across about having a plan for when something unexpected starts happening."

A good way to begin developing a ditching plan is to make an inventory of your resources. If you are flying a large airplane (more than 12,500 pounds/5,700 kilograms maximum certificated takeoff weight) or a turbine-powered airplane, the regulations require that you "become familiar" with the emergency equipment aboard the airplane and with the procedures for using the equipment.[2]

One definition of *familiar* is "thoroughly conversant by use or study." This typically involves more than looking at the equipment (e.g., life raft, life vests, first aid kit) and reading the placards. Lt. Cmdr. Keith Lane, assistant chief of Lockheed Martin C-130 Hercules crew training at the U.S. Coast Guard Air Station in Clearwater, Florida, U.S., gave the following example:[3]

"We have life raft-release handles in the 'Herc,' and anyone would think that they need to pull the handle out a little bit," he said. "The reality is that you have to pull the handle out about 18 inches [46 centimeters]."

Lane said that a thorough discussion of emergency equipment is part of periodic in-flight ditching drills conducted by C-130 crews.

Taking Stock

The inventory of resources should include an evaluation of their suitability and your ability to use them.

The first aid kit aboard your multimillion-dollar airplane might be suitable for bandaging a cut finger or for relieving a headache, but how suitable will that first aid kit be if fellow crewmembers or passengers require serious medical attention after a ditching? Maybe you should carry a more comprehensive medical kit aboard the airplane *and* obtain appropriate medical training to use it — just in case.

What about your life raft? Did the boss opt for the most inexpensive life raft on the market? Think about spending hours or days on rough water in *very* close proximity to your colleagues in something that might not be more durable than a floating kiddie pool.

The standard equipment and supplies provided with even top-of-the-line life rafts are meager. Maybe you should specify more suitable equipment and assemble a waterproof "ditch bag" as a supplement. The ditch bag should be capable of being removed rapidly through an emergency exit and should contain such items as drinking water, emergency ("space") blankets (made of laminated layers of polyester film, such as Mylar, with a reflective coating that can be used either to retain body heat or to protect from sunlight), sun block, waterproof flashlights and extra batteries, a handheld aviation very-high-frequency (VHF) radio, a handheld marine-band radio, a handheld satellite telephone, plastic bags (useful for *many* purposes), a spare strobe light, whistles and other items that will be worth their weight in gold (see "Don't Leave the Aircraft Without It," page 155).

Supplies provided with even top-of-the-line life rafts are meager.

Among ditch-bag items that are indispensable is a backup radio beacon, said U.S. Coast Guard Lt. Cmdr. Paul Steward.[4] Although the type of emergency locator transmitter (ELT) currently required aboard airplanes likely will activate on impact, it will stop transmitting a distress signal and a homing signal when the ELT antenna becomes submerged. Moreover, the automatic fixed ELTs installed in most aircraft generally cannot be taken out of the aircraft for use in a life raft (see "Stay Tuned: A Guide to Emergency Radio Beacons," page 139). Thus, if the airplane sinks rapidly after a ditching, an ELT signal might be broadcast only for a few seconds.

"It is good to have a portable beacon as a backup, be it a waterproof PLB [personal locator beacon], an EPIRB [emergency position-indicating radio beacon] or a backup ELT that is waterproof, floats and can be carried into the life raft," Steward said.

If one of your regular passengers is dependent on a medication, a week's worth of that medication also should be included in the ditch bag. A discussion of the post-ditching survival at the next flight-department meeting likely will reveal other ditch-bag essentials.

Emergency/survival equipment (life vests, life rafts, etc.) usually has printed instructions for proper use, but the crew should determine whether the instructions are legible and thorough — or even applicable (the instructions may not match the equipment).

Flight Attendants Are Essential

An indispensable resource on over-water flights is a trained cabin crewmember — a flight attendant or an aviation maintenance technician who periodically receives adequate cabin-safety training that is tailored to the operating environment (see "Assigning Seats to Flight Attendants Requires Care in Business Aircraft," page 23).

U.S. regulations, however, do not require flight attendants to be aboard general aviation airplanes (including those used in corporate operations and fractional

Professional flight attendants know how to serve passengers … and how to save their lives.

ownership operations) carrying fewer than 20 passengers or aboard aircraft with fewer than 20 passenger seats used in on-demand operations; furthermore, aircraft not certificated for two pilots can be flown by one pilot in an on-demand operation if the aircraft is equipped with an approved autopilot.[5] Thus, fare-paying passengers often are engaged in commercial flights conducted by a single pilot, who, in a ditching situation, likely would not be able to prepare them for the water landing or for evacuation.

Colette Coley, cabin/flight attendant program manager for FlightSafety International (FSI), said that there are several reasons why professional flight attendants or trained maintenance technicians should be assigned to overwater flights.[6]

"The flight attendant needs to be there to provide passenger services, such as food and beverages, on a long flight," she said. "There is more to these basic services than most people imagine. The flight attendant has to be concerned with food safety, ensuring that the food is stored at the proper temperature, for example.

"More important are the variables that come into play if a water landing becomes necessary. It is very important to have a trained person prepare the passengers and be with them during the water landing."

Trained is the key word: A professional flight attendant will be a far more valuable resource in an emergency situation than someone who has not completed formal training in cabin safety and is taken along to provide only in-flight "hostess" services.

Preparing the cabin and passengers for a ditching should not be a task added to the flight crew's workload.

"There will be much to do in the cabin and in the cockpit to prepare for a ditching," Coley said. "The best place for the cockpit crew is the cockpit."

Just as a flight crewmember making his or her first overwater flight in the airplane should be shown where the emergency equipment is stowed and thoroughly briefed on its use, a newly hired or contract cabin crewmember should be prepared similarly.

"A flight attendant must prepare for every flight," Coley said. "If I am going to be flying in an airplane that I have never been on before, then I need to go a day or so ahead of time to talk to the chief pilot and learn about the airplane and the passengers."

Get Ready and Set Before You Go

Surviving a ditching largely will depend on the flight crew's knowledge and skill in flying the airplane *and* the cabin crewmember's knowledge and skill in preparing the passengers and the cabin.

The preflight briefing could be the crew's last opportunity to thoroughly prepare the passengers for a ditching. If a problem occurs while flying low over water — or if a problem requires a rapid descent from altitude — the pilots will have their hands full flying the airplane, and the flight attendant might have sufficient time only to tell the passengers to don their life vests, secure their restraints and brace for impact.

"The challenges to crew and passengers in water-related accidents are formidable, and the preparation of crew and passengers for such events is crucial if they are to survive," said a 1998 report by the U.S. Federal Aviation Administration (FAA) Civil Aeromedical Institute (now the Civil Aerospace Medical Institute).[7]

Continued on page 30

Assigning Seats to Flight Attendants Requires Care in Business Aircraft

In the absence of regulations that require flight attendants, some operators of business aircraft have been influenced by training organizations and pilots to reconsider long-held policies. Precedents set by airlines may influence the resulting cabin-safety practices.

In many countries, operators of business aircraft are not required by civil aviation regulations to carry flight attendants in general aviation operations. Current standards and recommended practices of the International Civil Aviation Organization (ICAO) also provide limited guidance that pertains directly to using flight attendants in business aircraft. As a result, significant variations in cabin-safety practices exist, and some practices — such as routinely assigning a flight attendant to the cockpit-observer jump seat for takeoff and landing — show that there is no international consensus about them. Nevertheless, many operators of business aircraft voluntarily exceed official requirements based, in part, on the principles and precedents of air carriers.

If an operator's policies do not address cabin-safety issues adequately, cockpit crews may object to the inconsistent practices by citing safety concerns. For example, one U.S. pilot conducting flights under U.S. Federal Aviation Regulations (FARs) Part 135, *Commuter and On-demand Operations*, submitted the following report to the U.S. National Aeronautics and Space Administration Aviation Safety Reporting System: "I do not believe that all the problems are companywide. For the most part, I feel they are [in] our individual operation. There is a total disregard for training. [For example,] I have two [women] who are carried as flight attendants. Neither [flight attendant] has had a good initial course, much less a recurrent training program. Yet the airplane is operated [under] Part 135. The flight crew operates the majority of its flights internationally. … On one of our last flights, we were required to make an emergency return. Operations had stacked four computer-paper boxes of catering in the main doorway, thus blocking emergency egress. Our flight attendant is required to sit in a jump seat locked between the pilot [seat] and copilot [seat], thus blocking egress from the cockpit in an emergency. … This operation is an accident waiting to happen."[1]

In 1993, 31 U.S. operators of large business aircraft responded to questions about their policies and practices for utilization of flight attendants under FARs Part 91, *General Operating and Flight Rules*.[2] Principal findings from the survey responses were that 71 percent of the operators said that they assigned flight attendants to domestic flights, and 87 percent said that they assigned flight attendants to international flights.

One-third of operators who used flight attendants said that they used maintenance technicians (called a "third crewmember" or "flight mechanic") who had received the same cabin-safety training as flight attendants. Some operators said that anecdotal experiences — in which a flight attendant conducted emergency procedures and controlled the situation while passengers showed signs of panic during incidents involving smoke, fire or emergency evacuation — had convinced the operators of the safety value of a flight attendant on business aircraft. Other operators said that flight attendants were used on all international flights but on no domestic flights.

The following reasons were cited by operators that did not use a flight attendant on any aircraft:

- Carrying a flight attendant would be inconsistent with the company's culture, style or employee morale. (For example, a corporate chairman believed that having a flight attendant on the aircraft would convey an inaccurate impression to employees about work conducted by the chairman on the company airplane);
- A flight attendant was deemed unnecessary because the same passengers traveled on all trips in the airplanes, and these passengers were trained in cabin safety; and,
- Flight attendants were considered helpful but not essential.

Three large U.S. airlines that also provided comments to researchers in the 1993 survey, however, said that a flight attendant in the cabin provides a shorter response time and a disciplined, knowledge-based response to emergency conditions, such as initiating immediate movement of passengers in an emergency evacuation to increase the probability of passenger survival. Actions that would be instinctive to untrained passengers — such as opening the nearest exit — could jeopardize safety, the airlines said. On the other hand, flight attendants frequently helped to manage an in-flight medical emergency and helped the captain to distinguish minor health incidents from those that required landing at the nearest suitable location that had appropriate medical care.

Worldwide, national requirements for carrying a flight attendant on commercial aircraft typically are based on the passenger-seating capacity (aircraft seats or passengers) of the aircraft, such as providing one flight attendant when more than 19 passengers are carried, said Donald Spruston, director general of the International Business Aviation Council (IBAC).[3] IBAC represents 11 national associations and regional associations of business aircraft operators at the international level, has ICAO observer status and represents business aviation on most of the panels and the planning and implementation groups of ICAO.

"Requirements for carrying flight attendants are very similar; I am not aware of countries that vary significantly by requiring flight attendants in general aviation operations," Spruston said. "Because business aircraft are becoming larger, have longer range and are used in more intercontinental operations, no doubt there is an increasing safety requirement for the use of flight attendants. Good communication and management of the cockpit and cabin have become more important during the past 10 years."

Although IBAC has been involved in ICAO's flight-crew-licensing panel and the recently reactivated operations panel, Spruston said, IBAC representatives have not reported any recent committee discussion of issues or work-agenda items related to flight attendants in business aircraft. IBAC has developed a set of performance-based standards for voluntary adoption by international operators of business aircraft that will influence indirectly how flight attendants function on business aircraft.

"Completed in 2002 and introduced by a number of flight departments, our International Standard for Business Aircraft Operations [IS–BAO] was developed and tested by IBAC members during a two-year period," Spruston said. "These standards require that flight departments establish processes and documentation using principles of ISO 9000-series quality management."[4]

Before issuing a voluntary certificate of registration, the IS–BAO program requires that member operators have specific processes for duty-time limitations and training, including training standards and recurrency training for flight attendants.

"Essentially, we have used the principles of ISO 9000, but have included only safety-related provisions in building an aviation-oriented safety standard," Spruston said. "IS–BAO does not contain anything as to level of cabin service — nothing is included about whether a passenger is treated well in the back of the aircraft. This reinforces our position that every crewmember's primary responsibility is safety; therefore, anything else that a flight attendant may do in terms of customer service is an add-on benefit."

To be registered in the program, operators must meet the requirements of ICAO Annex 6, *Operation of Aircraft,* Part II, *International General Aviation – Aeroplanes,* and satisfy all the national requirements of the state of registry for providing the nationally required number of cabin crewmembers, he said.

> **"Good communication and management of the cockpit and cabin have become more important during the past 10 years."**

"If operators decide to have a flight attendant, they must have training for this person; IS–BAO does not stipulate the exact requirement," Spruston said. "The standards are not prescriptive in details of what has to be provided or the seating assigned to a flight attendant, but are designed to ensure that the operator sets up the appropriate type of training, requires that all crewmembers meet the operator's standard and demonstrates that the operator has appropriate training for the cabin crew as well as the cockpit crew. There must be more focus on the related training requirements and crew resource management, which we have included as an important safety requirement in the IS–BAO program." Revisions will be introduced annually in January by an IBAC standards board in response to the changing consensus on codes of practice and best practices, he said.

IBAC's member associations — such as the U.S. National Business Aviation Association (NBAA) — also consider cabin-safety practices at the national level or regional level. For example, NBAA emphasizes that the seating policy of operators of business aircraft should ensure that the flight attendant has access to passengers, can communicate with passengers and can conduct effectively cabin emergency procedures, including emergency evacuation, said Joe A. Evans, NBAA director of operations and staff liaison to the NBAA Flight Attendant Committee.[5]

"Flight attendants should be seated in a corporate aircraft so that they are prepared to assist the pilot-in-command in all cabin and passenger safety issues and security issues," Evans said. "When a member company uses an assigned flight attendant on board a corporate aircraft, that person should possess the proper safety training and security training. We have listed voluntary recommended training practices in the *NBAA Management Guide*."

No aircraft seat approved for occupancy during takeoff and landing is considered inherently more safe than another, said Nancy Claussen, a cabin safety inspector with the U.S. Federal Aviation Administration (FAA).[6] Nevertheless, a seat equipped with a combined safety-belt and shoulder-harness unit — in a forward-facing seat or an aft-facing seat rather than in a side-facing seat — would be preferable for a crewmember who has been assigned safety-related duties, she said. This type of restraint system is required for flight attendants under FARs Part 121, *Domestic, Flag and Air Carrier Operations*, in transport category aircraft.

"Although FAA does not recognize the flight attendant as a required crewmember in FARs Part 91 operations, protecting every flight attendant is critical as a cabin-safety factor," Claussen said. "Our cabin-safety regulations were written prior to such new industry dynamics as the increased use of business jets and fractional ownership. FAA is working to address many issues in these operations to ensure a high level of safety. We have concluded from several reports of experimental research that when one or more flight attendants was present in the cabin of a transport airplane, emergency egress times were significantly less than when passengers evacuated the aircraft without a flight attendant present. Some cabin-safety training organizations are trying to take Part 121 requirements for flight attendants as a guide and voluntarily parallel them; I support their efforts to increase the level of safety by having trained crewmembers aboard the aircraft to assist passengers in an emergency."

One source of relevant safety principles is the European Joint Aviation Requirements, which say that a civil aviation authority may require an increased number of flight attendants in a transport airplane because of factors such as "the location of cabin crew seats, taking into account cabin crew duties in an emergency evacuation." Considerations for seat assignment to a flight attendant in European transport aircraft also include the following factors: "When determining cabin crew seating positions, the operator should ensure that they are: close to a floor-level exit; provided with a good view of the area(s) of the passenger cabin for which the cabin crewmember is responsible; and evenly distributed throughout the cabin, in the above order of priority. [The same factors apply to operators of helicopters in commercial air transportation.]"[7]

Another source of relevant safety principles is the airworthiness requirements for transport category airplanes in the following FARs:

- "Each seat, berth, safety belt, harness and adjacent part of the airplane at each station designated as occupiable during takeoff and landing must be designed so that a person making proper use of the facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in [FARs Part 25, *Airworthiness Standards, Transport Category Airplanes*] 25.561 [*General*] and 25.562 [*Emergency Landing Dynamic Conditions*];"[8]
- "Each seat located in the passenger compartment and designated for use during takeoff and landing by a flight attendant required by the operating rules of this section [of the FARs] must be: near a required floor-level emergency exit, except that another location is acceptable if the emergency egress of passengers would be enhanced with that location. A flight attendant seat must be located adjacent to each Type A or [Type] B emergency exit. Other flight attendant seats must be evenly distributed among the required floor-level emergency exits to the extent feasible; to the extent possible, without compromising proximity to a required floor-level emergency exit, located to provide a direct view of the cabin area for which the flight attendant is responsible; positioned so that the seat will not interfere with the use of a passageway or exit when the seat is not in use; located to minimize the probability that occupants would suffer injury by being struck by items dislodged from service areas, stowage compartments, or service equipment; either forward [facing] or rearward facing with an energy-absorbing rest that is designed to support the arms, shoulders, head and spine; [and,] equipped with a restraint system consisting of a combined safety-belt and shoulder-harness unit with a single-point release. There must be a means to secure each restraint system when not in use to prevent interference with rapid egress during an emergency;"and,[9]
- "Each forward observer's seat required by the operating rules must be shown to be suitable for use in conducting the necessary en route inspection."[10]

Trainers of Flight Attendants Suggest Revised Practices

Representatives of two U.S. training companies that interact frequently with operators of business aircraft — FACTS Training International and FlightSafety International — believe that these cabin-safety issues deserve greater attention.

Clients' cabin-safety practices often are discussed during procedures training that is specific to the operation of corporate/business aircraft, said Douglas B. Mykol, N.D. (doctor of naturopathic medicine), chief executive officer of FACTS Training International and AirCare International.[11]

"I estimate that 50 percent of the cabin-class business jets and all of the heavy-jet corporate aircraft currently provide a flight attendant for every flight," Mykol said. "An additional 20 percent of business-aircraft operators include a flight attendant for their longer flights and for international flights. Over the years, there has been a slow change of attitude in regard to flight attendants in business aircraft. When practical for the size of the aircraft, a flight attendant should be considered a 'no go' checklist item [that is, the departure should not be conducted without a flight attendant] — similar to a vital part of the aircraft's emergency equipment.

"Many operators still consider assigning the flight attendant in terms of service-related issues. It has been an uphill battle for many years to get the flight attendant/third crewmember recognized as a valuable safety asset."

Proper training of personnel who are assigned to perform flight attendant duties is one of the most critical issues currently facing operators of business aircraft, he said.

"There are still many operators putting an untrained person aboard the aircraft as a third crewmember," he said. "We have been aware of examples of this practice such as using a pilot's friend, an executive's secretary or a restaurant employee who the pilot met the night before the flight. Obviously, a person acting as a flight attendant creates an immense liability — financially, ethically and morally because the passengers most likely will view a person who acts like a cabin crewmember as a trained flight attendant.

In an emergency, the passengers will look to this crewmember for assistance."

Although Mykol believes that most operators of business/corporate jets currently assign the cabin crewmember to sit in the cockpit-observer jump seat for takeoff and landing, FACTS cabin safety specialists discourage this practice, he said.

"We estimate that 90 percent of U.S. cabin-class aircraft operators have the flight attendant sit in the cockpit-observer jump seat for takeoff and landing," Mykol said. "We believe that this common practice should be avoided because the flight attendant primarily is on board for passenger-safety reasons. It is very difficult for a flight attendant who is sitting in a forward-facing jump seat — facing away from the passengers — to assist in the event of an emergency."

Some operators of business aircraft have established policies and procedures that assign the flight attendant to a specific seat in the cabin for takeoff and landing.

"We highly recommend this policy and also recommend that the cabin crewmember be seated in an aft-facing seat, which typically provides a view of the entire cabin and passengers," Mykol said. "From the cabin, the flight attendant can observe, assess, correct and respond to emergencies and safety issues in a much more timely fashion.

"In a planned emergency, the aft-facing brace position allows for both viewing the cabin and issuing voice commands to the passengers during impact. Most other forward-facing brace positions require the cabin crewmember to be bent over to grab the ankles with the head down. This position results in the cabin crewmember not being able to see the cabin or passengers, and any voice commands will be directed toward the floor instead of toward the passengers." A flight attendant seated in a cockpit-observer jump seat similarly cannot issue voice commands directly toward the passengers.

Ideally, pilots and flight attendants will be trained to work together as a crew in problem-solving and to conduct routinely a preflight conference on unique safety factors of each flight such as seating, emergency evacuation and crew commands.

"Most professional flight attendants and training organizations would like to see regulations for training and minimum qualifications for the flight attendant, but this concept causes much concern within NBAA and among some operators," Mykol said. "While standards are usually good for the industry and for safety, aircraft operators would incur costs to operate at this higher standard."

A positive trend in recent years has been improvement of procedures training on cabin emergencies for pilots.

"While emergency-procedures training is required for every Part 135 crewmember, including pilots, I have seen many Part 135 operators send their flight attendants to formal training, but conduct only a brief in-house safety meeting to train pilots," he said. "This is slowly changing. Currently, each of our cabin-safety classes typically consists of about 30 percent pilots, 20 percent flight engineers/maintenance technicians and 50 percent flight attendants. About 20 percent of our clients send their entire crews to cabin-emergency-procedures training. Usually, within the first two hours, pilots appreciate being empowered with new skills."

Consciousness about these issues has been raised partly by the participation of pilots in cabin-safety training, said Colette Coley, cabin/flight attendant program manager for FlightSafety International.[12]

"Training provides pilots more hands-on experience with the equipment in the back of the airplane and what it is like to talk passengers through a planned emergency landing," Coley said. "Whether the crewmember is in the cockpit or the cabin, there is better understanding. On occasion, pilots have gone back to their companies and discussed the value of flight attendants on business aircraft."

On some business aircraft, however, operators have found using a flight attendant to be unfeasible or impractical primarily because of limited cabin space or unsuitable cabin configuration, Coley said.

"In the past, some operators who have used our training have placed the flight attendant on the cockpit-observer seat, which is not — in our opinion — the best position because the flight attendant is on board primarily for passenger safety," she said. "Based on the types of business aircraft in which we have provided training, FlightSafety International does not recommend the use of the cockpit-observer seat. The best place for the flight attendant is in the cabin with the passengers, functioning as the safety backup for the cockpit crew."

The flight attendant should occupy the closest aft-facing seat or closest forward-facing seat to the primary emergency exit; Coley said that she would not recommend any side-facing seat, even if that is the seat closest to the primary emergency exit. Some operators currently provide a combined seat-belt and shoulder-harness unit with a single-point release for all passenger seats.

"Typically, with contract flight attendants, discussion of seat assignment is done during the preflight briefing," she said. "If the flight attendant knows ahead of time about the trip, he or she should take time to meet with the crew or the chief pilot and find out more about the operator's standard operating procedures, what type of emergency equipment is on the airplane and where it is located, where the flight attendant will be seated, the scope of responsibilities — for example, some operators require the cockpit crew to conduct preflight checks of all cabin emergency equipment — and passenger load and catering details. We encourage flight attendants to learn as much as possible before the day of the flight — otherwise, they should meet the airplane earlier in the day of the flight to be briefed by the cockpit crew. Even if preflight equipment checks are not delegated to a contract flight attendant, flight attendants are trained to perform a preflight inspection to familiarize themselves with everything on that airplane and where everything is located."

The flight attendant must know from experience what is required for safety; for example, if the galley is aft, an aft fire extinguisher and aft personal breathing equipment (PBE) will be required, she said. Flight attendants also know that one interior configuration may be significantly different than the interior of the same aircraft type that an operator has parked nearby — for example, fire extinguishers may be placed at the forward bulkhead and the aft bulkhead in one airplane, but may be placed in a mid-cabin location and in the front of the cabin in another. Taking nothing for granted about emergency-equipment stowage is critical because some operators select the most inconspicuous cabin locations, Coley said.

"We definitely are influenced by lessons learned from Part 121 operations; there is nothing wrong with applying them to corporate aviation if it makes sense," she said. "We have to consider every aspect of training based on its own merits but we are always watching and learning from other types of operations so that mistakes are not duplicated just because a practice is not required by regulations in business aircraft. In an emergency situation, a properly trained and qualified flight attendant will enhance the safety of every individual on the airplane."

U.S. Operator Sets Policy, Provides Client Education

Cabin safety requires a continuing commitment after basic policies have been established, such as when to use flight attendants in a business aircraft and how the seat will be assigned to the flight attendant for optimal safety. Factors such as cost, resistance to change and clients' misunderstanding of crew roles and responsibilities can affect implementation of the policies.

"We are using flight attendants on a regular basis for the Boeing 727 and the Boeing Business Jet; the Dassault Falcon 50, Falcon 900 and Falcon 2000; the Bombardier Global Express, Challenger 601 and Challenger 604; and the Gulfstream II, III, IV, V and 200," said Charles McLeran, chief operating officer for TAG Aviation USA. "We rarely use flight attendants on Raytheon Hawker-series airplanes or smaller aircraft.[13]

"One obstacle that we run into with some aircraft owners is cost. Typically, they will want a flight attendant in cabin-class airplanes, but for other aircraft — the Falcon 50 and the Challenger 601, for example — they may not want a flight attendant on the airplane. Other owners or clients ask for a flight attendant only for specific types of trips — such as for a long international trip, when entertaining guests or when providing an elaborate meal service.

"In an emergency situation, a properly trained and qualified flight attendant will enhance the safety of every individual on the airplane."

Otherwise, the issue may be that some customers would prefer to have the cabin all to themselves."

Some advantages of assigning a flight attendant to a business aircraft are readily apparent, but others might not be obvious to operators, owners and passengers, said Ann Holmes, director, cabin standards and services, for TAG Aviation USA.

Operators of business aircraft — especially cabin-class aircraft and large transport aircraft with executive interiors — increasingly subscribe to medical advice services that provide communication with a physician on the ground. When medical advice is required, the presence of a cabin crewmember enables the captain and first officer to focus first on safety of flight in handling the in-flight medical emergency, Holmes said.

If the operator is enrolled in MedAire's MedLink service, for example, and an injury or illness occurs, the flight attendant can communicate directly with the MedLink physician, provide information about the passenger, discuss with the pilots the physician's recommendation about landing as scheduled or diverting the flight for the nearest appropriate medical care, and apply the medical advice in the cabin while the cockpit crew conducts the diversion.

"Without a flight attendant, one of the pilots would have to assess the passenger's symptoms and discuss with MedLink any recommendation to divert," Holmes said. "All TAG Aviation flight attendants have training in cardiopulmonary resuscitation [CPR], use of the automated external defibrillator (AED) and first aid. All the aircraft that we operate carry a basic first aid kit, and many carry an enhanced medical kit."

All cabin equipment must be used correctly and safely; otherwise, there could be significant risk of distraction to pilots caused by a passenger's unfamiliarity with cabin equipment or the passenger's inability to resolve apparent malfunctions, McLeran said.

"This has been a significant issue among our customers because about 75 percent of the aircraft we use in on-demand operations are owned by private individuals," McLeran said. "The typical charter passenger will not know how to operate these systems. Even aircraft owners sometimes become confused about operating cabin equipment such as a satellite TV system or wireless local-area-network system for laptop computers, which may not be intuitively easy to operate. Apparent malfunctions often are operator-error issues. Moreover, if no flight attendant is aboard, a passenger sometimes will go to the cockpit for such assistance at the same time that the crew might be entering a high-density traffic environment, for example. While one pilot might be able to help a passenger with such problems in cruise, we have learned from experience that the flight attendant has a very important operational function aboard these airplanes."

As to where the flight attendant should be assigned to sit in a business aircraft, practices vary among operators, Holmes said.

"The assumption among many operators is that the flight attendant will sit in the cockpit-observer jump seat," Holmes said. "We concur with FACTS and FlightSafety International, which highly recommend that the flight attendant sit in the cabin — not in the jump seat. On many cabin-class airplanes such as the Falcon 900 series, Challenger series and Gulfstream series, the main entry door adjacent to the cockpit is not the primary emergency exit. Typically, the primary emergency exit is an overwing exit; therefore, a flight attendant seated at the cockpit is in a position farthest from the overwing exit."

Positioning a flight attendant in the cockpit-observer jump seat also runs counter to the well-developed practice of airlines, McLeran said.

"When I began flying business aircraft, experience in the airline industry caused me surprise to find that a vast majority of flight attendants ended up sitting on the jump seat," McLeran said. "We changed this practice when TAG began conducting line observations. Now, the vast majority of our flight attendants are sitting in the cabin."

The possibility that an injured flight attendant inadvertently could block an evacuation path also is a concern, McLeran said.

"A major problem could occur if during a serious unplanned emergency — such as a runway excursion — the flight attendant suddenly became a serious obstacle to the cockpit crew in completing the duties they must perform," McLeran said. "That is a risk you take on a business jet — something to be concerned about 100 percent of the time — when you routinely use the cockpit-observer jump seat.

"Although aviation professionals may joke about the pilots being first to arrive at an accident scene, if they are incapacitated when the aircraft stops, the flight attendant is critical to getting the passengers off the airplane to a safe place on the ground. The flight attendant also has been trained on how to evacuate injured pilots. In safety demonstrations, we have asked the aircraft owner or passengers to assist pilots who are slumped over in the seat by getting the pilots out of their seats. Typically, they cannot figure out how to disconnect the belts by rotating the release mechanism of the single-point harness."

In the current environment, operators of business aircraft have many reasons to reassess their policies on flight attendants.

"TAG Aviation operates under a safety-policy memorandum that says that our preference is that flight attendants maintain a seating position in the cabin," McLeran said. "A new company flight attendant manual also will say that the flight attendant should occupy a cabin seat. With respect to aircraft owners, however, we are in a safety-consulting position and some owners are opposed to this policy. When these owners are aboard the aircraft, they want the flight attendant to occupy the cockpit-observer jump seat even for takeoff and landing. We say in print what our policy is and follow this policy with clients other than aircraft owners. If an aircraft owner overrides this policy, we will attempt to explain why this issue is so important — but the situation puts the crew in a difficult situation to resolve."

The most persistent issue in seating a flight attendant on a business aircraft seems to be some passengers' perceptions that comfort, cabin service and privacy are the highest priorities, Holmes said.

"Many clients want to fly with the same crewmembers on trips because they have developed confidence in them as individuals and in their expertise," McLeran said. "Clients also should know that they can discuss private matters or proprietary business information without regard to the flight attendant's presence or seat assignment in the cabin. When passengers have private conversations, the flight attendant will 'hear nothing, see nothing, say nothing.' The basis for this includes the confidentiality clause in their employment agreement, screening by clients and pre-employment checks of their references, and the reputation that they must earn in this business for being discreet and for assuming the demeanor of a trusted executive assistant and safety professional."

Flight Safety Foundation has recognized the following additional principles of cabin safety, which have precedents in airline operations:

- Flight attendants have provided a first line of defense for detecting and enabling the cockpit crew to respond to unsafe conditions (such as unusual sounds, smoke, odors, fumes, visible equipment malfunctions, unsafe stowage of bags or relocation of equipment by passengers that would block emergency exits or an aisle, and securing loose articles);

- Some emergency tasks can be conducted most quickly when the flight attendant has eye contact with passengers (for example, to observe nonverbal passenger behavior and to determine that passengers are in the correct position after the brace command) to communicate with voice commands and hand signals, and rapid access to stowed equipment (such as flashlights, medical kit, oxygen-related devices or life raft);

- The flight attendant should have ready access to the galley at all times to stow items and/or to secure equipment under various flight conditions;

- The flight attendant should be in a position to help prevent an unnecessary or hazardous evacuation initiated by a passenger, including inappropriate activation of equipment such as an escape slide;

- In some aircraft, any cockpit-observer jump seat or folding cockpit-observer seat and any harness must be stowed securely so that exit paths are not blocked for the flight crew during an emergency; operators should consider the extra time that would be required to secure a folding seat, belt and harness during an emergency evacuation; and,

- The comfort of the flight attendant's assigned seat should be considered in terms of fatigue, which might affect a flight attendant's performance during an emergency.

Comparison of comments in the 1993 survey[14] with comments in 2003 showed that frequently mentioned issues have changed little in deciding when and how to assign flight attendants to business aircraft. If these issues continue receiving attention from operators, training organizations, regulators and safety specialists in industry associations, greater consensus could reduce the degree of inconsistency in current practices. ■

— FSF Editorial Staff

[FSF editorial note: This article has been reprinted from *Cabin Crew Safety* Volume 38 (May–June 2003).]

Notes

1. U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS). Report no. 356743, January 1997. NASA ASRS is a confidential incident-reporting system. The ASRS Program Overview said, "Pilots, air traffic controllers, flight attendants, mechanics, ground personnel and others involved in aviation operations submit reports to the ASRS when they are involved in, or observe, an incident or situation in which aviation safety was compromised. … ASRS de-identifies reports before entering them into the incident database. All personal and organizational names are removed. Dates, times, and related information, which could be used to infer an identity, are either generalized or eliminated." ASRS acknowledges that its data have certain limitations. ASRS *Directline* (December 1998) said, "Reporters to ASRS may introduce biases that result from a greater tendency to report serious events than minor ones; from organizational and geographic influences; and from many other factors. All of these potential influences reduce the confidence that can be attached to statistical findings based on ASRS data. However, the proportions of consistently reported incidents to ASRS, such as altitude deviations, have been remarkably stable over many years. Therefore, users of ASRS may presume that incident reports drawn from a time interval of several or more years will reflect patterns that are broadly representative of the total universe of aviation-safety incidents of that type."

2. Speas, R. Dixon; Becker, Otto A.; Conte, John L. "Utilization of Flight Attendants, Business Aircraft Operations, Companies of Fortune 50 Category." Tucson, Arizona, U.S.: PRC Aviation, February 1993. This report was distributed to Flight Safety Foundation and to members of the U.S. National Business Aircraft Association (now National Business Aviation Association). "Fortune 50" refers to the 50 largest U.S. companies as rated annually by *Fortune* magazine.

3. Spruston, Donald D. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. June 4, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Joint Aviation Requirements–Operations (JAR–OPS) 1, *Commercial Air Transportation (Aeroplanes)*, Subpart O, Cabin Crew, 1.990, for example, says, "An operator shall not operate an aeroplane with a maximum approved passenger seating configuration of more than 19, when carrying one or more passengers, unless at least one cabin crewmember is included in the crew for the purpose of performing duties, specified in the operations manual, in the interests of the safety of passengers."

4. The International Organization for Standardization (ISO) — a network of national standards institutes in 146 countries — developed ISO 9000-series standards as a voluntary international reference for quality requirements in business-to-business interactions. ISO 9000 provides generic quality-management system standards for organizational processes/activities that enhance and continually improve customer satisfaction by meeting customer requirements and by meeting applicable regulatory requirements.

5. Evans, Joe A. Interview and e-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. March 12, 2003, and June 6, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

6. Claussen, Nancy. Interview and e-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. March 12, 2003, and June 3, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

7. Joint Aviation Authorities. IEM OPS 1.990, *Number and Composition of Cabin Crew*, and IEM OPS 1.31(b), *Cabin Crew Seating Positions.*

8. U.S. Federal Aviation Regulations (FARs) 25.785(b).

9. FARs 25.785(h).

10. FARs 25.785(l).

11. Mykol, Douglas B. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S., March 22, 2003. Flight Safety Foundation, Alexandria, Virginia. Mykol is a member of the Flight Attendant Committee of the U.S. National Business Aviation Association.

12. Coley, Colette M. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S. March 18, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

13. McLeran, Charles; Holmes, Ann. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S., March 21, 2003. Flight Safety Foundation, Alexandria, Virginia.

14. Speas et al.

In an advisory circular on ditching, the U.K. Civil Aviation Authority (CAA) recommends that passenger briefings before overwater flights include information about the following:[8]

- "Contents and features found on the life [vest], including how to inflate it if the bottle [carbon-dioxide gas cartridge] fails;
- "Location of the life raft(s);
- "The order in which people should vacate the aircraft in the event of a ditching and who will be responsible for taking the life raft with them;
- "That life [vests] must *not* be inflated until clear of the aircraft;
- "To remove headsets and [eye]glasses, and to stow [eye]glasses on their person prior to touchdown;
- "Tighten seat straps/harnesses prior to touchdown on the water and … assume a braced position; [and,]
- "Reference points on the aircraft's internal structure that they should reach for [to improve their orientation] when exiting the aircraft, as well as any features which might impede exit."

Time to Consider 'What If?'

A valuable exercise while monitoring the flight control system during cruise flight would be to discuss ditching procedures and the location and use of the emergency equipment aboard the airplane. The discussion will help the crew to develop their action plan and get them one step ahead of any problem that might occur.

Such discussion is a key element of the ditching drills conducted by U.S. Coast Guard C-130 crews during semiannual training flights.

"We simulate a ditching and go through the basic procedures for all the crew positions: the pilots, flight engineer, the navigator, the radio operator and the drop-and-load master," said Lane. "They all have different duties and their own checklists.

"Much of the drill involves discussion. We discuss two different scenarios: one in which you will have some time to prepare for the ditching — for instance, a situation in which you cannot get fuel out of a tank; the other is that you will not have a lot of time — for example, if you have a wing fire."

The ditching procedure recommended in a flight crew operating manual (FCOM) for a turbine business airplane typically is based on technical analysis by the manufacturer and the incorporation of procedures recommended by other manufacturers.

"Our engineering and flight-test people got together and worked out analytically what the ditching procedure for the Citation X would be and then submitted it for certification with the airplane flight manual," said Michael Pierce, Citation marketing manager for Cessna Aircraft Co.[9]

Procedures for some airplanes are based on ditching tests conducted with other aircraft. The FCOMs for the Raytheon Hawker 800, Hawker 800XP and Hawker 1000, for example, say that the recommended ditching procedures are not based on ditching tests of the airplanes — "no such tests have been carried out" — but that the recommendations "contain the best available advice, being based largely on model ditching tests on the [U.K. Royal Air Force] Dominie and general procedures of other aircraft." (The Dominie is a military version of the de Havilland Dragon Rapide, a twin-engine biplane that first flew in 1934.)[10]

The basic procedures recommended by the airplane manufacturers are similar.

"The procedures really do not vary much from one aircraft to the next," said Bill Campbell, director of regulatory compliance for CAE SimuFlite.[11] "Nobody really has any experience in conducting emergency landings on the water, and the manufacturers are careful to say, 'This is our best guess — we have not demonstrated this maneuver to anyone, so we are not entirely sure.'"

A note at the top of the ditching checklist for the Citation X is typical. It says, "Ditching was not conducted during certification testing of the airplane. Should ditching be required, the following procedures are recommended."

The Hawker 800, Hawker 1000 and Citation X are not certificated for ditching (see "Ditching Certification — What Does It Mean?" page 66). Nevertheless, the recommended ditching procedures for business airplanes that have been certificated for ditching also are based largely on analysis.

For example, at the top of the ditching checklist for the ditching-certificated Gulfstream V is this note: "No tests or actual ditching have been made. The following procedures will improve the chances of a successful ditching."

Thinking Outside the Box

As the FSF editorial staff conducted research for this article, it became clear that some of the recommended procedures developed by the airplane manufacturers differ from procedures recommended by specialists in water-survival instruction.

The FSF *Airplane Flight Crew Ditching Checklist* (page 31) is intended as a framework for discussion of ditching procedures.[12] The procedures apply to transport category business jets operated with cabin crewmembers and might not be appropriate for other types of airplane operations.

Continued on page 32

Flight Safety Foundation
Airplane Flight Crew Ditching Checklist
(Operations With Cabin Crew)

Fly the airplane.

Preliminary

- ❑ Notify air traffic control of the nature of the emergency and intentions to ditch.
- ❑ Select transponder code 7700.
- ❑ Activate emergency locator transmitter (ELT) (unless ELT signal interferes with radio communication).
- ❑ Change course toward nearest land or vessel.

Preparation

- ❑ Notify cabin crew/passengers of the emergency and intentions to ditch, and provide an estimate of time until water contact.
- ❑ Select "Seat Belts/No Smoking" light.
- ❑ Deactivate landing-gear-warning system and terrain awareness and warning system (TAWS)/ground-proximity warning system (GPWS) to prevent unnecessary warnings (unless TAWS/GPWS altitude callouts will be used during approach).
- ❑ Reduce fuel to minimum required for approach/landing.

Approach (at/below 2,000 feet)

- ❑ Set radio altimeter to signal 50 feet (if radio altimeter does not provide altitude callouts); set barometric altimeter to indicated radio altitude or to TAWS/GPWS altitude callout.
- ❑ Evaluate sea conditions; plan to land parallel to swell or, if drift exceeds 10 degrees, into wind on back side of swell.
- ❑ Depressurize cabin and ensure that main air valves and dump valves are closed.
- ❑ Close engine/auxiliary power unit bleed valves.
- ❑ Landing light, as required.
- ❑ Landing gear lever "UP."
- ❑ Flaps/slats per flight crew operating manual (FCOM) (typically, "FULL").
- ❑ Ensure ELT is activated.

Before Ditching

- ❑ Airspeed per FCOM (typically, slowest speed at which control can be maintained).
- ❑ Command/signal "brace."
- ❑ Move throttle levers to "CUTOFF" or "STOP" position just before touchdown.
- ❑ Pitch attitude per FCOM (typically, slightly higher than normal landing attitude).
- ❑ Pilot flying: both hands on control yoke.

After Ditching

- ❑ Announce on radio frequency in use that airplane has been ditched and evacuation has begun.
- ❑ Ensure that cabin is depressurized.
- ❑ Command evacuation.
- ❑ Secure flight deck; leave lights on.
- ❑ Evacuate flight deck and deploy life rafts.

Note: This information, which focuses on transport category turbine airplanes with flight attendants aboard during overwater operations, was assembled for discussion of ditching procedures and is not intended to supersede operators' or manufacturers' requirements or recommended procedures.

CHECKLIST

Prompt notification of air traffic control is essential.

For example, ditching checklists for transport category airplanes typically recommend that the flaps be extended fully, to help achieve the slowest possible speed at which the airplane remains controllable on touchdown. Some aviation-magazine articles on ditching light general aviation airplanes, however, have said that extending full flaps is inadvisable because they could cause the airplane to pitch down excessively on contact with the water.

Another common recommendation for light airplanes is to open emergency exits and doors before ditching, to prevent them from being jammed shut by distortion of the fuselage during impact. U.S. certification standards require transport category airplane manufacturers to minimize the probability that emergency exits will become jammed during a "minor crash landing."[13] Transport category airplanes also are required to have "ditching emergency exits" — that is, one exit above the waterline on each side of the airplane.

Every Tick of the Clock Counts

An item that is at or near the top of every business airplane ditching checklist is to notify air traffic control (ATC).

Early recognition of a problem that might require a ditching and prompt notification of ATC that a ditching is possible increase the likelihood of receiving assistance during the emergency and of timely involvement and response by search-and-rescue (SAR) authorities (see "The Search-and-rescue System Will Find You — If You Help," page 111).

The most common reaction to an emergency situation, however, is denial.

"Usually in a crisis situation, 70 percent of people will deny what is happening," said the FAA.[14] "If critical decisions are delayed, loss of life can occur."

A crew might react to a low-fuel indication, for example, by concluding that the gauges are not functioning properly. By denying that they might have a serious problem, the crew robs themselves of precious time they need to gather information, plan their actions and prepare themselves and their passengers for the likely outcome.

"It is really important to let people know that you have a problem as soon as you can," said Paul D. Russell, a maritime safety specialist and accident investigator, and a retired U.S. Coast Guard captain with more than 5,000 flight hours in fixed-wing and rotary-wing aircraft.[15]

"Don't wait to let somebody know that you are having a problem," Russell said. "The sooner you let ATC know that you might end up in the water, the sooner they can begin mobilizing the rescue coordination centers [RCCs]. It takes time for them to come to your assistance; with early notification, you lessen your time in the water.

"It is always better to alert people early than to wait. You can call and cancel if the problem goes away. You do not want to be so proud that the first information [ATC and SAR personnel receive] is a signal from your ELT."

Try the Assigned Frequency First

The flight crew should use the assigned radio frequency to notify ATC that they have a problem. The controller will want to know the airplane's position, the nature of the emergency and the crew's intentions.

The controller also might want to know the number of people aboard the airplane, airspeed, fuel remaining (in hours and minutes), weather conditions and the types of emergency equipment aboard the airplane (e.g., life rafts, life vests, ELTs, signaling devices, etc.).

Steward said that limited time to communicate and the possibility of disruption of radio communication also are reasons to notify ATC of a problem as soon as the problem becomes apparent.

"In a ditching situation, pilots may not be able to maintain radio communication very long, so when putting out a distress call ['mayday, mayday, mayday'] or an urgency call ['pan-pan, pan-pan, pan-pan'], they must include at least three critical things: the aircraft's tail [registration] number, position and number of people aboard," he said. "Heading, altitude, rate of descent, where they are going and/or where they anticipate ditching also are valuable."

Professional pilots typically do a good job in promptly notifying ATC about problems, Steward said.

"Pilots of commercial aircraft and business jets are, relatively speaking, cool customers who get out that information, knowing that any failure aboard the aircraft may affect communication systems," he said. "For example, we have talked to aircraft crews who reported a low-fuel status or an engine problem and basically said, 'I am just letting you know.'"

A flight crew departing from the United States typically will be in VHF radio contact and in radar contact with ATC within about 200 nautical miles (370 kilometers) of shore.

"Generally speaking, we 'see' about 200 miles out from wherever we have a radar antenna," said Tony Ferrante, manager of the FAA Air Traffic Investigations Division.[16] "For instance, we have a radar system located on Bermuda, which gives us the ability to look 200 miles in any direction of Bermuda. As far as radio coverage goes, that all depends on where we have remote communication air-ground transmitter sites — we call them RAG sites. Generally, VHF radio coverage is similar to radar coverage, about 200 miles."

Beyond 200 miles in oceanic airspace controlled by FAA — which includes much of the Atlantic Ocean, Pacific Ocean and Caribbean Sea — the crew likely will be communicating by high-frequency (HF) radio with ATC through ARINC (formerly Aeronautical Radio Inc.).

"For example, if you are over the North Atlantic Ocean, 1,200 miles [2,222 kilometers] from the U.S. shoreline, you will be talking with an ARINC radio operator who is on a direct line to a controller at New York Center who is actually responsible for your aircraft separation," Ferrante said. "The controller has your flight plan and knows a lot about you, including, in most cases, your fuel state."

ARINC radio operators relay messages between the controller and the flight crew.

"Normally, the radio operator types the pilot's voice message into a special computer program that links us to the controllers," said Richard "Ace" Stutz, manager of air traffic communications support for ARINC.[17] "They type the message in a special format, hit a button, and the message is sent to the controller who controls that sector of the ocean. The message used to come out on a printer behind the controller, but now the message comes up on a CRT [cathode ray tube]. If it is a position report, it also activates another program in the FAA that moves a symbol on a [CRT] screen that is similar to a radar screen, so the controller gets a graphic presentation of the aircraft's position."

Communication with ARINC typically is conducted via HF single-sideband radio. The crew is assigned a primary HF frequency and a secondary HF frequency that are selected from a "family" of frequencies used in the area in which the airplane is being flown.

Pilots flying over deep water communicate with ATC through ARINC radio operators.

"The frequencies are published as a family for each part of the ocean — for example Central West Pacific, North Pacific, South Pacific, North Atlantic A, North Atlantic E, Caribbean A, Caribbean B," Stutz said. "Each part has a family of six or seven HF frequencies assigned to it. For example, North Atlantic A has 3016 kHz [kilohertz], 5598 kHz, 8906 kHz, and a 13-meg [megahertz (MHz)], a 17-meg and a 21-meg frequency."

The HF frequencies — as well as the VHF radio frequencies and satellite-communication (SATCOM) radio frequencies and telephone numbers used in specific areas — are published by Jeppesen on its oceanic charts and by the U.S. National Imagery and Mapping Agency (NIMA) in the *Flight*

Information Handbook (*FIH*), a supplement to the NIMA oceanic charts.

Stutz said that two HF radio frequencies are assigned by ATC to a flight crew because of HF signal-propagation characteristics, which are affected by several factors, primarily the time of day. HF signals "skip" off the ionosphere — the highest layer of the atmosphere — which varies in height according to the time of day.

"The rule of thumb is: the higher the sun, the higher the frequency," he said. "As the sun comes up and starts heating the troposphere [the lowest layer of the atmosphere] and lifts the ionosphere, you need a higher frequency to get the same skip off the ionosphere."

Bill Roig, a professional pilot with 32,000 flight hours and more than 150 ocean crossings in general aviation aircraft, said that the higher HF radio frequencies generally are usable during the daytime and the lower frequencies are usable at night.[18]

"HF usually works very well," he said. "About three years ago, I flew a single-engine airplane to Japan. From the time I left Oakland [California] and arrived at Honolulu [Hawaii], the HF communication was as good as being on the telephone. Then, from Honolulu over to the Marshall Islands, Saipan and Japan, I had good radio contact the whole way."

Ferrante said that loss of HF communication with a flight crew occurs rarely.

"The likelihood of losing radio communication with an aircraft over water is very remote; it hardly ever happens," he said. "Generally speaking, on the oceanic tracks, we never have issues like that."

Anyone Out There?

If a loss of radio communication does happen, and no one answers on the primary HF frequency, the flight crew should try the assigned secondary HF frequency.

In the unlikely event that ATC (through ARINC) still does not reply, the pilot should select another frequency from an appropriate navigational chart or from the *FIH*.

ARINC operators do not monitor emergency radio frequencies; they do, however, monitor all of the frequencies in the families for the areas they are working. Stutz said that the primary frequency is channeled to one earpiece in the radio operator's headset; the secondary frequency and the other frequencies in the family are channeled into the other earpiece.

ATC renders whatever assistance is possible to a crew in distress.

"So, if the pilot changes to one of the other frequencies in the family, we should still hear him calling," he said. "The pilot should say which frequency he is using. This allows the radio operator to quickly identify which frequency the call is coming in on and to answer it rapidly. Otherwise, he would have to search all the frequencies until he finds the caller.

"When we receive an emergency call, we follow up [the text message] with a phone call to the controller, just in case they did not read the text message."

In an emergency, the flight crew typically will not be asked to establish radio communication on another frequency.

"We attempt to keep the crew on the frequency [on which the emergency call was received] and move other aircraft off the frequency," Stutz said. "If we cannot do that, we will try to move the crew to a different discrete frequency."

If a flight crew is communicating with ATC, they should insist upon remaining on the frequency in use. If ATC has no option but to assign a different frequency — especially an HF frequency — the crew should tell ATC that if communication has not been established within 60 seconds, the crew will return to the previous radio frequency.

Stutz said that ARINC can set up a "phone patch" to allow the crew to communicate via radio directly with the controller and with personnel at the SAR coordination center, if the controller requests SAR-coordination-center personnel to be included in the phone patch.

Crews of SAR aircraft and SAR vessels will be told which radio frequency is being used by the flight crew in distress.

SAR Shepherds

Ferrante said that ATC renders "whatever assistance is possible" to a crew in distress.

Depending on the location and the time available, a SAR aircraft might be dispatched to intercept and escort the crew. The *International Aeronautical and Maritime Search and Rescue Manual* (*IAMSAR Manual*) said that assistance available from an escort aircraft includes the following:[19]

- "Guiding [the crew] to the vessel alongside which it plans to ditch;
- "Giving advice on ditching procedures;
- "Evaluating the sea conditions and recommending a ditching heading;
- "Informing [the crew of] the vessel on how it can assist the ditching aircraft;

- "Dropping survival [equipment] and emergency equipment;
- "Informing the SMC [SAR mission coordinator] of the location of the ditching;
- "Directing [maritime] vessels to the scene; and,
- "Providing illumination for a night ditching if this cannot be done by the vessel or if the ditching is taking place away from vessels."

The U.S. Coast Guard has launched C-130s and helicopters to intercept and escort crews of distress aircraft.

A U.S. Coast Guard C-130 may be launched to escort an aircraft in distress.

"During an escort, our crews usually will not be able to do anything other than to monitor the distress aircraft, help during any communication failure, let the RCC know the status of the aircraft and be on site if a ditching does happen," Steward said.

Where Are You?

Assistance cannot be provided if no one knows where you are. Thus, ATC's first step toward providing assistance is to get a precise fix on the airplane's location.

"We would first do everything we could to determine your position so that we could start search-and-rescue procedures and get all of those notifications made based on your lat/lon [latitude/longitude] coordinates," Ferrante said.

One of the reasons why an accurate position report is important is that ATC and SAR authorities will plot the airplane's flight path to determine probable future positions and where the airplane likely will be ditched.[20]

"If pilots provide their position, altitude, course and speed, the U.S. Coast Guard can deduce accurately — working with ATC — their estimated point of ditching," said Steward. "We want to know any changes in course, altitude or speed, and we want information to be as current as we can get."

Lat/lon coordinates can be obtained readily from on-board equipment, such as the flight management system (FMS) or a global positioning system (GPS) receiver. Nevertheless, the crew should know the airplane's location with respect to the nearest coast or island. Among the "what-ifs" to consider is failure or malfunction of the navigation equipment.

"The business aircraft being flown on overwater routes typically are equipped with FMSs and kind of fly themselves," said Allen Stanfield, director of pilot training at the FlightSafety International Savannah (Georgia, U.S.) Learning Center.[21] "These airplanes will take off from New York and get you to Paris in about six hours. If you let the airplane do its thing and an emergency causes you to lose your automation, you might not know exactly where you are. So, it is important to have a chart out and to know where you are."

Calling Any Station

Should the crew have no success in establishing radio communication with ATC on any of the assigned or published frequencies, a distress call or an urgency call should be transmitted to "any station" on 121.5 MHz, the VHF aeronautical emergency frequency, and the transponder should be set to the emergency code, 7700.

Most of the world's SAR facilities continuously monitor 121.5 MHz for distress calls from pilots and for distress alerts from radio beacons. The International Civil Aviation Organization (ICAO) requires pilots of all aircraft to monitor 121.5 MHz during long overwater flights.[22]

Stanfield said that transmitting an "any-station" call on 121.5 MHz is an alternative to trying to establish radio communication with someone on an HF frequency that is not among the published family of frequencies for the area in which the airplane is being flown.

"HF transmissions are very subject to environmental conditions," he said. "In an emergency situation, I do not have time to mess around with HF. There are so many aircraft crossing the oceans right now that, if you cannot raise ATC, you likely can talk to another aircraft on 121.5 and have them relay a message to ATC."

The FAA *Aeronautical Information Manual* (*AIM*)[23] and the *IAMSAR Manual* say that the flight crew might be able to hail a ship on the international maritime distress frequency, 2182 kHz, or on 4125 kHz.

Nevertheless, trying to establish HF radio communication with a ship might require time, a scarce resource for a flight crew facing an imminent ditching.

"Coast Guard vessels and cruise ships maintain a constant listening watch, but merchant ships typically do not have a radio operator on duty at all times," Russell said. "If I have an emergency that is requiring me to ditch, and I am coming down with a planeload of people, I would be spending my time getting my equipment ready, the cabin ready, making sure people are touching things so they know how to get out of the airplane, and briefing for how we are going to conduct the landing.

"I don't want people trying to raise a ship on HF to get a ditching heading. I want them to be flying the airplane."

ATC can arrange through an RCC for direct emergency HF radio communication between a flight crew and the crew of a merchant ship. More commonly, messages are relayed by the crew of a SAR aircraft, SAR maritime vessel or military vessel, or by personnel at a ground station, such as a coast radio station linked to an ATC facility or to an RCC.

Pilots should not dismiss as impractical the possibility of arranging through ATC — with an RCC working behind the scenes — to ditch an aircraft near a ship, said Dan Lemon, a U.S. Coast Guard SAR coordination specialist.[24]

"The ship's crew can help the pilots before the ditching with lighting and information about sea state and direction of waves," Lemon said.

Backup Communication

The *IAMSAR Manual* says that a cellular telephone could be used for backup emergency communication.

"The user must know or find the telephone number for a SAR facility or ATC facility," the manual said. "The caller should be prepared to provide the SAR facility with the following information: cellular telephone number, cellular service provider (which might provide an approximate position based on assessment of signal strength), roam number, other means of available communications and an alternate point of contact.

"The cellular telephone then must be left on to receive further communication or turned on at a specific schedule agreed by the caller and the SAR facility [or ATC facility]."

If no one answers on radio, try a cellular phone.

Over the ocean, however, a satellite telephone would be much more useful than a cellular telephone. Steward said that a satellite telephone could be used for backup emergency communication with the U.S. Coast Guard.

"We can communicate directly via satellite telephones from several providers if the crew has the emergency line or can call an operator who can transfer the call to the U.S. Coast Guard," he said. "We do not particularly like text messages, and we try to discourage their use for distress communication. If text messages are a means of distress alerting that can be relayed to us in whatever fashion, however, we will take what we can get and respond."

Stanfield said that many business airplanes capable of transoceanic flights are equipped with other communication systems, such as an airborne flight information system (AFIS), that can be used as a backup for emergency communication.

"AFIS is almost like e-mail," he said. "Messages can be sent between the cockpit and the company or the flight-planning resource through your FMS."

Lane recommends that flight crews carry a handheld marine-band radio as a backup, so that they can try to summon help on Channel 16 (156.8 MHz FM [frequency modulation]), the maritime hailing and distress frequency. Lane said that Channel 16 is monitored by the U.S. Coast Guard and by most maritime vessels.

Similar to transmitting an "any-station" call on 121.5 MHz, the crew can try to establish radio communication on Channel 16 with a SAR facility or someone in the area who can provide assistance and/or relay a message to ATC.

"I always carried a marine-band radio when I went hiking or hunting in Alaska because there always were a lot of ships in the area and a lot of small planes with VHF FM radios," Lane said. "I knew that if there was an emergency, there were a lot of people monitoring Channel 16."

Several FCOMs recommend that the ELT be activated while the airplane is airborne. Many ELTs, however, transmit a distress signal on 121.5 MHz, and all ELTs transmit a homing signal on 121.5 MHz. The 121.5 MHz signal will interfere with voice communication conducted on that frequency and might interfere with voice communication on adjacent frequencies. Therefore, after activating the ELT, the crew should check for interference with radio communication and deactivate the ELT if necessary.

Ditching With Power Increases Your Options

The compulsion to remain flying as long as power is available will be strong, but the crew should not wait until the fuel is exhausted before ditching the airplane. The consensus is that, if possible, the ditching should be conducted with power.

Having engine power available will greatly increase the crew's options and improve the likelihood of conducting a successful ditching.

"If all your engines are silent when you get close to the water, you may be down to standby instruments and have very poor lighting, which will affect your ability to fly the airplane," Russell said. "You will have less capability of maneuvering the airplane. You will be committed to land and to accept whatever you hit."

With power available, the flight crew is better able to observe the water and select a good site for the landing.

"A power-on ditching gives us the ability to maneuver the aircraft, to circle the landing site to size up the sea conditions," Stanfield said. "If the pilot does not like what he sees on the approach, he can take the aircraft around and do it again. Power gives us a chance to make a successful ditching."

If, however, all engines become silent in flight, the U.K. CAA recommends that the crew maintain the airspeed for best glide performance and turn toward the nearest coast or toward a maritime vessel.

"Remember that a medium-size vessel is the best choice to ditch near, since a large ship may take many miles to slow down," CAA said. "In any event, avoid landing immediately in front [of a ship]; landing alongside and slightly ahead is better."

The best-glide speed typically is published in the emergency procedures section of the FCOM that discusses power loss from all engines. The best-glide speed results in the airplane traveling the greatest distance during descent.

The "Dual Engine Failure" checklist for the Gulfstream IV, for example, indicates that at best-glide speed, the glide ratio of the airplane is approximately 15-to-1, said Stanfield. This means that the airplane will travel 15,000 feet (4,575 meters) — approximately 2.5 nautical miles (4.6 kilometers) — for every 1,000 feet of altitude during descent.

Although best-glide speed would be selected to get to, or closer to, shore or a ship, in some circumstances the crew might want to maintain the airplane's minimum-sink speed, to stay in the air as long as possible. For example, if a ship is nearby, selection of the minimum-sink speed will give the crew more time to prepare for ditching next to the ship.

The minimum-sink speed may or may not be published in the FCOM.

"For minimum sink speed, the manuals for the G-IV and G-V both tell you to fly at 1.25 times the stall speed with gear up and flaps full down," Stanfield said. "That is the airspeed that will give you minimum forward speed and minimum sink at impact."

Setting Up for the Splash

The ditching checklists for most business airplanes recommend that the crew prepare the passengers and the cabin for ditching, but the checklists provide no details or few details on how to accomplish this. Few FCOMs include ditching checklists for cabin crewmembers.

A ditching checklist is essential for cabin preparations. The first item on the FSF *Airplane Cabin Crew Ditching Checklist* (page 39) is to obtain information from the flight crew about the nature of the emergency, how much time is available to prepare the passengers and the cabin, and what signals (e.g., flashing "Seat Belts/No Smoking" sign, public-address [PA] system announcements) will be given to brace for impact and to evacuate the cabin.[25]

"The pilots will have a lot going on in the cockpit, and if they do not provide the information, the flight attendant must ask the questions," said Coley.

Breaking the news to the passengers typically is the flight crew's duty. Ken Burton, president of STARK Survival Co. and an experienced water-survival instructor, said that when the flight crew makes a PA system announcement to inform the passengers of the situation, they should help instill confidence in the flight attendant by telling the passengers that the flight attendant has been trained for this type of emergency and is taking charge of cabin preparations for ditching.[26]

FSI teaches flight attendants to read a prepared announcement if the crew asks them to break the news to the passengers. Before doing so, the flight attendant should adjust the cabin lights to full bright, to help attract the passengers' attention and to improve visibility in the cabin.

How the passengers react to the situation will vary considerably. The flight attendant can expect disorientation, anxiety, fear, uncertainty and/or anger. Some passengers may panic; others may be immobilized by their plight.[27]

"You cannot make a general statement about the emotional climate that can be expected in the cabin," said Nora Marshall, chief of the Survival Factors Division of the U.S. National Transportation Safety Board Office of System Safety.[28] "Usually, however, the passengers will listen to the flight attendant."

Providing specific information about the nature of the emergency and briefing passengers on what they need to do to increase the likelihood of their survival can help reduce the passengers' anxiety.

"The range of emotions is going to be incredible," Coley said. "By giving the passengers information about the situation and engaging them in a safety briefing, the flight attendant can help the passengers become mentally prepared and reduce the levels of these emotions."

This Time, the Passengers Will Listen

If time permits, passenger preparation should include a thorough review of the information that was presented during the preflight briefing.

"The regulations require a preflight briefing before an overwater flight, but how well people pay attention to the briefing is questionable," said Bob Cohen, staff instructor and quality-assurance instructor for CAE SimuFlite.[29]

The passenger-briefing cards, which likely were ignored during the preflight briefing, should be removed from the storage areas and handed to the passengers (see pictograms, page 40).

Coley said that while rebriefing the passengers, the flight attendant should don a life vest. This will reinforce the demonstration for the passengers and also ensure that the flight attendant does not forget to don a life vest.

The briefing should be sufficiently thorough to enable the passengers to fend for themselves. The flight attendant should ensure that all passengers know where the emergency equipment and survival equipment are located and how to use the equipment.

"The flight attendant must lay it on the line and tell the passengers that 'yes, I am here for your safety, but if something happens to me, then you have to be responsible for yourself and know what actions to take,'" Coley said.

The flight attendant then should tell the passengers to remove their neckwear (ties, scarves, etc.), loosen their collars and don additional clothing, such as sweaters, jackets, coats and hats. Even if the passengers do not have to get into the water while evacuating the airplane, they likely will get wet in the life raft; the extra clothing will help delay the onset of hypothermia (see "Is There a Doctor Aboard the Life Raft?" page 187).

Nevertheless, do not overdo the clothing, said Burton. Too many layers of clothing will restrict movement, possibly hindering the ability to assume the brace position or to exit the airplane. If the clothing becomes saturated by water, it likely will hinder the person's ability to board the life raft.

Anything in the passengers' possession that could cause injury on impact — such as eyeglasses, jewelry (*including* earrings), hearing aids, dentures and sharp objects carried in pockets (e.g., pens, keys) — should be collected and stowed. Essential items can be placed in the ditch bag. Burton said that eyeglasses can be tucked away in socks (you might lose your shoes on impact, but not your socks).

Some ditching checklists recommend telling passengers to remove their shoes before ditching, to prevent damaging the life rafts during evacuation. This recommendation, however, may be a holdover from days gone by when the material from which life rafts were constructed was not as tough as it is today (see "Life Raft Evaluation: Pooling the Resources," page 258).

"If you have seen pictures of the interior of an airplane after a survivable emergency landing, think about getting out of that airplane with bare feet," said Russell. "You want to have your shoes on. Unless you are wearing shoes with stiletto-type high heels, your shoes will not rip the life raft."

Continued on page 40

Flight Safety Foundation
Airplane Cabin Crew Ditching Checklist

Preparation

- ❑ Obtain information from flight crew, as necessary: nature of emergency, time available for preparation, signals for brace and evacuation.
- ❑ Adjust cabin lights to bright.
- ❑ Distribute passenger-briefing cards.
- ❑ Conduct safety briefing.
- ❑ Instruct passengers to remove neckwear, loosen collars and don additional clothing, as necessary.
- ❑ Collect and stow personal items.
- ❑ Reposition passengers and assign buddies, as necessary.
- ❑ Rebrief able-bodied passengers, as necessary.
- ❑ Show passengers which exits they are likely to use.
- ❑ Ensure that all passengers have donned life vests and caution them not to inflate their life vests until they are outside the aircraft.
- ❑ Ensure that passenger seats are upright and seat belts are fastened correctly.
- ❑ Ensure that passengers understand instructions.
- ❑ Distribute anti-seasickness medication; ensure that all occupants take the medication.
- ❑ Prepare ditch bag.
- ❑ Stow loose items; secure doors/dividers.
- ❑ Ensure that emergency equipment is accessible and secured.
- ❑ Ensure that exits are unobstructed.
- ❑ Advise flight crew that cabin has been prepared for ditching; remind pilots to don life vests.
- ❑ Prepare yourself; conduct silent review.

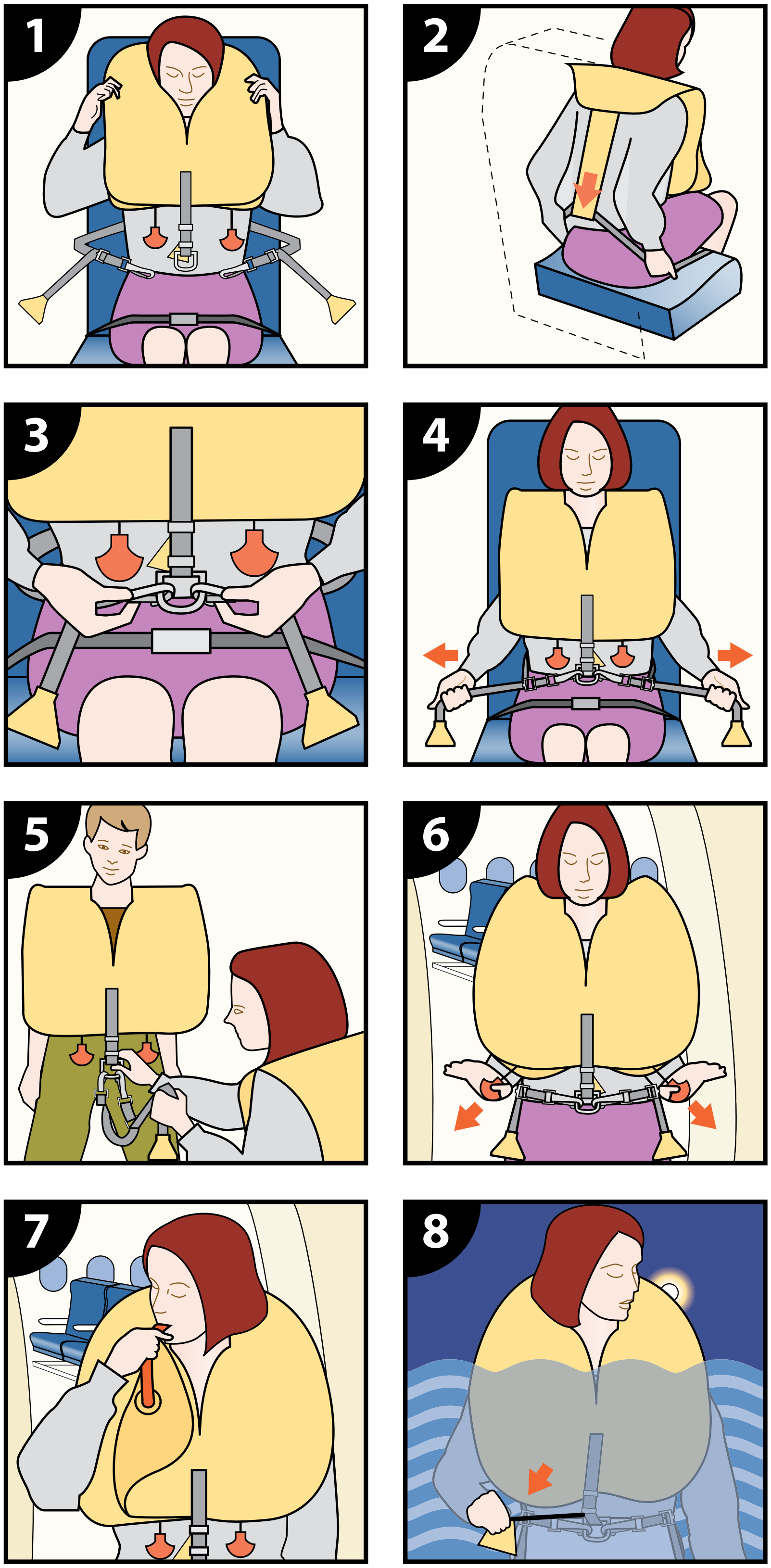
Before Ditching

- ❑ Shout "brace" upon receiving signal from flight crew.

After Ditching

- ❑ Upon receiving evacuation signal from flight crew or if no evacuation signal is received after aircraft has come to a stop, check emergency exits, secure life raft mooring/inflation lines at exits and organize passengers for evacuation.
- ❑ Open usable exits.
- ❑ Push life rafts onto wing and evacuate passengers; confirm deployment of life rafts.
- ❑ Confirm life vests inflated, board life rafts and conduct roll call. Coordinate with aircraft captain to cut life raft mooring/inflation line, as appropriate.
- ❑ Confirm that life raft ELT is activated.
- ❑ If life rafts are unavailable, use line to connect all survivors in a single group.

Note: This information, which focuses on transport category turbine airplanes with flight attendants aboard during overwater operations, was assembled for discussion of ditching procedures and is not intended to supersede operators' or manufacturers' requirements or recommended procedures.



A passenger-briefing card with pictorial instructions reinforces a verbal briefing.

Enlisting Able-bodied Passengers

Flight attendants are trained to select "able-bodied passengers" (ABPs) to assist in emergencies. In addition to providing assistance during evacuation, if the crew is killed or incapacitated during a ditching, the ABPs would have to take charge of the evacuation, deploy the life rafts and assist the passengers in getting into the life rafts.

Flight attendants aboard corporate/business airplanes have a much greater opportunity than airline flight attendants to know their passengers, and they can use their knowledge of the passengers' backgrounds when selecting ABPs.

"Generally, the guidelines are to select those with experience in the military, law enforcement, emergency medical service or fire safety — experience in any industry in which you are accustomed to dealing with emergency situations," Coley said. "There is a small enough crowd in a corporate jet that you can have conversations with the passengers and get a feel for who is more likely to react in a positive way in the event of an emergency."

Although a person might appear to be a good candidate to assist in an emergency, he or she might not be willing or able to help.

"You must ask people if they will help," Coley said. "And it is OK if someone says they do not want to, because they are not going to be any good to you."

The flight attendant should ask passengers seated next to the emergency exits if they want to be seated there and if they are capable of operating the exits. If not, the seats should be reassigned to ABPs, and the ABPs should be re-briefed on the operation of the emergency exits and the location and operation of the life rafts.

If other seats near the emergency exits are vacant, passengers should be moved to them. Family members — and others with emotional ties — should be seated near each other.

Burton recommends that obese passengers be seated in aft-facing seats, if possible, because they cannot bend over far enough to assume a proper brace position. If obese passengers are seated in forward-facing seats, they could receive internal injuries when their torsos are compressed on impact.

Who's Your Buddy?

Any passenger who might require assistance during the evacuation — nonswimmers, children, elderly passengers, handicapped passengers, etc. — should be paired with a "buddy" who can render that assistance.

"If there are children aboard, I am going to pair them with adults," Coley said. "If there is a child aboard with his mother, the mother is, of course, going to be responsible for the child, but I might ask [another] passenger to keep an eye on them during the ditching and evacuation."

FAA Advisory Circular (AC) 91-70, *Oceanic Operations*, includes the following recommendations for pairing passengers: "Older persons should be paired with able-bodied men [any ABP willing to help] to assist them. Children and nonswimmers should be paired with swimmers whenever possible; experienced swimmers should be paired with more dependent persons."

Knowledge of the passengers' strengths and weaknesses will help in pairing them. Nevertheless, questions might have to be asked, such as: "Who cannot swim?" Those who cannot swim should be paired with those who can swim; however, the nonswimmers should be reassured that their life vests will keep them afloat and that swimming skills are not necessary for evacuation.

After the passengers are seated and assigned buddies, they should be shown which exits they likely will use during evacuation, as well as alternate exits. The primary exits likely are the overwing exits, with the cabin doors as alternates.

"The bottoms of the front door and/or rear door could be under the water line," said FSI's Stanfield. "So, we want to brief the passengers on the exits."

The flight attendant then should ensure that all passengers have properly donned their life vests, that they have their seat belts fastened tightly across their laps and that their seat backs are upright.

Some ditching checklists recommend that soft items — such as pillows, blankets, extra clothing, etc. — should be distributed to passengers with instructions to place the items in front of their faces and torsos when they are told to assume the brace position.

Burton said that this is especially important for obese passengers or disabled passengers seated in forward-facing seats, to limit compression of their torsos on impact.

Knowledge of the passengers' strengths and weaknesses will help in pairing them.

FAA, however, says that "pillows and blankets provide little, if any, energy absorption … increase the possibility of secondary impact injury [and] could create additional clutter in the aisles, which could be a detriment in an emergency evacuation."[30]

Before turning his/her attention to the cabin, the flight attendant should ensure that the passengers have understood all of the instructions. The flight attendant should solicit questions and ask questions, such as "Where is your alternate exit?" and "Who is your buddy?"

One item that is on none of the ditching checklists reviewed for this article — but should be on all of them — is an FAA recommendation to have all occupants take anti-seasickness medication (unless specifically medically inappropriate) *before* the airplane reaches the water.[31] Anti-seasickness medications require some time — typically, 30 minutes — to take effect.

"One thing that happens to almost everybody who is in a life raft on anything but calm seas is that they get sick," Russell said.

Anti-seasickness (anti-emetic) medications are useless when taken *after* a person becomes nauseated. Vomiting will cause dehydration, a hazard to survival. One caveat to consider is that most anti-emetic medications induce drowsiness; however, some sources say that the body's increased production of adrenaline during a ditching will overcome the drowsiness.

Scavenging the Cabin

If time permits, the flight attendant should finish assembling the ditch bag, adding essential items carried aboard by the passengers, such as prescription medications, cash, credit cards, passports and other personal identification (which likely will be useful after being rescued and transported ashore or to a ship).

Blankets, extra clothing, soft drinks, food, utensils, paper cups, plastic bags, soap, toilet paper, paper towels — *anything* that can be scavenged from the cabin, galley, lockers and lavatory that might be useful for survival — should be included in the ditch bag.

"The life rafts likely have rations and other items, but why leave behind a good first aid kit, bottled water and anything else that can supplement what's aboard the life raft?" said Stanfield.

To remove or not to remove life rafts from storage before ditching — a subject of debate among safety specialists.

The flight attendant should keep in mind, however, that the ditch bag must fit through the emergency exit and *be able to float*. Ken Burton recommends that if a purpose-made ditch bag is not available, the items should be distributed among several small ditch bags. Durable (heavy-duty or industrial-grade) plastic trash bags that can be knotted or tied off in such a way that they trap air and can float are suitable containers.

Any loose items remaining in the cabin — and in the cockpit — should be collected and stowed in the lavatory and storage compartments to prevent them from becoming projectiles and injuring the occupants during the ditching. Doors and dividers should be locked to prevent them from opening.

Anything stowed in the lavatory and storage compartments likely will not be accessible after ditching. The doors and dividers may become warped and immovable. Crews of large military airplanes ditched during World War II said that equipment stowed in the rear of the airplanes often could not be retrieved because of in-rushing water.[32] They said that their airplanes tended to flood quickly, and water either covered equipment laid out for salvage or washed it into the tail (see "Lessons From Another Era," page 9).

Preparing the Life Rafts

Some ditching checklists recommend that life rafts be removed from their storage areas and secured with seat belts to empty seats near the emergency exits, so that they are readily available.

Burton said that this is a good procedure because a life raft might be difficult to remove from its storage area. Normal cabin-pressurization cycles tend to cause a life raft to swell, he said. If the life raft is packed in a nonflexible container, there should be no problem; but if the life raft is packed in a valise ("soft pack"), the swelling could cause difficulty in extracting the life raft from its storage compartment.

"It's difficult enough to get a life raft out; it is a tight fit as it is," Burton said. "And over time, the life raft swells. In many aircraft, life rafts are carried in closets. If you close the door and leave it in there, you're not going to get it out.

"Someone will say, 'Well, I could take the 'crash ax' and chop the closet open.' I would say, 'Be my guest. The airplane is sinking.' The average time for an aircraft to float after a ditching is six minutes."

Burton said that another reason to remove life rafts from storage before ditching is that impact damage might trap the life rafts inside the storage compartments.

"Most life rafts fit so snugly into the areas where they are stored that, if the fuselage warps and compresses the storage area, there's a great possibility that the life rafts cannot be extracted," he said. "The doors that enclose the life raft may not open.

"There was an issue with the Gulfstream III that went into Lac le Bourget in France about five years ago: The flight attendant could not get the life raft out from under the seat."[33]

Burton said that if all seats are occupied, the life rafts should be secured to the forward bulkhead, which is not likely to deform on impact. Ditch bags should be secured to empty seats, the bulkhead or to the life raft mooring/inflation lines.

After the life rafts are removed from storage and secured, a common recommendation is to secure the mooring/inflation lines to the designated tethering points or to seat structures. Burton says that the mooring/inflation lines should not be secured until *after* the airplane has been ditched, because the life rafts might have to be moved to alternate exits, which will take precious seconds. He said that some mooring/inflation lines have clips that can be secured quickly to the tethering points.

Nevertheless, many inflation/mooring lines do not have clips, and the end must be tied to a seat belt, a seat attachment or other tethering point, which will require time, manual dexterity and basic knot-tying skill to ensure that the line does not become loose when most needed.

Several safety specialists recommend that life rafts not be removed from storage until after the airplane comes to a stop on the water. For example, Stanfield said that instructors at FSI's Savannah center adhere to the recommendation on most Gulfstream ditching checklists — that the life rafts be removed from storage after the airplane has been ditched.

"The reason we do not recommend removing life rafts from their storage areas beforehand is that they might become flying objects inside the cabin," Stanfield said. "Removing the life rafts is a crew duty *following* ditching."

After preparations have been completed, the flight attendant should tell the captain that the cabin and passengers are ready for the ditching and evacuation. If the pilots have not yet donned their life vests, the flight attendant should remind them to do so.

The flight attendant then should prepare herself/himself for ditching (by removing and stowing jewelry, etc.), take a seat, assume the brace position and conduct a silent review of what steps have been taken and what safety procedures remain to be taken, said Coley.

Cockpit Preparations

Several ditching checklists recommend that the flight crew pull the circuit breakers for the landing-gear-warning system and the ground-proximity warning system (GPWS) or terrain awareness and warning system (TAWS)[34] to reduce unnecessary warnings.

Nevertheless, the crew might want to keep the GPWS/TAWS on line if it is the only system aboard that provides altitude callouts.

"GPWS and EGPWS [enhanced GPWS] altitude callouts can be very helpful in a ditching situation, especially in helping you time the flare if you cannot see the water," said Don Bateman, chief engineer, Flight Safety Systems, Honeywell.[35]

Bateman said that GPWS/TAWS equipment typically provides callouts at 500 feet, 100 feet, 50 feet, 40 feet, 30 feet and 10 feet above the surface. With the landing gear retracted, the equipment also will provide continuous warnings such as "too low, gear" unless there is a mode selector that allows the crew to deselect the gear warnings.

Most business-jet ditching checklists are predicated on the assumption that the crew is conducting a ditching with power, and they recommend that the fuel load be reduced to a minimum before ditching.

The Gulfstream V checklist, for example, says, "Plan the descent and ditching to ensure minimum fuel remaining but ample fuel aboard to make a controlled, power-on landing."

The crew should ensure that sufficient fuel remains to conduct the descent and the approach, and to maneuver the airplane for landing. The maneuvering likely will involve flying low over the water at an airspeed just above stall and making slight heading changes to position the airplane for touchdown parallel to a swell or on the back side of a swell.

The Learjet 55 FCOM says that having minimum fuel remaining in the tanks after a ditching will improve the airplane's buoyancy on the water.

Setting the Altimeter

When the airplane is at or below 2,000 feet, the crew should set the radar-altimeter "bug" to 50 feet, if the radio altimeter does not provide altitude callouts, to provide an additional indication that impact is imminent.

One useful tip for civilian pilots, who likely will not be able to obtain a local altimeter setting from ATC when over the deep ocean, is the method that U.S. Navy P-3 pilots are taught for setting the barometric altimeter:

"One of the steps on our checklist is to match up our barometric altimeter to our radio altimeter," said Miller. "We have a radio altimeter on both the pilot's and copilot's sides, and they begin working at 5,000 feet."

The flight crew also can set the barometric altimeter to a GPWS/TAWS altitude callout.

The crew should ensure that sufficient fuel remains to conduct the descent and the approach.

Some airplanes have specific equipment that must be prepared before ditching. The following are examples:

- The Airbus A319 has a "ditching pushbutton" that closes the outflow valve, emergency ram air inlet, skin air inlet/outlet valves and pack flow-control valves.

- The no. 2 pressurization outflow valve in the Bombardier Global Express must be closed before any takeoff near a body of water when the airplane is above maximum landing weight.

- The Cessna Citation Excel, Citation Sovereign and Citation X have a "water barrier" (photo, right) that must be attached to the frame around the bottom of the cabin door to prevent water from entering the cabin if the door is used for evacuation. (The ditching checklists for the Citations say, "If possible, the main cabin door should remain closed and evacuation [should be] made through the emergency [overwing] exit. However, the water barrier will allow use of the cabin door as an additional egress route.")

- The Dassault Falcon 10 and Falcon 20 have cabin-door ditching latches that must be engaged; opening the cabin door on the water is prohibited.

- The Falcon 50 has a "ditching handle" that closes the auxiliary power unit (APU) air inlet and prevents water from entering the airplane.

Sizing Up the Sea Conditions

Pilots are accustomed to landing into the wind. Before a ditching, however, there is a more important factor to consider — moving mountains of water called swells.

The flight crew should observe swell movement and select a ditching heading that will avoid striking a swell head-on.

"Selection of a good ditching heading may well minimize damage and could save your life," the *AIM* says.[36] "It can be extremely dangerous to

To use the cabin door as an additional exit after a ditching in some Cessna Citations, the crew must remove a folded 'water barrier' (top) from storage and install it around the cabin door (middle and bottom).

land into the wind without regard to sea conditions; the swell system or systems must be taken into consideration."

Sea conditions are the product of complex processes.[37] A swell can be defined generally as a form of wave that is caused by a distant disturbance, such as a storm. A swell appears as an undulation of the sea surface and does not "break" (topple) until close to shore. Swells created by two or more distant disturbances and traveling in different directions can be present; the largest and most dominant swells are called primary swells, and the smaller swells are called secondary swells.

Sea conditions also might include "wind waves" — that is, waves caused by winds from a local storm or from a passing weather front. Wind waves can be superimposed on the crests of swells and appear as whitecaps when they break. Wind can cause the waves to break with sufficient force onto a ship or airplane to cause considerable damage.

If flight visibility is sufficient, the flight crew can begin evaluating sea conditions when the airplane is about 2,000 feet or higher above the surface.

"At this altitude, the relatively regular pattern of the predominant system stands out in clear relief," says the FCOM for the U.S. Coast Guard HU-25 (military version of the Falcon 20).[38] "Note the compass heading from which the swell front approaches."

The selected ditching heading should make it possible to land the airplane parallel to a swell — or, when surface wind velocity is very strong, to land the airplane on the back side of a swell. (The *AIM* says that regardless of the direction of swell movement, the *back side* of a swell is the side that is away from the observer.)

The *AIM* says that the size of consecutive swells can vary considerably, but that swells more than 25 feet (eight meters) high, from crest to trough, are not common. The manual also says that in the likely event that more than one swell system exits, sea conditions can become confusing.

"One of the most difficult situations occurs when two swell systems are at right angles," the *AIM* says. "For example, if one system is eight feet [two meters] high and the other three feet [one meter high], plan to land parallel to the primary system and on the downswell of the secondary system. If both systems are of equal height, a compromise may be advisable — select an intermediate heading at 45 degrees downswell to both systems."

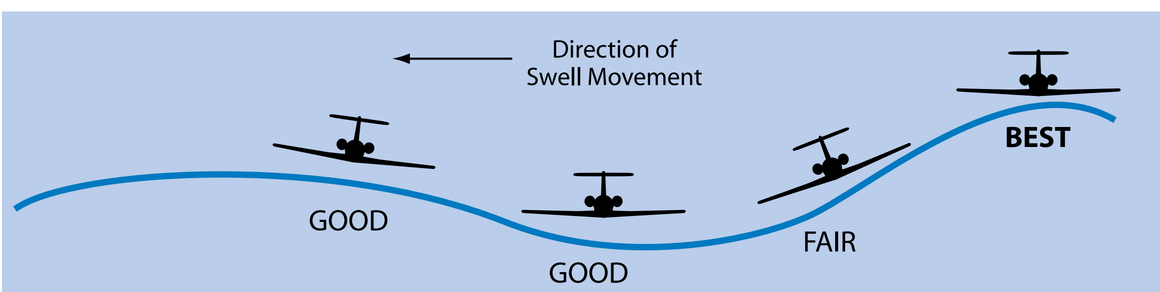
(The *AIM* should be consulted for a more thorough discussion of the complex issues and techniques associated with ditching.)

The HU-25 manual says, "A formidable secondary swell system may necessitate a heading downswell and partially downwind."

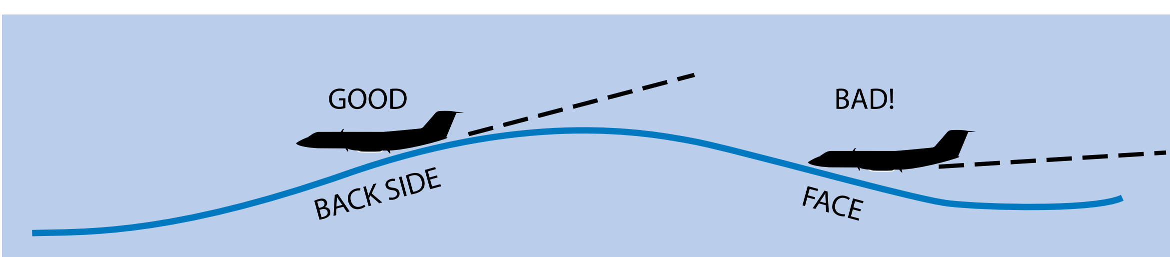
The flight crew should determine the direction and velocity of the surface winds. Swell movement will provide no clue to this.

"Swells, once set in motion, tend to maintain their original direction for as long as they continue in deep water, regardless of changes in wind direction," the *AIM* says.

Clues to wind direction and wind speed can be found by observation of whitecaps, streaks of foam and spray on the water.



Landing parallel to the major swell is the preferred technique.



Very strong winds may require landing across and on the back side of the swell.

Nevertheless, the crew should understand what they are looking at.

"Some [pilots] may have difficulty determining wind direction after seeing the streaks on the water," the *AIM* says. "Whitecaps fall forward with the wind but are overrun by the waves, thus producing the illusion that the foam is sliding backward. Knowing this, and by observing the direction of the streaks, the wind direction is easily determined. Wind velocity can be estimated by noting the appearance of the whitecaps, foam and wind streaks."

Some ditching checklists include guidelines for determining wind speed based on observing the sea. If such guidelines are not provided, the flight crew might want to carry a copy of the Beaufort Scale (Table 1). Developed in 1806 by Francis Beaufort, a U.K. Royal Navy officer, the

Table 1
Beaufort Wind Scale With Corresponding Sea State Codes

	Wind Speed		World Meteorological Organization	Average	Maximum		
Force	**Knots**	**Kilometers per Hour**	**Wind Description**	**Wave Height, feet (meters)**	**Wave Height, feet (meters)**	**Estimating Wind Speed by Effect of Wind on Waves Observed Far From Land**	**Sea State Code**
0	Under 1	Under 1	Calm	0 (0)	0 (0)	Sea like mirror. Calm.	0
1	1–3	1–5	Light air	0.25 (0.1)	0.25 (0.1)	Ripples with appearance of scales; no foam crests.	
2	4–6	6–11	Light breeze	0.5 (0.2)	1 (0.3)	Small wavelets; crests of glassy appearance, not breaking.	1
3	7–10	12–19	Gentle breeze	2 (0.6)	3 (1.0)	Large wavelets; crests begin to break; scattered whitecaps.	2
4	11–16	20–28	Moderate breeze	3 (1.0)	5 (1.5)	Small waves, becoming longer; numerous whitecaps.	3
5	17–21	29–38	Fresh breeze	6 (2.0)	8 (2.5)	Moderate waves, taking longer form; many whitecaps; some spray.	4
6	22–27	39–49	Strong breeze	10 (3.0)	13 (4.0)	Large waves forming; whitecaps everywhere; more spray. Rough.	5
7	28–33	50–61	Near gale	14 (4.0)	18 (5.5)	Sea heaps up; white foam from breaking waves begins to be blown in streaks. Very Rough.	6
8	34–40	62–74	Gale	18 (5.5)	25 (7.5)	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks.	6
9	41–47	75–88	Strong gale	23 (7.0)	33 (10.0)	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility. Very Rough.	6
10	48–55	89–102	Storm	29 (9.0)	41 (12.5)	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced.	7
11	56–63	103–117	Violent storm	37 (11.0)	53 (16.0)	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced.	8
12	64–71	118 and over	Hurricane/typhoon	45 (14.0)	—	Air filled with foam; sea completely white with driving spray; visibility greatly reduced. Phenomenal Waves.	9

Note: Wave heights are significant wave heights (the average of the highest one-third of the waves), assuming open water with no current or other complicating factors. Statistically, one wave in one thousand will be almost twice as high as the maximum wave height.

Source: *American Practical Navigator: An Epitome of Navigation*, Nathaniel Bowditch, LL. D., Volume I, 1984 Edition.

scale has been adapted slightly over the years to provide estimates of wind speed and wave height based on the appearance of the sea.

U.S. Coast Guard C-130 pilots are taught to land into the wind when wind velocity exceeds 30 knots.

"The 'Herc' manual says that in high winds, it is recommended that ditching be conducted upwind, on the back side of a swell, to take advantage of lowered forward speed," said Lane. "The manual also says: 'However, it must be remembered that the possibility of ramming nose-on into a wave is increased, as is the possibility of striking the tail on a wave crest and nosing in.'"

U.S. Coast Guard HU-25 pilots are taught to select a ditching heading that is a compromise between landing parallel to the primary swell and landing directly into the wind.

"If the wind exceeds 20 knots, select an intermediate heading by taking into consideration the wind and the primary swell," the HU-25 manual says. "The stronger the wind, the more the ditching heading should be into the wind. The higher the swell, the more the ditching heading should be parallel to the swell."

The most important point to remember is that you do not want to land into the *face* of a swell.

"The last thing in the world you want to do is to land head-on into a swell," said Russell. "Unless you have very strong winds that will substantially slow down your landing speed, flying into a swell would be like running into a brick wall."

The *IAMSAR Manual* provides this advice: "Never land into the face (or within 35 degrees of the face) of a primary swell unless the surface winds are an appreciable percentage of the aircraft stalling speed in the ditching configuration."

A Lost Art

The U.S. National Search and Rescue Committee (NSRC) recommends that pilots practice evaluating sea conditions during overwater flights.[39]

"This ensures a tentative ditching heading at all times and provides practice in identifying swell systems," NSRC said. "In some ocean areas, there are prevailing swells from a fairly constant direction. These conditions should be recognized regularly by pilots flying certain routes."

This recommendation, however, might be practical only for pilots who routinely fly low over water — U.S. Coast Guard C-130 pilots, for example.

"When we are out on patrol, we try to evaluate sea conditions," said Lane. "To help us get better at it, we check our observations by hailing a cutter or a commercial vessel on [maritime] Channel 16 and asking what they have for seas."

On a typical ocean crossing in a business jet, high above the water, the crew is not going to see enough to practice evaluating sea conditions.

"Evaluating sea conditions is an art that no one in civilian aviation practices anymore, except people flying floatplanes down low — and even they do not conduct a lot of open-water landings," Russell said. "When we were conducting open-water

If you were flying, what would you estimate as your height over the water? (Turn page for a better view.)

(See photo, page 47.)

landings in P-5Ms [Martin Marlins] in the Coast Guard, it took 25 [minutes] to 30 minutes to do a good evaluation of sea conditions, because we would begin at a high altitude to look at the primary swells and then drop down to look at the secondary swells."

Russell said that primary swells can be observed from as high as 5,000 feet and that secondary swells can be observed from at and below 2,000 feet.

Miller said, "Too high, it all kind of blends together. Too low, it is really hard to tell what is going on. Probably, a couple thousand feet is the best to evaluate sea conditions because you can distinguish the primary swell patterns."

Stanfield agrees that evaluating sea conditions is not something that business-airplane pilots practice.

"Last week, I was flying an airplane at 2,000 feet over the Atlantic," he said. "At that altitude, you should be able to determine where you want to put the airplane down. We were about 200 miles [370 kilometers] offshore, and I got to thinking that if we had a dual flameout, we would probably end up in the drink. So I started looking, just out of curiosity. That was the first time I have done that in 20 years of flying."

The flight simulators at FSI and CAE SimuFlite do not replicate sea conditions.

"You can train pilots to conduct the procedure down to impact, but you cannot put the airplane in the water," said SimuFlite's Cohen. "The surface shown in the simulator looks like water but does not act like water. If you land with the gear up, as is recommended by most procedures, the simulator acts as if you are scraping the ground. We really cannot simulate sea conditions — the swells, et cetera — because there is just no way to know what a crew may encounter during a ditching."

Although flight simulators typically do not simulate sea conditions, they likely are the best tool for ditching training.

Lt. Chris Buckridge, HU-25 standardization officer at the U.S. Coast Guard Aviation Training Center in Mobile, Alabama, U.S., said that although HU-25 pilots regularly conduct ditching drills in flight, the best practice they get is in the simulator.[40]

"The simulator gives them a realistic feel for a ditching because we can fly them down to the 'water,' whereas when they do their ditching drills out in the field during recurrent training every six months, they have to set a hard deck [i.e., go no lower than] 2,000 feet or 3,000 feet," he said. "The simulator will 'freeze' when they hit the water, then we go through the post-ditching actions on the emergency checklist, such as securing the engines, pulling the T-handles to secure the flow of fuel and hydraulic fluid to the engines, deploying our ELT, turning off our APU and batteries, and jumping out of the airplane."

Buckridge said that HU-25 pilots are presented with several ditching scenarios in the simulator.

"There are a variety of scenarios that instructor pilots can use, such as a dual engine flameout because of bad fuel or bird ingestion, which requires a power-off ditching," he said. "Among the power-on ditching scenarios is that we develop a fuel leak 400 miles [741 kilometers] from shore and we know that we do not have enough fuel to get home. In this scenario, we have adequate time to set up for a good water entry.

"In other power-on ditching scenarios, we do not have the luxury of time because of an electrical fire or a cabin fire, and we must get the jet in the water as quickly as possible."

Buckridge said that flammable materials, such as smoke markers, are carried aboard HU-25s.

"About two years ago, we had an airplane in the pattern at Corpus Christi [Texas] International Airport that had a rear-compartment-fire light illuminate," he said. "The crew declared an emergency, came around and landed. The fire never did go out. Had they been over water, they might not have been able to ditch before the tail came off."

Gear Up, Flaps Down

After evaluating sea conditions and selecting a ditching heading, the flight crew should depressurize the airplane. If the cabin remains pressurized after ditching, opening the emergency exits and/or door could be impossible or dangerous.

"If you try to open a door, especially one that opens inward first and then out, you might be trapped inside," said SimuFlite's Campbell. "If the door opens outward, the air pressure just might blow you out with it."

Miller said that another reason to depressurize the airplane is to avoid an explosive decompression during the ditching.

"Another step on the P-3 checklist has us close any of the holes that we opened to depressurize the aircraft before we hit," he said.

In a business airplane, the "holes" might include ram-air valves, engine bleed valves and APU bleed valves.

All the business-airplane ditching checklists reviewed for this article recommend that the landing gear remain retracted. The FCOM for the Fanjet Falcon provides the following explanation: "The landing gear must be retracted because a landing-gear-down ditching would end [with] an abrupt dive."

There are some specific exceptions to the use of full flaps for ditching. The ditching checklist for the Embraer Legacy, for example, says that in icing conditions, flaps should be extended to 22 degrees, rather than the full 45 degrees.

Navy P-3 pilots are taught to use a partial flap setting if one engine or two engines on the same side of the airplane have flamed out.

"If we have all of our engines operating and no unfavorable asymmetric condition, we would use full flaps," Miller said. "If we

"The simulator gives them a realistic feel for a ditching."

have any type of asymmetric handling problem, we will boost our speed a bit and stay a little cleaner by using two-thirds flaps."

The last item on the "Approach" section of the FSF ditching checklist is to ensure that the ELT is activated.

Thirty-second Warning

AC 91-70 recommends that passengers be given a two-minute warning before the ditching is conducted. Stanfield says that passengers should not be told to brace, however, until the airplane is 100 feet above the water or about 30 seconds from impact.

"A lot of us are not in the best physical shape these days," he said. "When we take a brace position, we are sitting down with a seat belt fastened and a life vest on; we are trying to hold a pillow over our face while bending over our knees. How long can we stay in that position? The least amount of time we have to be in that position prior to impact, the better."

Passengers should be told to brace for at least two impacts.

Passengers should be told to brace for at least two impacts — the second of which is likely to be more violent than the first — and that they should not discontinue the brace position or release their seat belts until the airplane has come to a stop.

Various brace positions are recommended (see "Studies Reveal Passenger Misconceptions About Brace Commands and Brace Positions," page 51). The following are examples:

- FAA says that in airplanes with seats spaced relatively far apart (typical of business jets), passengers in forward-facing seats should rest their heads and chests against their legs, grasp their ankles or legs, or wrap their arms under their legs. Passengers in aft-facing seats should rest their heads against the seat backs and either place their hands in their laps or grasp the sides of their seats. Feet should be placed flat on the floor and slightly ahead of the front edge of the seat.[41]

- Burton recommends that passengers place their arms (and elbows) inside the armrests and their hands below their buttocks or thighs (i.e., sit on them). He says that this reduces flailing of the arms during impact and the likelihood of breaking bones. Burton stresses that the lap belt must be secured tightly across the hips, not across the abdomen, to avoid internal injury.

Coley said that when the flight crew issues the signal to brace (verbal command or a flashing "Seat Belts/No Smoking" sign) or the flight attendant observes that impact is imminent, the flight attendant should shout "brace."

(In a ditching situation that involved very little warning and time for preparation, "grab ankles" might be a more effective command than "brace" if the procedure for taking a brace position was not explained or demonstrated to the passengers.)

A Landing Like No Other

The *AIM* recommends that when ditching with power, the airplane should be flown low over the water, about 10 knots above stall speed. Before touchdown, the wings should be trimmed to the surface of the water, rather than to the horizon, to minimize the possibility of a wing striking the water.

In an advisory publication on ditching, the Civil Aviation Safety Authority of Australia (CASA) said, "Keep the wings parallel with the surface of the water on impact (i.e., wings level in calm conditions). One wing tip striking the water first will cause a violent uncontrollable slewing action."[42]

The *AIM* says that a landing area 500 feet (153 meters) in length is sufficient for a ditching.

"Select and touch down in any area … where shadows and whitecaps are not so numerous," the *AIM* says. "Touchdown should be at the lowest speed and rate of descent which permit safe handling and optimum nose-up attitude on impact."

Several ditching checklists recommend that the pitch attitude be slightly higher than the normal landing attitude. Some checklists recommend specific nose-up pitch attitudes for touchdown. The Falcon 50 checklist, for example, says that the pitch attitude should be between 11 degrees and 13 degrees.

Continued on page 56

Studies Reveal Passenger Misconceptions About Brace Commands and Brace Positions

Many study participants were unaware of what command to expect before assuming a brace position. Some participants had inappropriate concepts of the proper brace position. These findings may be related to the lack of specific communication provided to passengers in preflight oral and videotape briefings, and on safety-information cards.

Unanticipated survivable accidents on landing or takeoff provide little or no time to give passengers special instructions regarding brace positions. Yet passengers who assume a correct protective brace position have less likelihood of being injured during impact.

The U.S. National Transportation Safety Board (NTSB) identified several accidents in which passengers who were in brace positions sustained significantly less severe injuries than other passengers.[1]

One of the accidents involved a de Havilland Canada Twin Otter, carrying 16 passengers and two crewmembers.[2] The aircraft struck terrain during a nonprecision instrument approach in instrument meteorological conditions. Most of the passengers were sleeping or reading and had no warning of the impending accident. One passenger, a 16-year-old male seated toward the rear of the cabin, awoke, looked out a cabin window and saw that the aircraft was going to strike trees.

The passenger immediately lowered his head and braced his arms and knees against the seat back in front of him. He suffered a fractured leg and wrist, and a scalp wound when his seat broke loose from the floor during the impact sequence. He was the only survivor.

One NTSB recommendation prompted by the accident was for air carrier-passenger preflight briefings to include reference to the appropriate emergency brace position.

The value of proper bracing in accident survival recently was reaffirmed by the European Transport Safety Council (ETSC). In a report identifying impact-protection improvements that have considerable lifesaving potential, the ETSC recommended that three-point lap-and-shoulder harnesses, rather than standard lap belts, be provided for passengers.

The ETSC said, "If all passengers assumed the brace position prior to impact, the additional benefits of a three-point shoulder harness would be small.

"In reality, however, for a variety of reasons, occupants generally do not assume a proper brace position, so a three-point lap-and-shoulder harness would be likely to improve occupant protection substantially." [3]

Two actions are needed to ensure that passengers will assume the best protective position:

- They must be told to assume a protective position; and,
- They must know the correct protective position for their seat location.

Passengers hear various commands. In a recent study,[4] several airlines were asked what commands their crewmembers would give passengers before an impending landing accident. Common responses were: "brace"; "head down, stay down"; and "grab your ankles."

One airline said that the cockpit crew would give the command "brace," while the cabin crew would give the command "head down, stay down."

Commands that passengers expect to hear vary. In another study,[4] a briefing card was shown to 84 adults and they were asked what command they would expect to hear when ordered to assume one of the protective positions. The results are in Table 1.

Although "brace," "head down, stay down" and "grab your ankles" are the only commands the contacted airlines train their crewmembers to give, only 24 percent of the 84 respondents said that they would

Table 1

Expected Commands to Assume a Protective Position in Aircraft Emergency

Expected Command	Number	(%)
"Get into an emergency [or crash] position"	44	(52)
"Head down"	14	(17)
"Lean forward" or "crouch forward"	8	(10)
"Brace"	6	(7)
"We're going to crash" or "We're going down"	4	(5)
No idea what command to expect	3	(4)
"Assume proper position"	2	(2)
Other	3	(4)
Total	**84**	

Source: Daniel Johnson, Ph.D.

expect to hear "head down" or "brace." None said that they would expect to hear "grab your ankles."

Thus, the commands that passengers expect to hear and the commands that crewmembers are trained to give apparently are not the same.

Passenger expectations vary when the command "brace" is given. Another study explored what emergency condition passengers would believe existed if crewmembers told them to "brace." Two interviewers questioned a total of 51 people.

Among the 51 respondents, 34 (67 percent) flew regularly as passengers. These relatively experienced passengers had flown an average of five flights in the two years preceding the survey. The experienced group included 21 men (62 percent) and 13 women (38 percent), with an average age of 32 years.

The 17 respondents (33 percent) who were relatively inexperienced airline passengers included 14 men (82 percent) and three women (18 percent), and had an average age of 45 years.

An interviewer told each respondent the following:

"Assume that you are in an aircraft coming in for a landing. It's nighttime, and you can't see anything outside. There are other passengers aboard, but you are not traveling with any friends or relatives. You are near the ground but still in the air when you suddenly hear over the loudspeaker the command 'brace, brace!' Describe what you think is happening."

As shown in Table 2, about 70 percent of the respondents said that they thought a crash landing was about to occur. Among the other respondents, about half said that they thought either turbulence or a bumpy landing was about to occur, and half said that they were not sure what was happening.

Thus, approximately 30 percent of the respondents would not have realized, if the command "brace" were given, that an emergency landing or an accident was about to occur.

Table 2

Perceived Emergency Condition Upon Hearing "Brace" Command

Expected Condition	Experienced Number (%)	Inexperienced Number (%)	Total Number (%)*
Crash landing	26 (76)	10 (59)	36 (71)
Turbulence	3 (9)	1 (6)	4 (8)
Bumpy landing	2 (6)	1 (6)	3 (6)
Unsure/other	3 (9)	5 (29)	8 (16)
Total	**34**	**17**	**51**

*Percentages do not total 100 because of rounding.

Source: Daniel Johnson, Ph.D.

Knowledge of appropriate brace positions varies. The 51 respondents then were shown a side view of three empty seats placed front to back, with a bulkhead in front of the most-forward seat. They were asked to imagine that they had boarded an aircraft and had not looked recently at a safety video or briefing card showing protective positions. They were asked to draw the positions that they would try to assume if they were in the front seat with the bulkhead directly in front of them; in a seat with another seat directly in front; and in any of the seats and holding an infant.

The respondents were told that drawing a stick figure — showing head, arms, trunk and legs — would be adequate. The interviewers discussed the completed drawings with each respondent to ensure that the interviewers understood what was depicted.

The appropriateness of the brace positions depicted in the drawings then was judged using the following criteria:

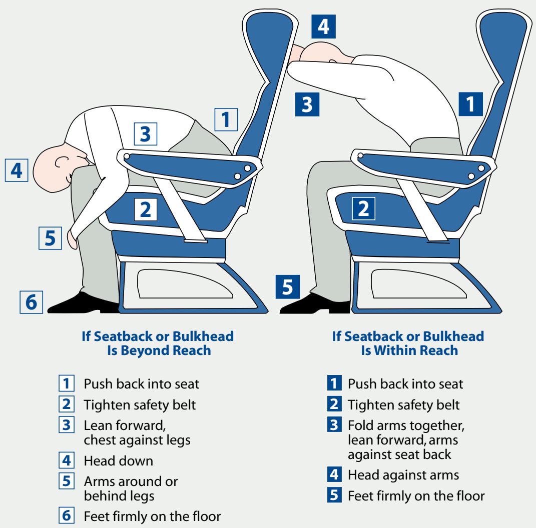
- A drawing was judged appropriate if the depicted position corresponded with one of the two brace positions included in an industry standard developed by SAE International.[5] One of these positions shows an adult bent forward at the waist, with hands around or under the legs, and feet planted firmly on the floor beneath the knees (Figure 1, page 53). Acceptable variations for this study included having the hands in front of the legs, or over or in front of the head (Figure 2, page 53). The other SAE position shows the adult's head against the arms and the arms against a seat back or bulkhead. (There was no requirement for the drawing to show a seat belt.)
- A drawing was judged to be inappropriate if the figure was sitting upright or had the arms and/or legs extended straight out (Figure 3, page 54). Some respondents drew figures crouching on the floor or kneeling on the seat facing aft; these drawings also were judged to be inappropriate.
- For drawings of an adult holding an infant, a position judged appropriate *for purposes of this study* required only that the adult be bent forward and that the infant be held on the adult's lap (Figure 4, page 54). Acceptable variations included having the adult's arms around the infant, under the adult's legs or folded over the adult's head. (An unrestrained infant cannot be held safely in many accidents. Because infants are allowed to travel unrestrained in air carrier aircraft, however, some positions are safer — at least for the adult — than others.)

The results are shown in Table 3, page 54.

A greater proportion of the experienced passengers among the respondents drew positions for the three seat conditions that were judged appropriate than did the respondents who were inexperienced passengers.

Figure 1

SAE Recommended Brace Positions



Source: SAE International

The percentages of experienced passengers' drawings judged appropriate were: front seat, 53 percent; other seat, 59 percent; and infant-in-arms, 44 percent. The percentages of inexperienced passengers' drawings judged appropriate were: front seat, 29 percent; other seat, 41 percent; and infant-in-arms, 18 percent.

Statistical (chi-square) analysis showed that the difference in the proportions of appropriate drawings by the experienced and the inexperienced passengers was not significant. Thus, the experienced passengers apparently did not learn more or remember more than the inexperienced passengers about the appropriate brace position for any of the seat conditions.

Only about half of the respondents drew an appropriate brace position for any of the three conditions.

One limitation of these studies is that what people say they would do in a situation is not necessarily what they actually would do, especially if there are physical or time constraints limiting their intended actions. A few respondents said that they would huddle on the floor or kneel over an infant on the seat — actions that time probably would prohibit.

The study did not account for the effect of actions by others on an individual's behavior. For example, respondents who said that they would do nothing after hearing the command "brace" actually might imitate passengers who were in a brace position.

After taking these limitations into account, however, the following conclusions may still be drawn:

- Crew commands to assume a brace position during an unanticipated accident on landing or takeoff are not always the commands passengers would expect to hear. Expected commands are probably more easily understood than unexpected commands;

- One-third of the respondents indicated that the command "brace" does not communicate the message that an accident with possible impact forces is imminent. Whether other commands such as "head down, stay down" or "grab your ankles" would be more effective is questionable; and,

- Only about half of the protective positions drawn by respondents were judged to be appropriate. Some of the other drawings depicted positions — such as getting out of the seat — that would put the passengers at greater risk. The most common unsafe position depicted was sitting upright rather than bent forward. One person stated emphatically that placing one's head against a stationary object such as a bulkhead or seat back would be unsafe. The reason for this misconception is not clear; perhaps it arises from equating aircraft travel to motor-vehicle travel, where sitting upright is an approved behavior. This body position, however, is unsuitable for air carrier travel because of the

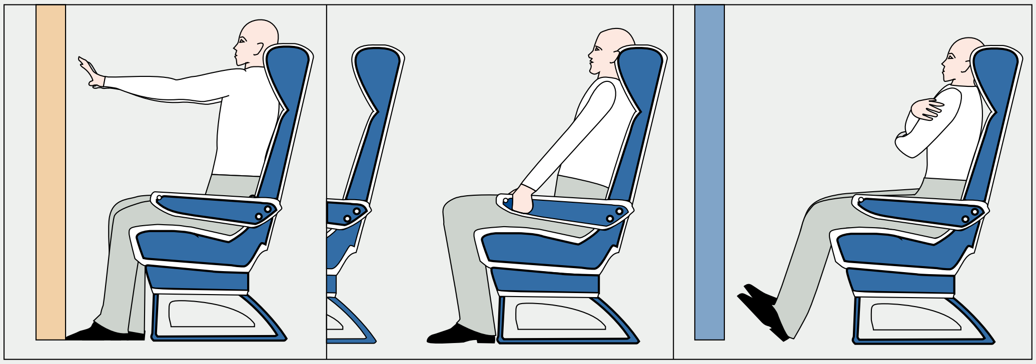
Figure 2

Representations of Test Subjects' Illustrations of Brace Positions Judged to Be Appropriate

Source: Daniel Johnson, Ph.D.

Figure 3

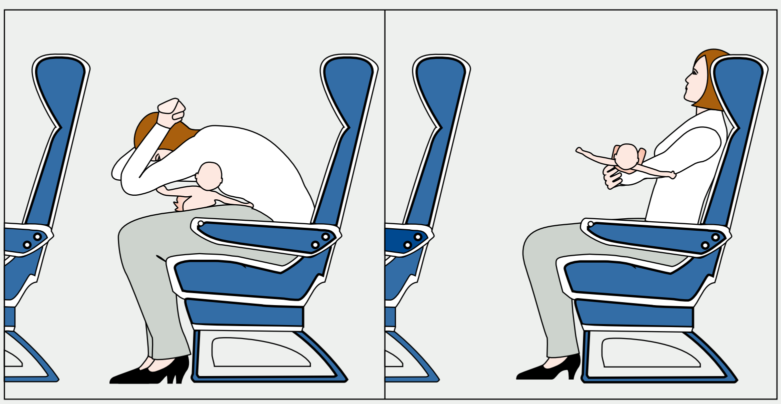
Representations of Test Subjects' Illustrations of Brace Positions Judged to Be Inappropriate



Source: Daniel Johnson, Ph.D.

Figure 4

Representations of Test Subjects' Illustrations of Brace Positions of Adult Holding Infant



Note: An unrestrained infant cannot be held safely in many accidents. For test purposes, the illustration at left was judged appropriate because it provides some protection for the adult; the illustration on the right was judged inappropriate.

Source: Daniel Johnson, Ph.D.

lack of shoulder harnesses and air bags in aircraft cabins.

Uncertainty regarding the appropriate brace position may result from the following communication problems:

- Flight attendants generally do not refer to the brace position in their preflight briefings;

- Some preflight safety videos do not depict the protective positions. Videos that do show the appropriate positions often fail to mention the command that passengers will hear; and,

- Although most passenger-safety-information cards show at least one protective position, they do not tell passengers what command they will hear.

An industry-wide effort should be made to increase passenger understanding of when and how to assume effective protective positions.

The first task is to standardize a protective-position command that is readily understandable and easy to follow. Commands such as "grab your ankles" may be easy to understand but difficult to follow because of cabin space limitations. The command "brace" is ambiguous. The command should be directive ("lean forward, head down, stay down," for example). The command should be

Table 3

Correctness of Brace Position Drawings

	Front Seat Number (%)	Other Seat Number (%)	Infant-in-arms Number (%)
Correct	23 (45)	27 (53)	18 (35)
Upright (incorrect)	15 (29)	19 (37)	21 (41)
Other (incorrect)	2 (18)	1 (2)	2 (4)
No idea (incorrect)	4 (8)	4 (8)	10 (20)
Total	**51**	**51**	**51**

Source: Daniel Johnson, Ph.D.

Postaccident U.K. Research Yields Recommended Passenger Brace Position

Cabin Crew Safety presented a 1995 report by the U.K. Civil Aviation Authority (CAA) that recommended a brace position that reduces the potential for the passenger's arms and legs to flail during impact.[6] The recommended brace position came from research commissioned by the CAA after an accident involving a Boeing 737-400 on Jan. 8, 1989.

The B-737, operated by British Midland Airways on a scheduled flight from London to Belfast, was climbing through 28,300 feet when one fan blade in the no. 1 engine separated and damaged the engine. The engine began to surge and vibrate. The flight crew mistakenly shut down the no. 2 engine and then diverted to East Midlands Airport in Kegworth, England.

"The shuddering caused by the surging of the no. 1 engine ceased as soon as the no. 2 engine was throttled back, which persuaded the crew that they had dealt correctly with the emergency," said the U.K. Air Accidents Investigation Branch (AAIB). "The no. 1 engine operated apparently normally after the initial period of severe vibration and during the subsequent descent."

The B-737 was 2.4 miles (3.8 kilometers) from the runway when the no. 1 engine lost power. The aircraft struck the ground short of the runway and then underwent a second, major impact on a highway embankment. Of the 126 occupants, 39 were killed in the accident, eight died later from their injuries, 74 survived with serious injuries and five sustained minor or no injuries.

The investigation revealed that the positions the passengers were in during the initial impact appeared to have had a significant effect on the type and severity of their injuries. Many passengers were seriously injured when their legs flailed against seat backs and luggage-restraint bars.

Based on research performed after the accident, the CAA provided the following description of the recommended brace position for passengers in forward-facing seats aboard large airplanes:

- "UPPER BODY: Should be bent forward as far as possible with the chest close to the thighs and knees, with the head touching the seat-back in front. The hands should be placed one on top of the other and on top of the head, with the forearms tucked in against each side of the face. Fingers should not be interlocked.

- "LEGS: The lower legs should be inclined aft of the vertical [that is, angled behind the knee joints] with the feet placed flat on the floor."

The CAA also recommended that passengers wear their seat belts as tight as possible and as low on the torso as possible. ■

— FSF Editorial Staff

tested to determine whether passengers will understand it.

The command should be printed on safety-information cards and presented in passenger-safety videos.

Finally, flight attendants should instruct passengers to read the passenger-safety cards and the information on protective positions, as recommended nearly two decades ago by the NTSB. ■

— Daniel Johnson, Ph.D.

[FSF editorial note: This article has been reprinted from *Cabin Crew Safety* Volume 33 (May–June 1998). Daniel Johnson, Ph.D., is a licensed psychologist and a certified professional ergonomist. He has retired as president of Interaction Research Corp. and currently serves as an advisor to the company, which designs, tests and produces safety cards for corporate, domestic and international operators.]

References

1. U.S. National Transportation Safety Board. *Safety Recommendations A-79-76 through A-79-78*. Recommendations to the U.S. Federal Aviation Administration. October 1979.

2. U.S. National Transportation Safety Board. Downeast Airlines, Inc. De Havilland DHC-6-200, N68DE, Rockland, Maine [U.S.], May 30, 1979. NTSB-AAR-80-5. May 12, 1980.

3. European Transport Safety Council. *Increasing the Survival Rate in Aircraft Accidents: Impact Protection, Fire Survivability and Evacuation*. Brussels, Belgium, December 1996, as reported in *Cabin Crew Safety* Volume 33 (January-February 1998).

4. Study was performed by the author.

5. SAE International. *Recommended Brace Positions*. Aerospace Information Report 4771. 1995.

6. Koenig, Robert L. "U.K. Studies Find that 'Legs-back' Brace Position Is Optimal for Forward-facing Passengers." *Cabin Crew Safety* Volume 30 (November-December 1995): 1–4.

The sight picture during approach to a water landing will be much different than the sight picture during an approach to a runway.

"Most people will not have experienced many landings without an undercarriage," CASA said. "Thus, you will be used to seeing a particular attitude at the round-out [flare]. In the ditching case, that attitude will be a little different because the aeroplane should be a little bit closer to the surface to [compensate] for the lack of an undercarriage. You will need to make some allowance for that. This is where a powered approach can be most beneficial, because you can use power to control that final descent onto the water."

For most pilots, a ditching will be a landing like no other they have conducted. The landing surface will be *moving*.

"It is going to be an experience that the pilot has never had before," Russell said. "If there is any wave action, the landing surface will appear to be moving; the normal sight picture on approach [to a runway] is that the landing surface is stable. It is a different visual picture."

The *AIM* recommends that if no power is available, the crew should maintain an airspeed on approach that is higher than the normal approach speed.

"This speed margin will allow the glide to be broken early and more gradually, thereby giving the pilot time and distance to feel for the surface — decreasing the possibility of stalling high or flying into the water."

The landing surface will be *moving*.

Depth perception will be impaired during an approach in instrument meteorological conditions or nighttime conditions — or during an approach to a calm sea. These conditions will increase the risk of flying the airplane into the water at too great a speed or descent rate, or stalling the airplane too high above the surface.

"Over glassy smooth water, or at night without sufficient light, it is very easy for even the most experienced pilots to misjudge altitude by 50 feet or more," the *AIM* says.

If the airplane is equipped with a head-up display (HUD), the crew should use it. While looking out the windshield, the pilot will see vital information on the HUD, such as airspeed and radio altitude, and symbology that will help him or her to fly a three-degree glide path to the water. An enhanced vision system (EVS) might be an additional benefit in providing an infrared image of the sea.

Without these enhancements, the crew's best option is to maintain a power setting and a pitch attitude that result in the slowest possible rate of descent and airspeed — and fly the airplane onto the water.

"Glassy seas are almost as bad as — maybe even worse than — rough seas, because it is so difficult to judge your altitude," said Russell. "On a dark night, you are not going to see anything. You have to fly the last stage off the radio altimeter, because that is your best indication of altitude.

"With a glassy sea below or on a dark night, what you want to do is to set up a minimum rate of descent at the slowest possible airspeed — you do not want to stall in, you want to stay just on the edge of a stall — and just fly it into the water."

Lane said that the U.S. Coast Guard C-130 manual recommends the following procedures for a nighttime ditching:

- "Make an instrument approach, holding airspeed 20 knots above stall speed;
- "At 500 [feet] to 700 feet above the water (use radio altimeter if available), set up approximately a 200-feet-per-minute rate of descent and establish an airspeed 10 knots above stall speed with gear up and wing flaps 100 percent [fully extended];
- "Use landing lights as necessary;
- "Hold wings level to avoid digging a wing into the water and cartwheeling the airplane; [and,]
- "Land at 10 knots above power-off stall speed with gear up and 100 percent flaps."

Recommendations vary on the use of landing lights at night. Most business-jet FCOMs say that landing lights should be used at night. The Hawker FCOMs include a caveat that landing lights should be used *unless* mist causes reflected glare. This is similar to what Lane's C-130 pilots are taught.

"On a clear night, use the landing lights because they will help your depth perception and help you judge your rate of descent — but it won't be until you get real close that you will see your lights on the surface," Lane said. "If you are in the clouds, the lights could become more of a hindrance than a help, so I would turn them off."

Russell said that some pilots have become disoriented while using landing lights during a night approach to a sea that is not calm.

"Some people say it is disorienting because you *suddenly* see the landing surface moving up and down, which tends to add an element of fear."

The crew should consider using their taxi lights, rather than their landing lights, says Australia's CASA.

"The very directional nature of landing lights could cause confusion for the pilot, whereas the more general light provided by taxi lights may prove more satisfactory," CASA said. "If the air is misty (a serious probability if there is blowing spray), the glare of external lights could upset your night vision and prove more of a hindrance than a help."

Worst-case Scenario

Miller said that a ditching at night or in low-visibility conditions is a "worst-case scenario" that Navy P-3 pilots learn to deal with in training.

"We do simulated ditchings on at least half the training flights," he said. "We set a simulated hard deck for the water, typically no lower than 4,000 feet because we are very near the stall region, and we practice a visual technique, in which you visually acquire the waves and the swells, and the worst-case scenario, which is at night or in the clouds and you cannot see the swells.

"In the worst-case scenario, we practice an instrument technique. Basically, we slow down to about 10 knots above stall speed, minimize our rate of descent to about 100 feet per minute and level the wings to the indicated artificial horizon."

This mirrors recommendations in the *IAMSAR Manual* — to maintain a descent rate of 300 feet per minute or less and a pitch attitude of about 10 degrees nose-up.

"Over smooth water or at night, [this procedure] minimizes the chance of misjudging the altitude, stalling the aircraft and entering the water in a disastrous nose-down attitude," the manual said.

A ditching at night or in low-visibility conditions is a 'worst-case scenario.'

If automatic callouts are not provided by a GPWS/TAWS, a "talking altimeter" or other device, the pilot not flying should call out radio altitude every 100 feet from 1,000 feet to 100 feet, then every 10 feet.

Most FCOMs recommend closing the throttles just before landing; some say that the throttle levers should be moved to the "cut-off" position. The pilot flying then should place both hands on the control yoke to avoid injury from uncommanded movement of the engine/propeller levers and to help maintain positive back pressure on the yoke to try to keep the nose up until the airplane has come to a stop.

"One thing that we learned from [actual P-3] ditchings is to let go of the power levers before impact," Miller said. "We found that when the propellers hit the water, the control linkage causes the power levers to go flying everywhere, and if you have your hand on them, there's the potential for injury. So, we train that in the last 50 feet, when you are getting ready for impact, to have both hands on the yoke."

Besides maintaining back pressure to keep the nose up, there is little the flight crew can do to control the airplane after the first impact.

"There will often be one or two minor touches — 'skips' — before the main impact with the water," the CAA said. "This main impact will usually result in considerable deceleration with the nose bobbing downward and water rushing over the cowling and windshield. It may even smash the windshield, leading you to think that the aircraft has submerged."

Orderly, Organized and Expeditious

After the airplane comes to a stop on the water, the most important task — for everyone — is to *get out of the airplane*. The crew should assume that the airplane *is* sinking and get everyone out of the airplane before water begins to enter the cabin or cockpit.

"Once water begins rushing in, you are *not* going to get out," Burton said. "You will have to wait until the cabin is full of water to get out the exit. Even with specialized training, this is likely to be difficult or impossible for the typical corporate or Part 135 passenger."

The crew should assume that the airplane *is* sinking and get everyone out.

If possible, the flight crew should announce on the radio frequency in use that the airplane is on the water and that the evacuation has begun. This will be useful information for ATC and SAR personnel; but, again, time is of the essence — the crew should make one call and not wait for acknowledgement.

Some checklists for turbine business airplanes include only one after-ditching task for the flight crew: *evacuate*. Others list a few tasks that the flight crew should perform, if possible, before evacuating the airplane. They include the following:

- Ensure that the airplane is depressurized before the emergency exits are opened. The Boeing Business Jet checklist, for example, says that this can be done by opening a cockpit window;
- Select the emergency-exit lights (which usually are powered by the emergency batteries) and command the evacuation;
- Pull the engine/APU fire handles, or push the fire switches; and,
- Turn off the battery switches.

To increase the airplane's conspicuity, however, the U.K. CAA recommends that the master switch and external lights remain on.

"If the aircraft floats for a while or sinks in shallow water, the lights may continue operating and provide a further sign of your position," the CAA said.

Continued operation of the airplane's electrical system and exterior lights, however, introduces the risk of inducing electrical current into the water — a condition that could be hazardous to survivors during the evacuation.

"Leaving the exterior lights on obviously would help rescuers find the aircraft, but there is always the risk that if the airplane has been damaged and you've got broken wires out there in the water, someone could be electrocuted," said Cohen. "And if a broken wire is shorting out to the airframe somewhere and there are sparks being produced, they might set fire to any jet fuel that might be leaking."

Richard Hill, program manager for aircraft cabin and fire safety at the FAA William J. Hughes Technical Center, said that the risk of jet fuel being ignited by an electrical arc is low but not nonexistent.[43]

"Jet fuel is more difficult to ignite than a more volatile fuel such as aviation-grade gasoline," Hill said. "It depends on several factors, such as the strength of the ignition source, the temperature of the fuel and the proximity of the ignition source to the fuel. The ignition source could heat the jet fuel enough to produce vapor that could ignite. The odds are against the jet fuel igniting easily, but it's not impossible."

Don't Count on Staying Afloat

If the flight attendant does not receive a verbal signal or a visual signal from the flight crew to evacuate the airplane immediately after the airplane comes to a stop, he or she should initiate the evacuation.

Several ditching checklists say that the airplane, if not seriously damaged during the ditching, likely will remain afloat long enough for evacuation to be completed. For example, the checklists for several Citation models say, "Under reasonable ditching conditions, the aircraft should remain afloat an adequate time to launch and board life rafts in an orderly manner."

The Boeing Business Jet ditching checklist says, "The airplane may remain afloat indefinitely if fuel load is minimal and no serious damage was sustained during landing."

The FCOM for the Airbus A319 is more specific; it says that at a landing weight of 62,500 kilograms (137,788 pounds) and with the center of gravity at 40 percent mean aerodynamic chord, the airplane will float for six minutes, six seconds.

Nevertheless, the crew should not count on the airplane staying afloat. When the airplane begins to take on water, it will sink rapidly, and occupants will not be able to evacuate with water gushing through the emergency exits.

"It is best to assume that you will have little time [and] evacuate the aeroplane quickly but in an orderly and organized manner," CASA says. "This is best achieved if all the passengers and crew have been comprehensively briefed during the descent phase prior to impact, so that everyone knows what they have to do and what their responsibilities are."

The flight attendant should look out windows on each side of the airplane to determine where the life rafts should be deployed.

"Typically, evacuation from corporate airplanes is conducted through an overwing exit," Coley said. "Other options have to be considered. We counsel flight attendants to assess dangers outside the cabin before they open any exit after a ditching. There might be wreckage outside an overwing exit that could damage the life raft, so an alternate exit would be selected."

Other factors to consider are wind conditions and water conditions. If possible, the evacuation should be conducted on the side of the airplane that has the least wind/water activity.

Crew Duties After Ditching

Some ditching checklists include specific crew duties following a ditching. The Hawker 1000 checklist, for example, says that the first officer should remove the emergency-exit hatch, exit the airplane and assist the passengers in exiting; the captain should ensure that all passengers exit the airplane, then exit the airplane, too, and make certain everyone's life vest is inflated.

The ditching checklists for the Gulfstream IV and Gulfstream V, which have two overwing emergency exits on each side of the cabin, recommend specific tasks for the captain, first officer and cabin crewmember. The checklists say that the captain should do the following:

- Select all emergency lights;
- Remove life raft no. 1 from its stowed position, secure the mooring/inflation line to a seat belt and get the life raft ready to be used;
- Remove the forward emergency-exit window and deploy life raft no. 1 out the window;
- Exit the airplane, follow the mooring/inflation line to the life raft and board the life raft; and,
- Direct the passengers to follow the mooring/inflation line to the life raft and assist the passengers into the life raft.

Occupants will not be able to evacuate with water gushing through the emergency exits.

The Gulfstream checklists say that the first officer should do the following:

- Ensure that the emergency lights are on and that the ELT has been activated;
- Remove life raft no. 2 from the stowed position;
- Remove the aft exit window and deploy life raft no. 2 out that window;
- Exit the airplane, follow the mooring/inflation line to the life raft and board the life raft; and,
- Direct the passengers to follow the mooring/inflation line to the life raft and assist the passengers into the life raft.

The Gulfstream checklists say that the cabin crewmember should do the following:

- Assist the captain and the first officer in removing the life rafts from storage;

- Assist the captain and the first officer in securing the life rafts; and,

- "Direct" the captain and the first officer to open the exit windows and deploy the life rafts.

The checklists recommend that occupants evacuate through exits on the same side of the airplane.

"For passenger accountability, we send them all out the same side of the aircraft," Stanfield said. "Then we can get our life rafts together and stay together as a group."

Developing an Evacuation Plan

Most ditching checklists do not include specific crew duties for evacuation, and it is up to the crewmembers to have a prearranged plan.

Burton recommends that a flight crewmember should be the first person out of the airplane. As a time-saving measure, however, he recommends that while the flight crew is completing their after-ditching cockpit tasks, the flight attendant should secure the life raft mooring/inflation lines near the emergency exit, open the emergency exit and, with the assistance of ABPs if necessary, place the life rafts outside on the wing.

Burton said that the first officer should exit the airplane and deploy the life raft. The captain should ensure that cabin preparations are complete before exiting the airplane and deploying the second life raft, if there is one.

All life rafts should be deployed, to give survivors more room and more supplies.

If there are more than two life rafts aboard the airplane, ABPs should deploy any life rafts remaining after the flight crew deploys the first two. *All* life rafts should be deployed, to give survivors more room and more supplies, and, when the life rafts are tied together, to provide a larger "target" on the water for SAR personnel to find.

After assisting passengers who are able to evacuate, the flight attendant should exit the airplane.

Difficult Decisions

There may be some difficult decisions to be made about trying to help passengers who are injured severely or are otherwise physically incapable of evacuating. Crewmembers and/or ABPs also may have to deal with passengers exhibiting behaviors that could hinder or prevent others from evacuating.

A study of emergency evacuations identified several behaviors that could impede an organized, orderly and expeditious evacuation.[44] The behaviors include the following:

- Disorientation and brief immobility;

- Inaction (sustained immobility);

- Anxiety that can cause difficulty in performing simple tasks (e.g., releasing a seat belt);

- "Social bonding," in which a person seeks traveling companions from whom he/she has been separated;

- "Affiliative behavior," in which a person seeks the familiar (e.g., attempting to retrieve carry-on baggage);

- "Fear flight," in which a person attempts to flee;

- Excessive altruism, in which a person jeopardizes his/her life while attempting to assist a fellow passenger; and,

- Panic, in which the person acts irrationally and destructively (e.g., fighting a fellow passenger or crewmember).

Crewmembers and ABPs should try to render assistance to passengers who cannot or will not evacuate promptly, but they should not jeopardize their own lives, says Deborah Kasman, M.D., assistant professor at the Georgetown University Medical Center Department of Internal Medicine and Center for Clinical Bioethics.[45]

"Your responsibility is to do what you can with your knowledge and ability," she said. "Nevertheless, you

> **"Any time you put people in the water, you have more problems."**

don't need to sacrifice yourself just because you're a pilot or a flight attendant.

"If you have time to take care of one person, you want to pick the one you are most likely to have success with. That might be whoever is closest to the exit. … If someone is fighting you or is unconscious and bleeding heavily — you're not going to pick that person."

A person who is conscious and severely injured, or trapped by wreckage, usually realizes that he/she cannot be saved and does not delay the would-be rescuer. Nevertheless, a person might beg for assistance despite a futile situation.

"The ethical thing to do is to recognize the futility of the situation and save yourself," Kasman said. "If the person is panicking and saying 'don't let me die,' you have to let that person die, you have to go. Something like that is horrible, and there's nothing good to say about it except that you did your best and made sure that two people did not die."

Even for people who are rational and have survived the ditching without a scratch, getting out of the airplane might not be as easy as stepping through the exit onto the wing. The crew should be prepared to show passengers how to get through the emergency exits.

For example, a certain amount of finesse is required to leave through an overwing exit located above a credenza in the Gulfstream V. This is how it is done: "Sit on the credenza. Swing your legs up and out the window. Roll over onto your stomach. Push your body out of the window and step onto the wing."[46]

To Get Wet, or Not to Get Wet

Several water-survival specialists say that after the life rafts are deployed, they should be pulled close to the airplane, if there is no risk of damaging the life rafts, so that survivors can board the life rafts directly from the wing, without getting wet.

"You do not want to get wet if you don't have to," said Paul Russell. "If you can step into the life raft from a wing without jeopardizing the life raft, that is what you want to do. The general rule is to stay out of the water. Any time you put people in the water, you have more problems."

Other sources, including FAA,[47] say that to get into the life rafts, you must get wet; pulling the life rafts close to the airplane in an attempt to stay dry risks puncturing the life rafts. (This occurred after a Scandinavian Airlines System Douglas DC-8 inadvertently was flown into a bay during an approach in instrument meteorological conditions to Los Angeles [California, U.S.] International Airport on Jan. 13, 1969. The impact broke the airplane into three pieces, and jagged metal punctured two of the three life rafts deployed.)[48]

"You must protect the life rafts," said Burton. "You simply cannot risk damaging the life rafts. If you do, you are lost. You are in the water with just a life vest. If you are in cold water, your chances of survival are not good."

Another consideration is that the pilots might not be able physically to pull the life rafts to the airplane if the wind and current are working against them. When a life raft inflates, ballast bags (which provide stability for the life raft) deploy automatically. Sea anchors (which reduce drift) often deploy automatically, also (although some require manual deployment). Ballast bags and sea anchors fill with water and create significant drag.

"Try holding a life raft that has a 35-foot [11-meter] mooring line and a fixed canopy against a 20-knot or 30-knot wind and a running sea," Burton said. "It will yank you right out of your boots. The life raft will move faster than the aircraft, even if they are traveling in the same direction."

Burton said that deploying a life raft on the wing, as recommended by some specialists, almost guarantees that the life raft will be damaged.

"If you choose that option, you take the chance of destroying the bottom of the life-raft floor and possibly not having a life raft when you do get in the water," he said. "Many wings have vortex generators, which are like razor blades."

Burton recommends deploying life rafts from the trailing edge of the wing. Before deployment, the pilot should ensure that the mooring/inflation line is attached to the designated tethering point on the airplane or tied to a seat belt or another suitable fixture on the airplane. The airplane likely will have weathercocked into the wind, and the wind will blow the life raft safely away from the airplane. A sharp tug on the mooring/inflation line inflates the life raft.

Burton recommends the following technique for getting from the airplane to the life raft:

- Enter the water with the mooring/inflation line under one arm;
- Wrap that arm around the mooring/inflation line and firmly grasp the waistband on your life vest (forming with your arm a "loop" through which the mooring/inflation line passes); and,
- Use your other hand to pull on the mooring/inflation line and propel yourself toward the life raft.

With the mooring/inflation line under one arm, the other hand is used to pull oneself toward the life raft.

The hand that is pulling on the mooring/inflation line also can be used to push a ditch bag ahead of you, toward the life raft. Burton says, however, that if the ditch bag impedes your progress or begins to sink, let it go.

"The most important thing is to get out of the airplane and into the life rafts as quickly as possible," he said. "Do whatever it takes to get in the life raft. Clothing will be wet, and most people are going to require assistance in getting into the raft. That is why getting a crewmember or an able-bodied passenger into the life raft first is so important."

To expedite the evacuation, Burton recommends that ABPs follow the pilots to the life rafts, so that they can assist the pilots in helping other passengers board the life rafts. The pilots should conduct a head-count to ensure that everyone who was capable of evacuating the airplane is aboard the life rafts. The life rafts then should be tied together to improve their stability and visibility on the water, and to keep everyone together.

A hazard reported by crewmembers involved in ditchings during World War II was the tendency of the wings and tails of large airplanes to rise and fall in rough water.[49] Before boarding life rafts, survivors in the water tended to seek handholds on the wings or tail to avoid drifting away from the airplane, and life rafts tended to move beneath a wing rising from the water. The slapping of wings and tails often knocked crewmembers unconscious and upset life rafts.

Survivors should resist the impulse to return to a still-floating airplane to try again to assist someone left behind or to retrieve supplies, personal belongings, etc. The airplane could continue floating for hours or days. On the other hand, it could sink in seconds.

"Do not, under any circumstances, return to a floating aircraft," the Gulfstream III and IV ditching checklists say. "Should the aircraft begin to sink, the onrush of water may prevent escape."

Now Comes the Hard Part

Data show that the chances of surviving a ditching are good. The CAA said that U.K. data and U.S. data on ditchings, including those conducted by pilots of light general aviation aircraft, indicate that 88 percent of ditchings involve few injuries to the occupants.[50]

"It appears that the ditching itself is generally successful, although subsequent survival and rescue do not necessarily follow," the CAA said.

Surviving a ditching, therefore, will be a prelude to the next challenge: staying alive until help arrives. ■

The bottom line, in our opinion …

- **When a ditching is the only option, there will be no time to train for survival.**
- **Flying the airplane is a full-time job. Given a choice, the operator of a multimillion-dollar corporate airplane carrying passengers should dispatch all flights with a flight attendant, an aviation maintenance technician or even a passenger trained in cabin safety.**
- **Coordination is critical. Flight crew and cabin crew must receive joint training on evacuation procedures and the location and proper use of emergency equipment.**
- **At the first indication of a problem that might require ditching, immediately tell ATC so that search-and-rescue resources can begin mobilizing.**
- **Ditch with power. Pressing on until the engines are silent will leave few options for selecting a landing site and increase the difficulty of ditching.**
- ***Do not land into the face of a swell.***
- **Don't count on your airplane floating. Assume that it is sinking, and *get out*!**

Notes

1. Miller, Andy. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 7, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
2. U.S. Federal Aviation Administration (FAA). Federal Aviation Regulations (FARs) Part 91, *General Operating and Flight Rules*. Subpart F, *Large and Turbine-powered Multiengine Airplanes*. Part 91.505, "Familiarity with operating limitations and emergency equipment."
3. Lane, Keith. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 8, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Steward, Paul; liaison officer to the Cospas-Sarsat International Satellite System for Search and Rescue and implementation officer for the Distress Alerting Satellite System, Office of Search and Rescue, U.S. Coast Guard. Interview by Rosenkrans, Wayne. Suitland, Maryland, U.S. April 9, 2003. Flight Safety Foundation, Alexandria, U.S. Steward retired from the Coast Guard in June 2003.
5. FAA. FARs Part 91.533, "Flight attendant requirements." FARs Part 135, *Operating Requirements: Commuter and On-demand Operations and Rules Governing Persons on Board Such Aircraft*. Part 135.107, "Flight attendant crewmember requirement." Part 135.105, "Exception to second-in-command requirement: Approval for use of autopilot system."
6. Coley, Colette. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 2, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
7. Cosper, Donna K.; McLean, Garnet A. *Analysis of Ditching and Water Survival Training Programs of Major Airframe Manufacturers and Airlines*. FAA Civil Aeromedical Institute. DOT/FAA/AM-98/19. July 1998.
8. U.K. Civil Aviation Authority (CAA). "Ditching." *General Aviation Safety Sense* Leaflet 21A. Feb. 9, 2001.
9. Pierce, Michael. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. May 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
10. Donald, David; general editor. *The Encyclopedia of Civil Aircraft*. San Diego, California, United States: Thunder Bay Press, 1999.
11. Campbell, Bill. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 11, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.
12. The Flight Safety Foundation (FSF) *Flight Crew Ditching Checklist* is a composite/generic checklist assembled from the basic procedures recommended for several business airplanes, procedures recommended by water-survival specialists and from other sources. The information is not intended to supersede operators' or manufacturers' requirements or recommended procedures.
13. FAA. FARs Part 25, *Airworthiness Standards: Transport Category Airplanes*. Part 23.809, "Emergency exit arrangement."

14. FAA. *Water Survival: The Skills You Never Want to Use.* Videotape produced for FAA National Aviation Safety Program, 1998.

15. Russell, Paul D. Interview by FSF editorial staff. Alexandria, Virginia, U.S. May 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. In the U.S. Coast Guard, Russell conducted more than 200 water landings and served in various positions, including commander of two air stations, chief of the Aviation Training Center Training Division and chief of search-and-rescue operations in the Northwest Region, before retiring in 1984 with the rank of captain. He is chief engineer, aviation system safety, Boeing Commercial Airplanes, and a maritime safety and accident investigator for Safety Services International.

16. Ferrante, Tony. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. June 30, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

17. Stutz, Richard. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 8, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

18. Roig, Bill; director of operations, Catalina Aerospace. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

19. International Maritime Organization; International Civil Aviation Organization (ICAO). *IAMSAR Manual* (*International Aeronautical and Maritime Search and Rescue Manual*), Volume III, "Mobile Facilities." 1998.

20. ICAO. International Standards and Recommended Practices. *Annex 11 to the Convention on International Civil Aviation: Air Traffic Services*.

21. Stanfield, Allen. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. April 30, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

22. ICAO. International Standards and Recommended Practices and Procedures for Air Navigation Services (PANS). *Annex 10 to the Convention on International Civil Aviation: Aeronautical Telecommunications.* Volume II: *Communication Procedures including those with PANS status.* Chapter 5, *Aeronautical Mobile Service — Voice Communications*. 5.2.2, "Establishment and assurance of communications." 5.2.2.1.1.1 says, "Aircraft on long overwater flights, or on flights over designated areas over which the carriage of an emergency locator transmitter (ELT) is required, shall continuously guard the [very-high-frequency] VHF emergency frequency 121.5 MHz [megahertz], except for those periods when aircraft are carrying out communications on other VHF channels or when airborne equipment limitations or cockpit duties do not permit simultaneous guarding of two channels."

23. FAA. *Aeronautical Information Manual* (*AIM*). Paragraph 6.3.1, "Distress and Urgency Communications."

24. Lemon, Dan. Interview by Rosenkrans, Wayne. Washington, D.C., U.S. June 24, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

25. The FSF *Cabin Crew Ditching Checklist* was assembled from basic procedures recommended by cabin-crew instructors and from other sources. This information is not intended to supersede operators' or manufacturers' requirements or recommended procedures.

26. Burton, Ken. Telephone interview by Rozelle, Roger. Alexandria, Virginia, U.S. Aug. 27, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

27. Cosper and McLean.

28. Marshall, Nora. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. June 30, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

29. Cohen, Bob. Telephone interviews by Lacagnina, Mark. Alexandria, Virginia, U.S. May 5, 2003, and Oct. 7, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

30. FAA. Advisory Circular 121-24C, *Passenger Safety Information Briefing and Briefing Cards*. Appendix 4, "Brace-for-Impact Position." July 23, 2003.

31. FAA, 1998.

32. Llano, George Albert. *Airmen Against the Sea*. Arctic, Desert, Tropic Information Center (ADTIC), Research Studies Institute, U.S. Air Force. ADTIC Publication G-104.

33. Airclaims — in *World Aircraft Accident Summary*, Issue 131, A98:5 — said that the crew was conducting a visual approach to the Chambery (France) airport on Feb. 6, 1998, when the airplane struck the water about 0.6 nautical mile (1.1 kilometers) from the runway. None of the five occupants was seriously injured. The occupants exited the airplane before it sank in 90 feet (28 meters) of water.

34. Terrain awareness and warning system (TAWS) is the term used by the European Joint Aviation Authorities and FAA to describe equipment meeting ICAO standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; *enhanced GPWS* and *ground collision avoidance system* are other terms used to describe TAWS equipment.

35. Bateman, Don. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 2, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

36. FAA. *AIM*. Paragraph 6.3.3, "Ditching Procedures."

37. Gill, Stephen; oceanographer, U.S. National Ocean Survey. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Aug. 13, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

38. Buckridge, Chris; HU-25 standardization officer, U.S. Coast Guard Aviation Training Center. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 16, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

39. U.S. National Search and Rescue Committee. *United States National Search and Rescue Supplement to the International Aeronautical and Maritime Search and Rescue Manual.* Washington, D.C. May 2000.

40. Buckridge.

41. FAA Air Carrier Operations Bulletin, "Brace for Impact Positions." 1-94-17.

42. Civil Aviation Safety Authority, Australia. *Ditching*. Civil Aviation Advisory Publication 253-1(0). April 2003.

43. Hill, Richard. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 7, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

44. Galea, Ed. "Passenger Behaviour in Emergency Situations." In *Passenger Behaviour*, edited by Bor, Robert. Aldershot, Hants, England: Ashgate Publishing, 2003.

45. Kasman, Deborah. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S. Aug. 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

46. Gulfstream Aerospace. Gulfstream Cabin Management Systems Gulfstream V safety features videotape.

47. FAA, 1998.

48. U.S. National Transportation Safety Board (NTSB) accident report no. DCA91A0012 said that 15 occupants were killed, 17 were seriously injured and 13 received minor injuries or no injuries. NTSB said that the probable causes of the accident were the pilot-in-command's improper IFR (instrument flight rules) operation, poor crew coordination and the flight crew's misreading of, or failure to read, their instruments.

49. Llano.

50. U.K. CAA, Feb. 9, 2001.

Further Reading From FSF Publications

FSF Editorial Staff. "Loss of Engine Power Sets Stage for Ditching on Moonless Night." *Accident Prevention* Volume 61 (January 2004).

FSF Editorial Staff. "Engine-intake Icing Sets Stage for Ditching of Shorts 360 During Cargo Flight." *Accident Prevention* Volume 60 (September 2003).

FSF Editorial Staff. "Fuel-quantity Miscalculation Cited in Ditching of Boeing Stratoliner." *Accident Prevention* Volume 60 (August 2003).

FSF Editorial Staff. "Inflatable Restraints Installed on Some Transport Aircraft." *Cabin Crew Safety* Volume 38 (July–August 2003).

FSF Editorial Staff. "Loss of Control Occurs During Pilot's Attempt to Return to Departure Airport." *Accident Prevention* Volume 60 (May 2003).

FSF Editorial Staff. "Able-bodied Passengers Extend Crew Capabilities During In-flight Emergencies." *Cabin Crew Safety* Volume 38 (January–February 2003).

FSF Editorial Staff. "Head-up Displays in Civil Aviation: A Status Report." *Flight Safety Digest* Volume 21 (December 2002).

FSF Editorial Staff. "Recommendations Warn Against Opening Cabin Doors While Airplanes Are Pressurized." *Cabin Crew Safety* Volume 37 (November–December 2002).

FSF Editorial Staff. "Consistent Use of 'Silent Review' Supports Quick, Correct Actions." *Cabin Crew Safety* Volume 37 (March–April 2002).

FSF Editorial Staff. "Enhanced Emergency Medical Kits Increase In-flight Care Options." *Cabin Crew Safety* Volume 36 (November–December 2001).

FSF Editorial Staff. "Many Passengers in Exit Seats Benefit From Additional Briefings." *Cabin Crew Safety* Volume 36 (May–June 2001).

U.S. National Transportation Safety Board. "Safety Study: Emergency Evacuation of Commercial Airplanes." *Flight Safety Digest* Volume 19 (December 2000).

FSF Editorial Staff. "Cabin Crews Must Capture Passengers' Attention in Predeparture Safety Briefings." *Cabin Crew Safety* Volume 35 (July–August 2000).

Wilson, Dale R. "Darkness Increases Risks of Flight." *Human Factors & Aviation Medicine* Volume 46 (November–December 1999).

Sallee, G.P.; Gibbons, D.M. "Propulsion System Malfunction Plus Inappropriate Crew Response (PSM+ICR)." *Flight Safety Digest* Volume 18 (November–December 1999).

FSF Editorial Staff. "Double Engine Failure Leads to Ditching of Cessna 402C." *Accident Prevention* Volume 56 (August 1999).

FSF Editorial Staff. "Flight Attendants Who Work Alone Need Specialized Training at Regional Airlines." *Cabin Crew Safety* Volume 34 (May–June 1999).

Sumwalt, Robert L. "Enhancing Flight-crew Monitoring Skills Can Increase Flight Safety." *Flight Safety Digest* Volume 18 (March 1999).

FSF Editorial Staff. "Analysis of Training for Emergency Water Landings Questions Assumptions, Inconsistencies." *Cabin Crew Safety* Volume 33 (November–December 1998).

Koenig, Robert L. "Exit-locating Devices, Aircraft Structural Strengthening and Improved Crew Drills Called 'Most Practicable' Accident-survivability Factors." *Cabin Crew Safety* Volume 32 (January–February 1997).

Koenig, Robert L. "U.K. Studies Find That 'Legs-back' Brace Position Is Optimal for Forward-facing Passengers." *Cabin Crew Safety* Volume 30 (November–December 1995).

Pope, John A. "Developing a Corporate Aviation Department Operations Manual Reinforces Standard — and Safe — Operating Procedures." *Flight Safety Digest* Volume 14 (April 1995).

Barthelmess, Sharon. "Positions Brace Passengers for Impact to Reduce Injuries and Fatalities." *Cabin Crew Safety* Volume 23 (January–February 1988).

Ditching Certification: What Does It Mean?

Dassault used a computer program to explore the ditching behavior of the Falcon 900.

Transport category airplanes used for business and corporate travel are not required to be certificated for ditching, but several are. Computer-aided analysis is the basis for most certifications.

— FSF EDITORIAL STAFF

Provisions for ditching certification are included in U.S. certification standards for transport category airplanes[1] and in European certification standards for large turbine-powered airplanes.[2]

The U.S. Federal Aviation Administration (FAA) requires ditching certification for transport category airplanes flown by air carrier operators in "extended overwater operations" (i.e., more than 50 nautical miles [93 kilometers] from the nearest shoreline).[3]

The European Joint Aviation Authorities (JAA) requires ditching certification for large turbine-powered airplanes with more than 30 passenger seats flown by commercial operators either 120 minutes at cruising speed or 400 nautical miles

[741 kilometers] from land suitable for an emergency landing.[4]

Ditching certification is not required for airplanes used in business/corporate flight operations. Nevertheless, several business jets have been certificated for ditching. Among those in current production are the Airbus A319; Boeing Business Jet and Boeing Business Jet 2; Bombardier Challenger 604 and Global Express; Dassault Falcon 50EX, Falcon 900C, Falcon 900EX, Falcon 2000 and Falcon 2000EX; and Gulfstream G100, Gulfstream G200, Gulfstream IV, Gulfstream V and Gulfstream V-SP.

Among current-production business/corporate jets that are not certificated for ditching are the Bombardier Learjet 31A, Learjet 45 and Learjet 60; Cessna Citation Bravo, Citation Encore, Citation Excel and Citation X; Embraer Legacy; and Raytheon Beechjet 400A and Hawker 800XP.

What's the Payback?

"Ditching certification is a complex and expensive effort," said Tim Travis, manager of executive and corporate communications for Raytheon Aircraft Co.[5] "Ditching certification has not been requested by customers."

Michael Pierce, marketing product manager for Cessna Aircraft Co., said that the company believes that ditching certification is not worth the effort and expense.[6]

"Ditching certification is a pretty involved process," he said. "For the cost and for what is involved in ditching certification, we just don't see a lot of benefit for our customers."

Pierce said that Cessna conducted analyses using computer modeling to show compliance with Part 25 certification standards, including those for "ditching emergency exits," which are required for all transport category airplanes.[7]

"We can prove analytically what the airplane is capable of to meet Part 25 regulations, but we don't take the extra step to certify the airplane for ditching," he said. "We just don't see that it's a good use of resources."

Robert Baugniet, director of corporate communications for Gulfstream Aerospace, said that the company sees ditching certification as a desirable product enhancement.[8]

"Because of the long-range, overwater capabilities of Gulfstream aircraft and their frequent use in that role, Gulfstream long ago determined it to be of advantage both to the commercial potential of the product line and to our operators to establish a means of compliance with ditching requirements," he said.

Georges Pellegrini, director of customer service and engineering support for Dassault International, said that experience has shown that the company took the correct decision to certify its business/corporate airplanes for ditching.[9]

"Ditching certification is not mandatory for this type of aircraft; however, it has been Dassault's choice to make the extra effort," he said. "Falcons are designed with the objective of maximum safety in all phases of flight, and ditching is not to be neglected. Experience has shown at least twice that Dassault was right; there are at least 14 people today who can confirm it."

The experience Pellegrini referred to involved two water-contact accidents. A Falcon 20 with six people aboard remained afloat for 25 minutes after being ditched in rough seas off the coast of Iceland on Oct. 11, 1987, and a Falcon 200 with eight people aboard overran the runway during takeoff from New Orleans, Louisiana, U.S., and floated for about one hour before sinking in Lake Pontchartrain. None of the occupants was seriously injured, and all exited the airplanes before they sank.

"Ditching certification is a complex and expensive effort."

"These examples show that Falcons are really engineered for ditching, giving plenty of time for the occupants to exit the aircraft safely," Pellegrini said.

(On April 8, 2003, during a cargo flight, a Falcon 20 with two pilots aboard was ditched in the Mississippi River after both engines flamed out on approach to Lambert–St. Louis [Missouri, U.S.] International Airport. Both pilots received serious injuries [see "The Unthinkable Happens," page 3].)

> The current standards basically are the same as those adopted … in 1953.

Standards Reflect a More Dangerous Time

Standards for ditching certification were adopted by FAA in the early 1950s, when airplanes were ditched more frequently than they are today.

"Although ditchings are virtually unheard of today, they were not uncommon prior to the introduction of the modern turbine-engine aircraft," said Mike Fergus, public affairs specialist for the FAA's Western–Pacific Region.[10] "As far back as 1949, the Civil Aeronautics Administration (the predecessor organization to the FAA) recognized the need to address ditching requirements. Civil Air Regulations defined requirements for obtaining overwater-operation certification and identified the need for survival equipment following a water landing.

"Even though the reliability of transport category aircraft has greatly improved, the FAA still requires emergency survival equipment to be installed on aircraft approved for extended overwater operations. We recognize that while the probability of a water landing is very low, it may still occur."

The European ditching-certification standards are almost identical to those in U.S. Federal Aviation Regulations (FARs) Part 25.801 (see "For Ditching Survival, Start With Regulations, But Don't Stop There," page 395). The current standards basically are the same as those adopted by the Civil Aeronautics Administration in 1953.[11]

Simulations indicated that the Embraer Legacy's emergency exits will stay above the waterline long enough to conduct an evacuation.

If a manufacturer requests ditching certification for an airplane, Part 25.801 requires the manufacturer to do the following:

- Incorporate "practicable design measure[s] … to minimize the probability that in an emergency landing on water, the behavior of the airplane would cause immediate injury to the occupants or would make it impossible for them to escape";
- Investigate "the probable behavior of the airplane in a water landing … by model tests or by comparison with airplanes of similar configuration for which the ditching characteristics are known." The investigation must include the effects on the airplane's hydrodynamic characteristics of projections such as scoops and flaps;
- Show that "under reasonably probable water conditions, the flotation time and trim of the airplane will allow the occupants to leave the airplane and enter [life rafts]"; and,
- Either include "the effects of the collapse of external doors and windows" in the investigation of the airplane's probable behavior in a water landing or ensure that "the external doors and windows [will] withstand the probable maximum local pressures."

In addition to Part 25.801, the manufacturer also must comply with three other sections of Part 25: Part 25.807(e), which requires uniform distribution of emergency exits in the airplane; and Part 25.1411 and Part 25.1415(a), which include requirements for safety equipment to be carried aboard the airplane, such as life rafts, life vests, signaling devices and lifelines (which are attached to the fuselage to enable the occupants to stay on the wing after ditching).

Ready or Not, the Standards Apply

Information on ditching certification is included in FAA Advisory Circular (AC) 25-17, *Transport Airplane Cabin Interiors Crashworthiness Handbook*. The AC says that two ditching conditions are examined during certification.

“The first condition is the ‘planned ditching’ case in which there is sufficient time to prepare the airplane for ditching, and adjustments have been made to airplane weight and CG [center of gravity],” the circular said. “The other condition is the ‘unplanned ditching’ case in which the airplane enters the water with insufficient time to prepare for ditching.”

Andrea Bottcher, a corporate communications specialist for Embraer, said that the company conducted computer modeling of an unplanned ditching situation to analyze the effectiveness of the Legacy’s emergency exits as ditching emergency exits.[12]

“The basic scenario considered for the analysis performed was an aborted takeoff followed by an unplanned ditching, with the aircraft in the MTOW [maximum-takeoff-weight] condition,” she said. “These studies took the various airframe characteristics into consideration, such as landing-gear-wheel position and size, use of the doors, volume of the compartments, etc.

“In addition, in order to have the outcome of the analysis fall on the conservative side, certain assumptions were incorporated into the computer modeling — for example, the buoyancy capabilities that some compartments might provide were not taken into consideration.

“The simulations demonstrated that the Legacy’s emergency exits would be above the waterline in a ditching scenario, thus assuring effective means for passenger evacuation.”

Like several other manufacturers, however, Embraer did not seek ditching certification.

“Ditching certification is required for extended-overwater operations under Part 121 [the requirements for domestic, flag and supplemental operations], which is not applicable to the Legacy,” Bottcher said.

AC 25-17 says that some terms in Part 25.801 are not defined by FAA and that application of the terms is left to the manufacturer’s judgment. One example is “reasonably probable water conditions.”

“The expression ‘reasonably probable water conditions’ is considered judgmental in application to compliance for ditching and has never been

Five minutes is an ‘appropriate flotation time’ to evacuate a Global Express.

Raytheon Aircraft says ditching certification is not on Hawker 800XP customers' shopping lists.

specifically defined as to sea-state force or wave height," the AC said.

An example of what an air carrier aircraft manufacturer, Lockheed-California Co., considered as reasonably probable water conditions is provided in a U.S. National Transportation Safety Board accident report.[13] The report said that a ditching study conducted by Lockheed during certification of the L-1011 assumed "a moderate sea state (three-[foot] to five-foot waves)."

FAA does not specify a minimum flotation time suitable for evacuation of an airplane after a ditching. AC 25-17 says that flotation time must exceed the manufacturer's "most-conservative estimate of time required to completely evacuate the airplane."

"The length of flotation time depends on each aircraft," said Leo Knaapen, communications manager for Bombardier Aerospace.[14] "Usually, for our aircraft [e.g., Challenger 604, Global Express], 300 seconds (five minutes) is considered to be appropriate flotation time for the occupants to leave the aircraft."

Knaapen said that several factors affect an airplane's flotation time.

"We always analyze the worst case; therefore, maximum takeoff weight and forward and aft CG limits are one main factor," he said. "The amount of water coming into the aircraft after ditching, plus the number of exits available for occupants to disembark, is another factor. The weight relief due to occupants leaving the aircraft and its effect on the overall CG of the aircraft also affect flotation time."

The airplane's "trim" in the water is another factor that affects evacuation.

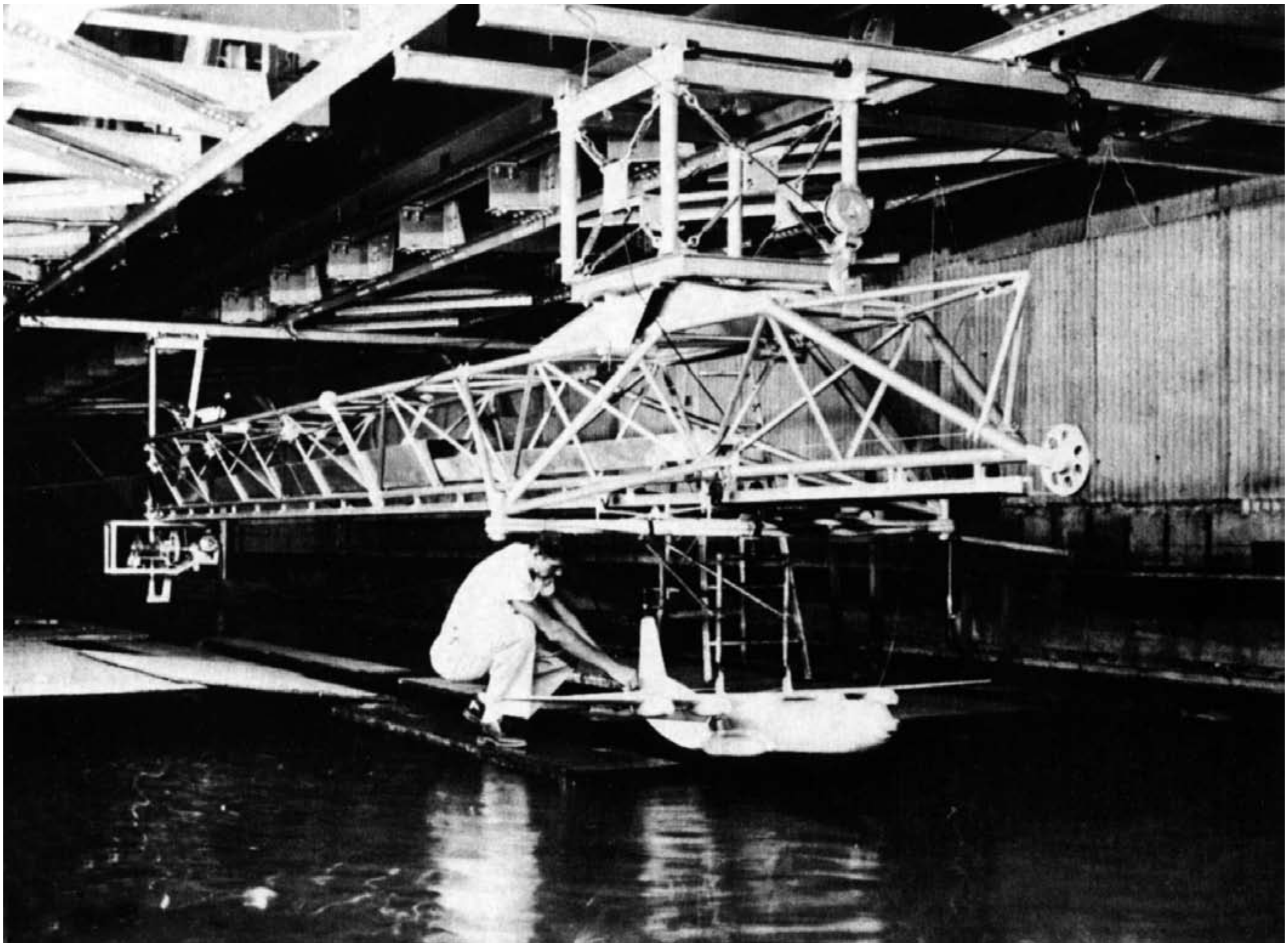
"'Trim of the airplane' is the flotation attitude — that is, nose-up versus nose-down and the 'roll' of the aircraft while sitting in the water," Fergus said. "If the aircraft floats with a 45-degree nose-up attitude, it may not be possible for the occupants to evacuate; thus, considerations of trim are necessary."

Fergus provided some examples of "practicable design measures" to prevent injury and facilitate evacuation.

"Practicable design measures would include ensuring that the required emergency exits can be opened after a ditching," he said. "Practicable design measures would also include sufficient fuselage structural capability to withstand a controlled water landing. The airplane design and [the manufacturer's recommended] landing procedures must also limit the ditching load factors such that they do not exceed the emergency landing loads defined in [Part] 25.561(b). This ensures that interior structural items will not break loose, resulting in injury to the airplane's occupants or the blocking of emergency exits."

Part 25.561(b) requires that the structure of a transport category airplane be designed "to give each occupant every reasonable chance of escaping serious injury in a minor crash landing," when the occupants, with seat restraints fastened, experience specific inertia forces — for example, 9 g (i.e., nine times standard gravitational acceleration) forward

"The length of flotation time depends on each aircraft."



Scale models were launched to strike the water at a specific airspeed and in a specific attitude.

and 6 g downward. AC 25-17 says that "load factors above these are considered to expose occupants to injurious loads."

Computer Simulations Make Model Tests Obsolete

Manufacturers investigate the probable ditching behavior of an airplane either by testing scale models of the airplane or by conducting engineering analyses and comparing the results with the findings of investigations of the "known" ditching behavior of similar airplanes.

"The model tests are much like scale-model wind-tunnel tests," Fergus said. "Whereas a wind-tunnel test seeks to evaluate the aerodynamic performance of an aircraft, a ditching scale-model test seeks to evaluate the hydrodynamic characteristics of the airplane when landing on water."

Dassault has used both scale-model tests and engineering analyses in certifying its business/corporate airplanes for ditching.

"The way we have studied ditching capability has evolved over the years with the development of new tools," Pellegrini said. "For example, for the Falcon 20 and Falcon 10, Dassault built a one-tenth-scale mock-up and simulated landings on water in a pool to determine that the behavior of the airplane was safe."

Among the findings of the scale-model tests was that the lower sills of the main doors on both airplanes would be under the waterline after ditching. As a result, Dassault included in its recommended ditching procedures a prohibition against the use of the Falcon 20's one-piece door for evacuation; the company also installed an emergency exit on the left side of the fuselage. The Falcon 10 has a two-piece (clamshell-type) main door; the recommended ditching procedures allow use of the

"Whether or not an airplane is ditch-certified, how you put it in the water is going to make a big difference."

upper part of the door but prohibit use of the lower part of the door for evacuation.

Ditching certification of the Falcon 50 was based on comparing the results of engineering analyses with the results of the scale-model tests of the Falcon 20, which has a similar fuselage.

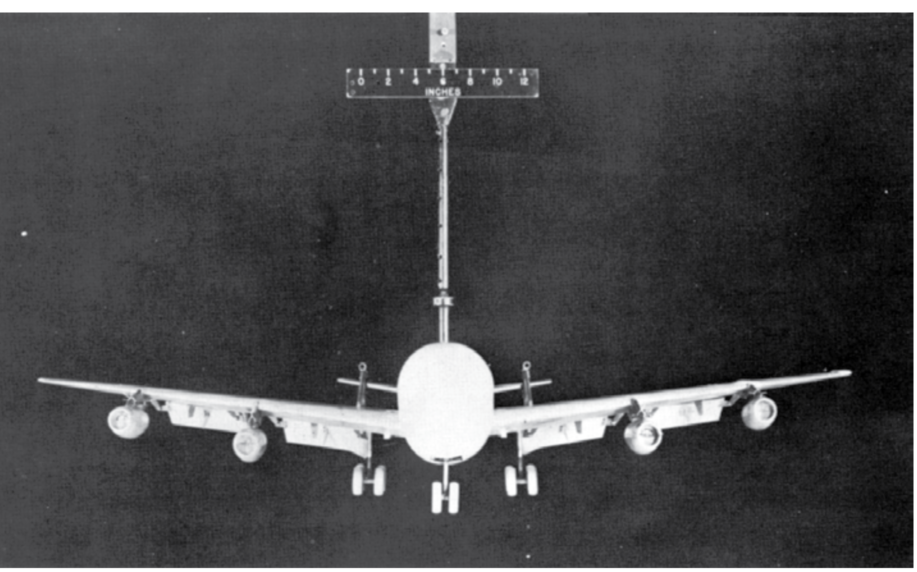
"The next model was the Falcon 900," Pellegrini said. "At that time, Dassault had developed a very powerful tool — CATIA [computer-assisted three-dimensional interactive application] — that allowed us to simulate aerodynamic and hydrodynamic behavior, and to exactly determine shapes, volumes, weight and balance well before the first airplane was ever flown.

"This was how we determined that the main door on the Falcon 900 — and later the Falcon 2000 — stands over the waterline and can be used for evacuation, eliminating the need for an emergency exit on the left side of the fuselage."

Pellegrini said that during ditching-certification studies, Dassault calculated that all the Falcon models will remain afloat at least 20 minutes.

"This calculation has always taken into account unfavorable conditions, such as an open main door (if allowed) and a certain height of waves," he said. "However, flotation time is subject to many parameters and is a rough estimate. The best information we get is from experience."

A 1/25-scale model constructed of cardboard, wood, tinfoil, fiberglass and plastic was used to investigate rough-water ditchings.



Paul Russell, chief engineer, aviation system safety, for Boeing Commercial Airplanes, said that because of the multitude of factors involved, the results of ditching-certification analyses might not be the same as the actual results of a ditching.[15]

"Ditching certification is a computer-assisted wild-ass guess," he said.

Bob Cohen, staff instructor and quality-assurance instructor for CAE SimuFlite, said that how an airplane behaves during a ditching depends to a great extent on how the flight crew lands the airplane.[16]

"Whether or not an airplane is ditch-certified, how you put it in the water is going to make a big difference," he said. "It is just my opinion that ditching certification is … how can I put it in a nice way? … It makes you feel good. When you spend twenty-four million dollars on an airplane, I guess it makes you feel better if it has been ditch-certified."

No Airplane Can Be Designed for a Safe Ditching

A 1956 report by the U.S. National Advisory Committee for Aeronautics (NACA, predecessor of the U.S. National Aeronautics and Space Administration [NASA]) said that the establishment of proper approach procedures, the incorporation of adequate facilities for evacuation and early rescue are among the most effective means of increasing the likelihood of survival in a ditching situation.[17]

"Performance requirements and the relatively low frequency of emergency landings even in wartime make it unlikely that airplanes will ever be designed specifically for 'safe' ditchings," the report said. "It appears possible, however, to reduce the hazards by some attention to the effects of the design parameters."

The report included the findings from ditching tests conducted at the Langley (Virginia, U.S.) Aeronautical Laboratory (now the NASA Langley Research Center) with scale models of 37 airplanes, including 18 military bombers, seven military fighters and 12 military/civilian transports. The airplanes were not identified in the report, but drawings of the airplanes included with summaries of the findings of the ditching tests provide clues to their identities (Table 1; Table 2, page 74; Table 3, page 75; Table 4, page 76).

The models, whose scales ranged from 1/8 to 1/25, were launched into a pool of water in such a manner that they would strike the water at a specific speed and in a specific attitude.

"Damage which was likely to occur in a full-scale ditching was simulated in the models either by the removal of parts, by the installation of simulated crumpled sections or aluminum-foil coverings which failed during the test, or by a combination of these methods," the report said.

AC 25-17 said that the results of the NACA ditching tests have been the basis for the ditching certification of early transport category airplanes and modern transport category airplanes.

"It became an acceptable practice for designers to substantiate the ditching behavior of a proposed airplane design by comparisons in basic geometric configuration to airplane designs approved for ditching by the models tested at Langley Field," the AC said.

The Bigger, the Better

The NACA report included the following general findings from the ditching tests:

- Wings — "From a ditching standpoint, the vertical location of the wing with respect to the fuselage is a compromise between having the wing low enough to provide buoyancy to help keep the airplane afloat after ditching and having the wing high enough so that the landing flaps and engine installations … do not seriously impair ditching behavior. It is generally considered that the most favorable position of the wing is slightly above the bottom of the fuselage or in a low midwing position. The thickness and size of the wing had little effect on ditching behavior other than the obvious effect on buoyancy."

- Landing gear — "It is considered advisable that ditchings be made with the landing gear retracted because an extended gear usually causes diving."

- Flaps — "For most of the models, there was only a slight nose-down moment observed [with flaps extended], and in no test was a flaps-up condition preferable. For certain models, … a flaps-down condition caused diving; but with the flaps retracted and with the corresponding increase in speed, the damage and deceleration were even more severe than in the dives. It is therefore preferable to have flaps down in a ditching in order to obtain a low forward speed and thus to decrease fuselage damage; however, the flaps should

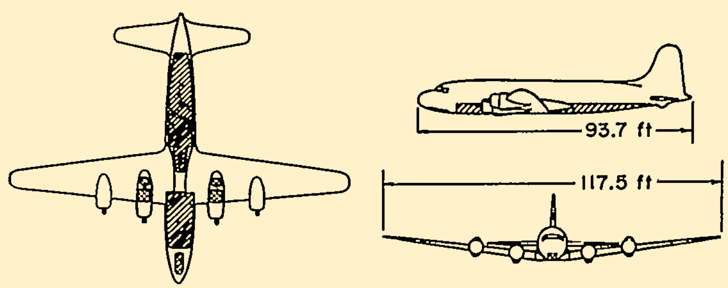
Investigators said that damage sustained by this model during ditching tests might be eliminated by installing hydro-skis on the airplane's belly.

Table 1
Summary of Model-ditching Investigation of Transport I

[Model scale, $\frac{1}{16}$; gross weight, 72,000 lb; center-of-gravity location, 28 percent M.A.C.; all values full scale]

(a) Without hydro-skis.

Damage simulated by use of scale-strength parts (hatched areas) and removal of other parts (crosshatched areas).



Landing attitude, deg	Flap setting, deg	Landing speed, knots	Length of run, ft	Maximum longitudinal deceleration, g units	Average longitudinal deceleration, g units	Motions of model (*)
Undamaged model						
2	50	98	650	2	½	h
7	50	87	600	1	½	h
12	50	79	450	1½	½	h
Damaged model						
7	50	87	200	6	1½	b
†12	50	79	250	4½	1	b

*In this column, the letters indicate the following motions:
b ran deeply—the model settled deeply into the water with little change in attitude
h ran smoothly—the model made a very stable run
†Recommended ditching attitude and flap setting.

Remarks: The damage sustained by the scale-strength sections was not severe in calm water ditchings.

Source: U.S. National Advisory Committee for Aeronautics be weak enough to fail before producing an undesirable diving moment."

- Engine installation — "In general, [jet-engine] wing-root nacelles have very little effect on dynamic behavior and will have little influence on structural damage. The strut-mounted nacelles … will probably be torn off in a ditching but will have little effect on dynamic behavior. With engine nacelles mounted under the fuselage, various effects can be expected, depending on the rigidity and the fore and aft location of the installation. If the engines are too far aft, a dive may be produced; a forward location may cause porpoising, but generally an intermediate position can be found that will produce a smooth run. Side-mounted engine nacelles will probably require the horizontal tail to be mounted high on the vertical tail. Generally, with a high tail, the rear part of the fuselage runs deeply in the water, and the nacelles cause considerable spray and drag as they enter the water. If the nacelles tear away during a ditching, extensive structural damage may result, and possibly the aft portion of the fuselage will be torn away."

- Horizontal stabilizer — "The horizontal-tail location can affect the attitude at which the airplane will run on the water. When the horizontal tail is located very high on the vertical tail, the model will … trim higher than when the horizontal tail is in a low position. Occasionally, a horizontal tail was partially torn away in the scale-model tests, but no appreciable change in behavior due to this damage was noted."

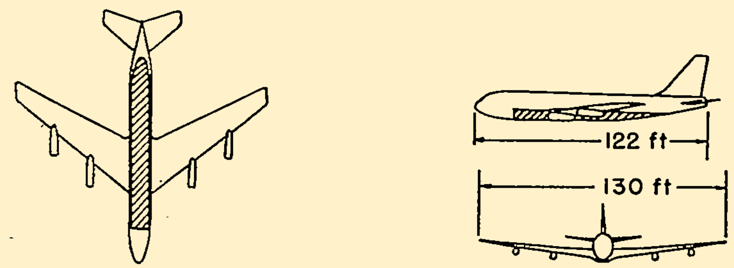
- Fuselage strength — "Most airplanes could be ditched with relative safety if extensive damage to the fuselage could be avoided; therefore, the strength of the fuselage bottom is probably the most important parameter influencing ditching behavior. It is impractical to consider designing fuselages which will not fail in ditching, but damage may be reduced by using ditching aids [e.g., a 'hydroflap' or 'hydro-ski' on the bottom of the fuselage to prevent the airplane from diving]. Transport airplanes have marginal-strength fuselages — the lower part of the fuselage sustains some damage when ditching but usually is not demolished. … Damage usually does not cause the behavior in transports to be violent, but water flooding into the fuselage through damaged sections is a hazard."

- Fuselage shape — "A high degree of longitudinal curvature [of the bottom, rear surface of the fuselage] results in a suction which causes the models to trim up in the water. … Trimming up is not necessarily detrimental

Table 2
Summary of Model-ditching Investigation of Transport A

[Model scale, 0.043; gross weight, 130,000 lb; center-of-gravity location, 26 percent M.A.C.; all values full scale]

Damage simulated by scale-strength parts (hatched area) and scale-strength nacelle struts.



Landing attitude, deg	Flap setting, deg	Landing speed, knots	Length of run, ft	Maximum longitudinal deceleration, g units	Average longitudinal deceleration, g units	Motions of model (*)
Undamaged model with scale-strength nacelle struts						
6	0	146	1,100	2½	1	s b
6	50	113	1,040	2½	½	h
9	0	127	1,090	2½	½	h
9	50	104	850	1½	½	h
12	0	119	890	1½	½	h
12	50	100	640	2	½	h
Damaged model with scale-strength nacelle struts						
6	0	146	700	6½	1½	b
6	50	113	450	6	1⅓	h
9	0	127	500	5½	1½	h
9	50	104	420	5	1	h
12	0	119	480	6½	1½	h
†12	50	100	470	5	1	h

*In this column, the letters indicate the following motions:
b ran deeply—the model settled deeply into the water with little change in attitude
h ran smoothly—the model made a very stable run
s skipped—the model rebounded from the water
†Recommended ditching attitude and flap setting.

Remarks: One or more of the nacelles were frequently torn off in a ditching but had little or no effect on behavior.

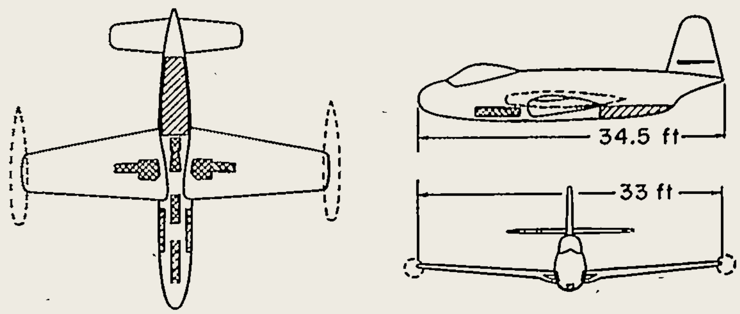
Source: U.S. National Advisory Committee for Aeronautics

Engine nacelles mounted on underwing struts were torn off when the model struck the water.

Table 3
Summary of Model-ditching Investigation of Fighter C

[Model scale, $\frac{1}{8}$; gross weight, 9,706 lb; center-of-gravity location, 31 percent M.A.C.; all values full scale]

Damage simulated by use of scale-strength parts (hatched areas) and removal of other parts (crosshatched areas).



Landing attitude, deg	Flap setting, deg	Landing speed, knots	Length of run, ft	Maximum longitudinal deceleration, g units	Average longitudinal deceleration, g units	Motions of model (*)
Undamaged model						
4	27	124	500	2	1½	u s p
8	27	107	550	1	1	u s p
12	27	97	400	2	1	u p
Damaged model						
4	27	124	200	9	3½	p d_2
8	27	107	150	10	3½	d_1
†12	27	97	100	7	4	d_1

*In this column, the letters indicate the following motions:
d_1 dived violently—the model stopped abruptly in a nose-down attitude with most of the model submerged
d_2 dived slightly—the model stopped abruptly in a nose-down attitude with the nose of the model submerged
p porpoised—the model undulated about the transverse axis with some part of the model always in contact with the water
s skipped—the model rebounded from the water
u trimmed up—the attitude of the model increased while running in the water
†Recommended ditching attitude and flap setting.

Remarks: The trimming up and diving of this model was extremely severe. The pilot should make sure that the safety harness is securely fastened in order to withstand the decelerations.

Source: U.S. National Advisory Committee for Aeronautics

Wing-tip tanks were not a detriment to ditching behavior.

but could contribute to undesirable results such as skipping and subsequent diving. A fuselage bottom with little longitudinal and lateral curvature tends to decrease trimming up but is undesirable because of the accompanying high water loads. There are indications that flattened cross sections in combination with high longitudinal curvature tend to cause skipping. … Moderately curved sections rearward of the center of gravity are desirable with respect to stability and water loads. … Curvature at the nose also has an influence on ditching behavior. A fuselage that is more or less straight on the bottom but curves up abruptly at the nose offers less nose-up moment and thus is more likely to dive than one that curves up gradually."

- Airplane size — "The physical magnitude of airplanes appears to affect the degree of violence of ditching behavior. … As the size of airplanes increases, the ditching behavior becomes less violent."

- Protuberances — "Protuberances under the wing or the fuselage of the airplane may cause undesirable ditching behavior and high longitudinal decelerations. Protuberances located rearward of the center of gravity are the most undesirable and may cause diving."

AC 25-17 said that all the NACA model tests were conducted in calm water "with the supposition that rough-water landings of particular models that were made parallel to waves or swells would exhibit the same general type of performance."

In 1959, NASA reported the results of rough-water ditching investigations conducted at the Langley facility with a 0.043-scale (approximately 1/25 scale) model of a 225,000-pound (102,060-kilogram) jet airplane that was launched into the

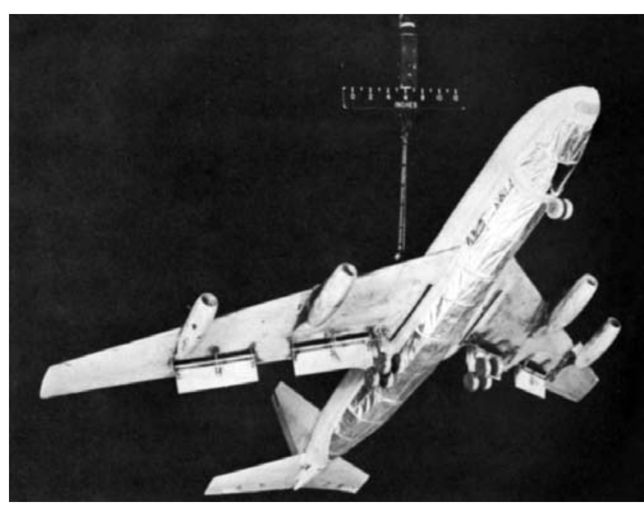
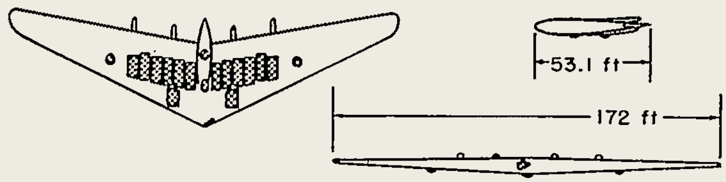


Table 4
Summary of Model-ditching Investigation of Bomber I

Model scale, $\frac{1}{20}$; gross weight, 150,000 lb; center-of-gravity location, 25 percent M.A.C.; all values full scale]

Damage simulated by removal of parts (crosshatched areas).



Landing attitude, deg	Flap setting, deg	Landing speed, knots	Length of run, ft	Maximum longitudinal deceleration, *g* units	Average longitudinal deceleration, *g* units	Motions of model (*)
Undamaged model						
9	50	111	400	--------	1½	h t p t
Damaged model						
4	50	124	500	5	1½	u p t
†9	50	111	300	5	2	u p
9	50	111	300	6	2	u p t
14	50	98	250	6	1½	b
14	50	98	250	7	1½	b t

*In this column, the letters indicate the following motions:
b ran deeply—the model settled deeply into the water with little change in attitude
h ran smoothly—the model made a very stable run
p porpoised—the model undulated about the transverse axis with some part of the model always in contact with the water
t turned sharply—the model pivoted quickly about a vertical axis
u trimmed up—the attitude of the model increased while running in the water
†Recommended ditching attitude and flap setting.

Remarks: The most pronounced ditching characteristic of this bomber model was its tendency to turn or yaw. Construction of the airplane is such that extensive damage is to be expected and it probably will be difficult to find ditching stations where crew members can adequately brace themselves and be reasonably sure of avoiding an inrush of water.

Source: U.S. National Advisory Committee for Aeronautics

The flying wing showed 'reasonably good ditching characteristics.'

face of four-foot (one-meter) waves (see photo, right).[18]

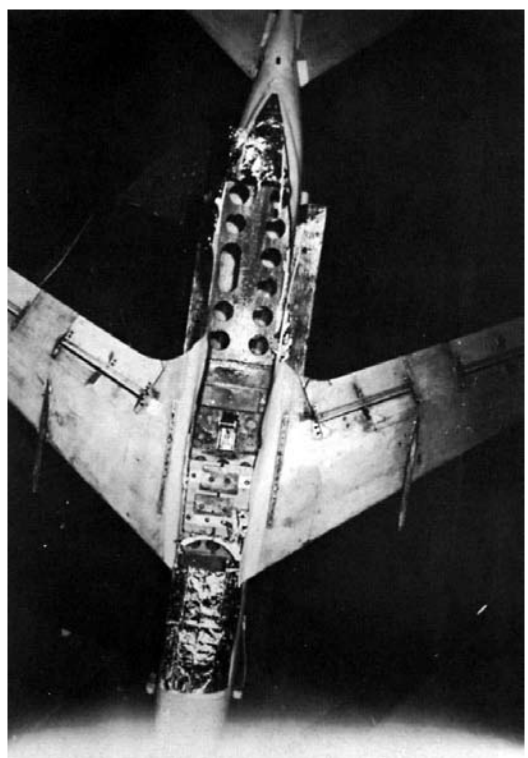
The report said that the model — which was 5.5 feet (1.7 meters) long and constructed with cardboard, wood, tinfoil, fiberglass and plastic — was "representative of the current high-speed multiengine jet transport designs."

Simulated airspeed was 120 knots, and the landing attitude was 12-degrees nose-up when the model struck the waves head-on. Data were obtained from visual observations, recorded accelerations and motion pictures.

"[The data indicated that] a rough-water ditching with the landing gear retracted will likely result in most of the fuselage bottom being torn away and the airplane sinking in a very short time," the report said. "Ditching with the landing gear extended will likely result in a dive if the main gear does not fail or in a deep run [in which the airplane moves through the water partially submerged] with appreciable damage throughout the fuselage bottom if the main gear fails."

These findings likely are one reason why the consensus among current recommended ditching procedures is that the flight crew should avoid ditching an airplane into the face of a swell (see "Prepare to Ditch," page 20). ■

Most of the lower fuselage was torn away when the model was 'ditched' into the face of four-foot (one-meter) waves.



The bottom line, in our opinion …

- **Ditching certification is an expensive and time-consuming process that some business-jet manufacturers have chosen not to pursue.**
- **Lack of ditching certification does not necessarily mean that an airplane will be unsafe in a ditching; there are requirements for structural strength and emergency exits that *all* transport category airplanes must meet.**
- **Ditching certification means, in part, that the airplane's probable behavior on impact has been investigated and that design measures may have been taken to protect passengers and to facilitate their escape.**
- **It does not mean that an airplane actually was ditched; scale models have been tested in the past, but ditching certification today is achieved mostly through computer analyses.**
- **Ultimately, the success of a ditching will depend largely on weather conditions and sea conditions, and the skill with which the flight crew lands the airplane.**
- **Rough-water ditching tests have shown that landing into the face of a swell likely will result in the bottom fuselage being torn away and the airplane sinking rapidly.**

Notes

1. U.S. Federal Aviation Administration (FAA). Federal Aviation Regulations (FARs) Part 25, *Airworthiness Standards: Transport Category Airplanes*. Subpart D, *Design and Construction*. Part 25.801, "Ditching."

2. Joint Aviation Authorities (JAA). Joint Aviation Requirements (JARs) 25, *Large Aeroplanes*. *Emergency Provisions*. JARs 25.801, "Ditching." JAA defines a large airplane as having a maximum takeoff weight of more than 5,700 kilograms/12,500 pounds.

3. FAA. FARs Part 121, *Operating Requirements: Domestic, Flag and Supplemental Operations*. Subpart H, *Aircraft Requirements*. Part 121.161, "Airplane limitations: Type of route."

4. JAA. JARs — Operations 1, *Commercial Air Transportation (Aeroplanes)*. Subpart B, *General*. JAR-OPS 1.060, "Ditching."

5. Travis, Tim. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. April 17, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

6. Pierce, Michael. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. May 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

7. FAA. FARs Part 25. Subpart D. Part 25.807, "Emergency exits." Part 25.807(d) says, "Whether or not ditching certification is requested, ditching emergency exits must be provided." The requirements include the following: An airplane with fewer than 10 passenger seats must have one exit above the waterline on each side of the airplane; an airplane with 10 or more passenger seats must have one exit above the waterline for each 35 passenger seats and at least two exits, with one on each side of the airplane.

8. Baugniet, Robert. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. Aug. 11, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

9. Pellegrini, Georges. Facsimile communication with Lacagnina, Mark. Alexandria, Virginia, U.S. April 29, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

10. Fergus, Mike. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. April 16, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

11. U.S. Civil Aeronautics Administration. Civil Air Regulations Part 4b, *Airplane Airworthiness; Transport Categories*. Subpart D, *Design and Construction*. Part 4b.361, "Ditching."

12. Bottcher, Andrea. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. June 19, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

13. U.S. National Transportation Safety Board. Accident Report, *Eastern Air Lines, Inc., Lockheed L-1011, N334EA, Miami International Airport, Miami, Florida, May 5, 1983*. NTSB/AAR-84/04.

14. Knaapen, Leo. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. July 3, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

15 Russell, Paul. Interview by FSF editorial staff. Alexandria, Virginia, U.S. May 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. As a U.S. Coast Guard officer, Russell conducted more than 200 water landings and served in various positions, including commander of two air stations, chief of the Aviation Training Center Training Division and chief of search-and-rescue operations in the Northwest Region, before retiring in 1984 with the rank of captain and beginning his career with The Boeing Co. Russell also is a maritime safety and accident investigator for Safety Services International.

16. Cohen, Bob. Interview by Lacagnina, Mark. Alexandria, Virginia, U.S. May 5, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

17. Fisher, Lloyd J.; Hoffman, Edward L. U.S. National Advisory Committee for Aeronautics Report 1347, *Ditching Investigations of Dynamic Models and Effects of Design Parameters on Ditching Characteristics*. November 1956.

18. Thompson, William C. U.S. National Aeronautics and Space Administration Technical Note D-101, *Rough-water Ditching Investigation of a Model of a Jet Transport With the Landing Gear Extended and With Various Ditching Aids*. October 1959.

Accident Experience Influences Helicopter Overwater Operations

Real-life experiences in the North Sea and the Gulf of Mexico show the value of appropriate equipment and realistic training.

— FSF EDITORIAL STAFF

Various helicopter water-contact accidents have revealed lessons learned about survival — or nonsurvival — of passengers and crewmembers (see "Imagine the Worst Helicopter Ditching — Now Get Ready for It," page 85).

For example, a March 1992 accident in the North Sea involved an Aerospatiale (now Eurocopter) AS 332L Super Puma equipped with headsets with quick-release jack-plugs for each passenger; windows modified for use as emergency exits; emergency exit illumination system (EXIS) lights around every door; two 14-person life rafts (one in a valise mounted across the right door frame, one in a box structure beneath two seats); a manually activated emergency flotation system comprising four flotation bags; and an automatic deployable emergency locator transmitter (ADELT).[1]

The helicopter struck the sea following a takeoff from an oil platform in winds gusting 50 knots to 58 knots, heavy showers of hail and snow, temperature of zero degrees Celsius (32 degrees Fahrenheit) and vertical visibility of 1,200 feet (366 meters). The sea temperature was 7 degrees Celsius (45 degrees Fahrenheit) and the wave height was estimated to be eight meters to 11 meters (26 feet to 36 feet). One of the two pilots and five of the 15 passengers survived; the aircraft was destroyed.

Causal factors were: "The [commander's] failure to recognize the rapidly changing relationship between airspeed and groundspeed, which is a fundamental problem associated with turning downwind in significant wind strengths. The commander, who was the handling pilot at the time … inadvertently allowed the airspeed and then the height to decrease while turning away from a strong gusting wind. Despite the application of maximum power, the helicopter was incapable of arresting its established descent within the height available. Incipient vortex-ring state and downdrafts may have contributed to this problem, as may the height of the wave crests. Several human factors, including possibly some fatigue and frustration, exacerbated by a demanding flying program in which the commander was managerially responsible, may have degraded the crew's performance to an extent that the normal safeguards of two-crew operation failed."

The report said that wreckage indicated that the mounted life raft probably had been released manually by a passenger; the emergency flotation system had been armed but the flotation bags were not inflated by the crew before impact. The ADELT deployed and activated (see "The Search-and-rescue System Will Find You — If You Help," page 111). Although the EXIS lights were serviceable, "most of the survivors had not noticed the EXIS lights around the cabin exits," the report said. The one life raft that was deployed apparently inflated satisfactorily, but severe damage occurred before and after rescue. Several survivors who had been clinging to the life raft said that it had received considerable damage, especially to the floor, during the initial deployment.

All Deaths Attributed to Drowning

The report said that all deaths occurred as a result of drowning and that, in some cases, drowning occurred after the onset of hypothermia (see "Is There a Doctor Aboard the Life Raft?" page 187).

> "All the injuries, both for survivors and the deceased, were superficial and slight to the extent that they should not have affected the ability of an individual to escape from the helicopter," the report said. "After impact, the helicopter rapidly adopted a right-side-down attitude and then became fully inverted before it sank. It was not possible to determine a precise time for this, but it is thought to have taken only a minute or two. The flight deck and cabin suffered relatively minor disruption in the impact with the sea, but all of the escape windows on the right side of the cabin were ejected and the right cabin door suffered distortion, which caused it to detach. The escape windows and the cabin door on the left side remained in position. The impact came without warning, and there was no evidence to suggest that all the occupants were other than in their seats with their harnesses properly fastened. The commander escaped from the aircraft via the right flight deck door window and came to the surface to see the copilot close by; it was not possible to determine how the latter had escaped. Water ingress to the cabin was rapid and, although the survivors who had been seated to the rear reported that they had time to take a deep breath of air, those at the front did not escape through the right-front escape window; S1 [survivor no. 1] and S5 exited through the escape window apertures nearest their seats; S2 removed the left-front escape window and exited through it, and S4 removed and exited through the escape window next to his seat on the left side. NS2 [nonsurvivor no. 2] was seen by S5 to leave through the escape-window aperture just behind his seat. Positive identification of the escape route of the other four [nonsurviving] passengers was not possible. … Five occupants did not escape from the cabin and were later recovered from the seabed. … All five occupants had released their seat belts and appeared to be in the process of escaping. The five passengers who did not escape were probably conscious after the impact because they had released their seat belts. … However, the predicted breath-holding time in the conditions prevailing was less than 20 seconds; this was probably the limiting factor in the case of the four occupants who were not apparently physically impeded in their attempt to escape.
>
> "One, NS5 … was found with the cord of an acoustical headset wrapped tightly around his neck. The quick-release jack-plug had failed to separate because it had been jammed into the seatback by the seat-headrest support. At what stage this entanglement occurred could not be determined. The life raft in the right cabin door was released from its stowage, probably by a passenger, shortly after the door had opened on impact; it started to inflate almost immediately, the inflation probably being initiated by the short [mooring/inflation line]. It suffered major damage, particularly to the floor, as a result of contact with parts of the helicopter. It did, however, inflate at least partially and provided support for some of the survivors.

"Both crew and passengers S1, S3, S5 and NS6 were known to have been at, or in the vicinity of this life raft. At an early stage, S1 attempted to assist NS6 into the life raft; the attempt was unsuccessful, and NS6 drifted away from the area. Because it was so badly damaged, the life raft was extremely unstable in the water and overturned on several occasions. On one [occasion], S3 was thrown into the sea and was unable to swim back to [the life raft]; the cord which retained the life raft survival [equipment] pack had wrapped around his leg and consequently became detached from the life raft and drifted away with him.

"Shortly after escaping on the left side, S4 found that he was very close to two other passengers; one, apparently dead. He later identified him as NS4, and he linked himself with the other, NS3. He could see the life raft inflated on the far side of the helicopter but was unable to get into it. The life raft stowed under seats … adjacent to the left cabin door was not deployed, and those who escaped from the left side were unable to get to the other life raft mainly because of the prevailing weather conditions and the fact that the fuselage was initially between them and it. … On this occasion, the standby vessel [which is required to be within five nautical miles (nine kilometers) of a manned offshore installation and normally moves close to the platform during helicopter takeoffs] was standing off by about 1.5 nautical miles [2.8 kilometers] and was unaware of the [accident] helicopter movement. … None of the survivors reported any problem with [life vest] operation although it was noted that [the life vests] tended to ride up the body, even when [they] had been correctly fitted. All the survivors reported difficulty deploying the spray screen [face shield]. … Of the five passengers who escaped but did not survive, NS4 and NS3 appeared to be floating normally with their [life vests] inflated; NS5 was floating face-down with his [life vest] deflated due to a tear in the buoyancy chamber, and NS1 and NS2 were floating upright with the inflated [life vest] having ridden up to such a degree that their faces were under the water. Of those who failed to escape, none had inflated their life [vests].

"Their survival equipment … functioned effectively for them to have remained alive and conscious in the prevailing conditions."

"The crew wore … crew [cold-water immersion] suits which appeared to have performed satisfactorily. The copilot's suit was [past] its servicing date, but there was no evidence to suggest that this in any way contributed to his nonsurvival, but inadequate clothing worn under the suit may have contributed to the eventual onset of hypothermia. The … passenger [immersion] suit was worn by all the passengers. The majority appear to have been correctly fitted, with the central zip up to at least three inches [eight centimeters] from the top. Evidence suggested that a majority also had the hood up when the accident occurred.

"None of the survivors reported feeling particularly cold, nor did any report difficulties with water entering the suit. None managed to extract and put on the gloves, and, although some managed to fit it, the strobe light kept falling off its Velcro attachment on top of the hood. The suit worn by NS2 was the only one which was positively identified as having taken in a significant amount of water; the suit was partially unzipped, but it was not possible to determine if it had been like this at the time of impact.

"The copilot was known to have survived for a considerable time, during which he was reported to have made every effort to maintain the morale of his fellow survivors. He eventually drifted away from the life raft; it is probable that he had succumbed to hypothermia and subsequently drowned. The five passengers who survived were in the water for between 40 minutes and one hour, 25 minutes. Their survival equipment must be considered, in general, to have functioned effectively for them to have remained alive and conscious in the prevailing conditions. One of the major problems experienced by the survivors, and no doubt by those who did not survive, was being swamped by water breaking over their heads. The effectiveness of the [life vest] spray hood in alleviating the problem cannot be assessed [in this accident] as none of the survivors managed to deploy it."

Survivors Recall Experiences

The following excerpts from interviews with two of the passengers who survived this accident show some of the specific difficulties that have been experienced in surviving a helicopter accident involving uncontrolled/inadvertent impact with cold water:[2]

- "Survivor A had been sitting in the foremost starboard seat in the cabin and had been aware shortly before impact that the aircraft was going to hit the sea. … Survivor B was in seat 12, aft of the door, and had no sensation of descending until the aircraft hit the sea. … In the event, the force of impact burst the window inwards, and after releasing his harness without difficulty, [Survivor A] was able to grasp the outside of the aircraft through the window aperture and lever himself out. … The first indication [to Survivor B] was a bang and the ingress of water at the rear of the cabin. The water was up to his chest in a matter of seconds, but he had time to take a couple of deep breaths before becoming immersed. He lunged for the nearest exit, which had fortunately blown in, but was restrained by his seat belt, which he had forgotten to release. While he was undoing [the seat-belt release], two others went out of the same exit, and he then followed them. He did not see any [exit] lighting, but it was reasonably bright under water and he was wearing safety glasses (which he lost going through the exit);

- "Having reached the surface, Survivor B inflated his [life vest] and initially went to the undercarriage of the inverted helicopter, which was still protruding above the surface. Fearing that he would be trapped under it, he then made his way to the damaged and partially inflated life raft, which Survivor A had already boarded. … Very soon, the [life] raft was overturned by a wave, and [Survivor A] found himself back in the water with his leg entangled with the rope securing the [life raft] survival [equipment] pack. He was freed from this by Survivor B but then lost contact with the [life] raft and the other survivors. Survivor B, together with three others (the two aircrew and another passenger) remained with the [life raft] and, after [the mooring/inflation line] had been released from the helicopter, they spaced themselves evenly around its circumference, rendering it fairly stable in the heavy sea. Survivor B managed to climb onto the inflated [life raft] and clung there until rescued;

- "Back in the water, [Survivor A] found that the [life vest], which had no crotch strap, tended to ride up until it was tight under his chin and armpits. He was obliged to maintain a continuous paddling motion with his arms in order to keep his head above water. [He] had the clear impression that if at any time he raised his arms, the [life vest] would have slipped up over his head and been lost. He managed to place the strobe light on his head, where it remained secure until his rescue. Survivor B did not experience the same difficulty with his [life vest], as he was not dependent on it for buoyancy. His strobe light was serviceable, but … it was washed away by the first wave;

- "Although he had not been aware of cold during his escape from the aircraft, once back in the water, Survivor A began to suffer badly from the cold. His hands became numb and useless, and he was unable to put on the gloves from his [immersion] suit. He found that he was facing downwind and had to battle constantly to surmount the waves which approached him from behind, often without warning. His vision was restricted to a narrow slit between the bottom of his hood and the top of his [life vest] and [immersion] suit. He smelled and saw a [rescue] helicopter, which then departed, and was occasionally able to see other survivors downwind when they happened to be at the top of a swell; [and,]

- "Survivor B was not aware of being cold for the first half hour, but his hands were numb and he was obliged to cling to the [life] raft with his arms. He and his companions experienced increasing distress at the apparent lack of rescue efforts, and this had a particularly adverse effect on one of the aircrew who was still in the water and who eventually died. The other passenger was swept away (but survived). For the last 10 or 15 minutes, Survivor B was on his own

"… His hands were numb and he was obliged to cling to the [life] raft with his arms."

In some water-contact accidents during takeoff or approach to an offshore oil platform, helicopter occupants had less than a one-minute warning before impact.

and was beginning to get very demoralized; he sensed the onset of hypothermia [Survivor A was hauled aboard a vessel with ropes; Survivor B was winched into a helicopter]. Both [had been] fortunate enough to be close to open escape hatches through which they were able to make their exit within a few seconds of impact. It is significant that both [were] strong and confident swimmers who were able to remain clear-headed and in control of their breathing when under water, both in the initial evacuation from the aircraft and subsequently during their frequent immersion under heavy waves."

Speed of Capsizing Allows Moments to Take Action

The following accidents also illustrate the survival challenges:

- In 1997, the crew of a Sikorsky S-76B had begun a second approach to a North Sea production platform when the helicopter "lost almost all forward speed and entered a steep descent towards the sea." The pilot's application of collective control and power could not prevent the helicopter from entering the water. The helicopter almost immediately rolled right to an inverted attitude, and water entering through a broken door window rapidly filled the cabin. The two crewmembers and all six passengers — wearing immersion suits and life vests — were able to evacuate the helicopter. They inflated their life vests and initially climbed onto the belly of the helicopter. The helicopter sank about 10 minutes after it struck the water. All occupants then stayed together while waiting approximately one hour for rescue. Water entered their immersion suits during the wait. One passenger was unconscious when rescued by the crew of a supply vessel, which was guided by helicopters circling the survivors. The passenger later died. The emergency flotation system was not armed when the helicopter struck the water, the accident report said. "The helicopter hit the water unexpectedly," the report said. "It is therefore doubtful if in this case — even if the 'Floats Armed' switch had been in the 'ARMED' position — the crew would have come to the point to activate the [emergency flotation system]. … It is understandable that the helirafts [life rafts that can be used with either side up in the water] were not used, given the time available and the necessary and rather cumbersome actions required to get the life rafts outside the helicopter. … In this case, a greater awareness of the existence and use of available survival assets could have shortened the time of immersion in the water, and better knowledge and use of the available personal survival equipment could have decreased the amount of body cooling";[3] and,

- During a flight to an offshore oil platform in the Gulf of Mexico, a pilot encountered deteriorating weather and conducted a series of orbits to wait for the thunderstorms and squalls to pass. During one orbit at about 1015 local time, the aircraft was struck by a 15-foot [five-meter] swell and rolled into the water. The accident report said, "All three occupants were able to extricate themselves, swim to the surface and inflate their life vests. The passengers stated [that] they all signaled to each other that they were not seriously injured; they then joined up and stayed together. … According to the passengers, the aircraft continued to float for about five to six hours, during which time one of them attempted unsuccessfully three times to retrieve the life raft from inside the aircraft. The passenger did retrieve another life vest which he gave to the pilot for additional [flotation] support. The passengers stated that it was during this time that the pilot stated, 'I'm sorry, fellas, we had a chance to land and we didn't.' He also said that he thought everything was 'all over for [him] anyway.' The passengers told him that they were all 'OK' and that they needed to concentrate on survival. After the aircraft sank, one of the passengers decided to attempt to swim to the … platform, which was estimated as being about two miles away. Shortly thereafter, the second passenger began swimming toward the platform; however, the pilot elected to float and await rescue. The first passenger reached the unmanned platform about three hours after setting out and was able to [call] his office. The passenger on the platform was rescued by a [U.S.] Coast Guard cutter about 1926, and the second passenger was recovered [rescued] by a work boat about 1935. The same work boat spotted the unconscious pilot face down in the water about 0128 the following morning. During the attempted recovery, the pilot's life vest came off and he sank below the surface."[4]

Time Until Rescue Varies From Minutes to Hours

Many different causes of helicopter water-contact accidents have been determined in accident reports. For example, European offshore helicopter accidents from January 1968 to December 2000 included 19 fatal accidents, of which 13 were accidents other than ditchings and one — in 1973 — was a ditching. The other water-contact accidents involved striking the water in the following circumstances: loss of control after mechanical failure, uncommanded descent into water in adverse weather, in-flight collision with structure, failure of main-rotor transmission, failure of tail-rotor transmission and tail rotor, loss of power, pilot disorientation in low-visibility conditions, fracture of main-rotor blade and tail-rotor failure.[5]

The report by the U.K. Health and Safety Executive said, "One hundred nineteen people died on their way to or from installations in 11 [of the 19 accidents] that occurred during the cruise phase. The helicopter crashed into the sea in all but one case [that occurred over land]." The same cruise-phase data showed 30 survivors among the 119 people on these helicopters.

"There have been 24 deaths from seven fatal accidents offshore at an installation or within the 500-meter [1,641-foot safety] zone," the report said. The same near-installation data showed that three of the fatalities were helideck crewmembers and that there were 22 survivors among the 43 people on these helicopters.

A 1995 report by the U.K. Civil Aviation Authority said that water-contact accidents in the U.K. sector of the North Sea during an 18-year period generally involved either ditchings in which all helicopter occupants survived, uncontrolled/inadvertent impacts with water, controlled descents into a rough sea or helicopters falling off a helideck.[6]

"From 1976 to 1993, the [U.K.] offshore industry has generated 2.2 million helicopter operating hours in the carriage of some 38 million passengers, for the loss of 85 lives in eight fatal accidents [four of which were considered nonsurvivable and one of which accounted for more than half of the total fatalities], representing a fatality rate of 3.86 per 100,000 flying hours," the report said. "The total of 19 deaths in the four survivable accidents represents a theoretical maximum number of lives that might possibly have been saved through the perfect functioning of the safety and survival system. … This would equate to an average of about one life per year. … Of greatest interest to [this study] are the seven survivable impacts with water [four resulting in deaths] and 11 ditchings [in which all occupants survived], representing event rates of 0.29 and 0.46 per 100,000 flying hours. One conclusion that can be drawn from this is that, since there is no vast difference in the likelihood of either eventuality, it would not be reasonable to optimize safety measures entirely in favor of one at the expense of the other, for example, in the cases of helicopter flotation [only manual deployment vs. manual/automatic deployment] and life raft deployment [interior stowage vs. exterior stowage]."

An analysis of U.S. civil rotorcraft accidents from 1963 through 1997 found that 3.5 percent of autorotative-accident landings involved ditching.[7]

In 1998, about 8,300 offshore helicopter flights per day were being conducted in the oil and gas industry, with an average length of 20 minutes, representing 87 percent of all helicopter hours flown worldwide. Industry data showed that 11 accidents (including six fatal accidents) and 35 fatalities (22 fatalities in one midair collision involving two helicopters) occurred in 1998 in offshore operations, representing 1.07 accidents per 100,000 flight hours.[8]

A review of U.S. National Transportation Safety Board reports on 24 water-contact helicopter accidents in the Gulf of Mexico from January 1993 to August 2003 found a variety of probable causes. These included the pilot's failure to maintain clearance from the ocean for unknown reasons; entanglement of part of a skid with a helideck hatch-door handle; inadequate maintenance leading to in-flight loss of control; loss of engine power; loss of tail-rotor effectiveness during a low-speed right-turn maneuver; internal engine fire; fuel exhaustion; fuel contamination; fuel starvation; failure to maintain yaw control; failure of the rotor-tachometer generator; failure to maintain proper main-rotor speed; tail-rotor-blade strikes that severed the aft portion of a tail boom; in-flight collision with another helicopter; tail-rotor-blade separation; and failure to release tiedowns before takeoff.

Preliminary information for seven other helicopter accidents for which final reports were not available indicated that they involved factors such as loss of control, loss of engine power, collision with water during a course reversal and striking an object on an oil platform.

Among all 31 accidents, reported altitudes above the water at the beginning of the accident sequences ranged from 150 feet to 2,000 feet. Helicopters struck the ocean in uncontrolled descents, controlled flight or falls from platforms in eight of the accidents. The pilot conducted an autorotation in 17 accidents and deployed the emergency flotation system in 10 accidents. In another accident, the tail rotor struck a five-foot [two-meter] wave after the pilot conducted a precautionary landing on the water, resulting in separation of the tail-rotor drive shaft.

Helicopters rolled to an inverted position (or struck the water while inverted) in 19 of the accidents and sank in nine of the accidents. In three accidents, the force of impact damaged or deflated part of the flotation system. Life rafts were used by occupants in four accidents, and an emergency breathing device was used by a pilot in one accident.

When reported, the elapsed time for survivors to be rescued ranged from "immediately" to nine hours. In one accident, a 26-hour search was suspended when the accident site could not be found. In another accident, the search was suspended after six days, and the aircraft wreckage was found 18 days later when it became entangled in the shrimp net of a boat. ■

The bottom line, in our opinion …

- **Get your first underwater-escape experience in training — not in an accident.**
- **Every second counts if underwater escape is required: Predicted breath-holding time in frigid water is less than 20 seconds.**
- **Even while floating in a cold-water immersion suit and/or life vest, breathing will be difficult during immersion by heavy waves.**
- **Make decisions about equipment and training based on how frequently people fly over water.**

Notes

1. U.K. Air Accidents Investigation Branch. *Report on the Accident to AS 332L Super Puma, G–TIGH, Near the Cormorant 'A' Platform, East Shetland Basin, on 14 March 1992.* April 26, 1993.
2. U.K. Civil Aviation Authority (CAA). *Report of the Review of Helicopter Offshore Safety and Survival.* Annex D, "Evidence From Cormorant Alpha Survivors." Civil Aviation Publication (CAP) 641. February 1995 (reprinted May 2002).
3. FSF Editorial Staff. "Helicopter Downed in North Sea After Lightning Strike Exceeds Lightning-protection System Capabilities." *Helicopter Safety,* Volume 24 (January–February 1998).
4. U.S. National Transportation Safety Board. Accident report no. FTW94LA021. Oct. 29, 1993.
5. Morrison, Graham. *Helicopter Safety Offshore.* U.K. Health and Safety Executive Offshore Technology Report 2000/089. 2001.
6. U.K. CAA. *Report of the Review of Helicopter Offshore Safety and Survival.* CAP 641.
7. Harris, Franklin D.; Kasper, Eugene F.; Iseler, Laura E. "U.S. Civil Rotorcraft Accidents 1963 Through 1997." U.S. National Aeronautics and Space Administration Report no. NASA/TM–2000–209597. December 2000.
8. International Association of Oil and Gas Producers. "Safety Performance of Helicopter Operations in the Oil and Gas Industry, 1998." Report no. 6.83/300, December 1999.

Imagine the Worst Helicopter Ditching — Now Get Ready for It

You're upside down, it's dark, the helicopter is full of water and you're holding your breath. Not all helicopter ditchings result in this demanding scenario, but to maximize the odds of your survival, you must be prepared.

— FSF EDITORIAL STAFF

Even helicopter operators that do not fly routinely over open water should ensure that crews are current in aircraft-specific methods for ditching with an emergency flotation system and for ditching without an emergency flotation system, and for surviving an uncontrolled descent into water during flight over rivers, lakes and coastal areas, international specialists said. Most overwater-survival systems for helicopter operations are designed for the known threats of a ditching — in which physical forces and human behavior are relatively predictable — but may not be adequate for uncontrolled/inadvertent impact with water or controlled descent into a rough sea.

The U.K. Civil Aviation Authority (CAA) has defined ditching as "a deliberate emergency landing on water." A helicopter ditching could be required for various reasons, including engine failure or a catastrophic in-flight problem — such as very low fuel or impending main-rotor transmission failure — that makes continued flight too hazardous.

Training prepares pilots to complete ditching procedures that enable all occupants to evacuate directly from an upright cabin to a life raft in many situations. Some scenarios after touchdown can be panic provoking, especially among untrained occupants who must hold their breath in an inverted helicopter, wait for the cabin to flood, release restraints and find and operate exits using memorized handholds and a few rows of lights in total darkness.

Some scenarios after touchdown can be panic provoking.

Complicating all ditching scenarios in helicopters are two contradictory survival requirements: evacuating as quickly as possible because of the tendency of helicopters to roll, capsize and rapidly sink; and waiting inside the cabin until rotors have been stopped so that the blades do not strike and kill survivors. The risk to survivors also increases in a water-contact accident in which neither the aircraft emergency flotation system nor life rafts are deployed, one accident report said.[1] Because of these unpredictable risks, pilots must control as many of the variables as possible.

"It is difficult to explain the apparent reluctance of some pilots to ditch their helicopter in case of emergency," said a U.S. Army training document. "It may [result from] the subconscious knowledge that the aircraft will most likely be a total loss, or fear of getting trapped. Based on actual experience, the ditching of a helicopter definitely presents much less of a problem, impact-wise, than a landing on very rough terrain or in high trees. If there are any problems, they are mainly self-imposed ones in the form of a premature evacuation of the occupants (before the main rotor has stopped) and failure to have all doors open at the time of water entry. … If it becomes absolutely necessary to make a landing over water, the pilot should make every effort to land as close to the shore as possible."[2]

When conducted correctly, a ditching with an emergency flotation system — with power or without power — presents the least risk of drowning or other injury to aircraft occupants who have been equipped and trained for this scenario. Occupants of the helicopter typically would deploy and directly board a life raft to wait for assistance. A power-off ditching and an emergency flotation system that cannot be activated or fails to activate properly typically presents the greatest risk of drowning or injury to aircraft occupants, even when they have been equipped and trained for ditching.

"U.S. commercial helicopters beyond gliding range of shore are required to have emergency flotation systems, life vests and life rafts; in an emergency, pilots normally would inflate the flotation bags and try to land on the water — either a normal landing or an autorotative landing," said Joel Harris, assistant director of standards for quality assurance, FlightSafety International. "When this has happened in the Gulf of Mexico, the system typically keeps the aircraft out of the water for a time while the U.S. Coast Guard sends a boat. If the aircraft does not have this system or the flotation bags do not inflate, the pilot first wants the rotors to stop turning — which requires rolling the aircraft so that the blades stop or break off."[3] Harris holds an airline transport pilot certificate and a flight instructor certificate with ratings in helicopters and airplanes. He has served as a U.S. Federal Aviation Administration (FAA) designated pilot proficiency examiner, a U.S. Federal Aviation Regulations (FARs) Part 135 check airman and a safety counselor. He has administered more than 10,000 hours of flight, simulator and ground school training to professional pilots.

Survival in helicopter water-contact accidents often is possible because of the relatively low speed of impact and the occupant protection provided by seats and restraint systems. Nevertheless, crewmembers and passengers expect that after surviving the impact, they could face other life-threatening challenges. In some operating environments, the risks of hypothermia and drowning must be managed by wearing cold-water immersion suits (also known as survival suits, exposure suits, helicopter passenger suits, aircrew immersion suits and helicopter offshore transport suits; see "Is There a Doctor Aboard the Life Raft?" page 187). Transport Canada said that "[an immersion suit] system reduces thermal shock upon entry into cold water, delays onset of hypothermia during immersion in cold water and provides some flotation to minimize risk of drowning, while not impairing the wearer's ability to evacuate from a ditched helicopter."[4] (See "Cold Outside, Warm Inside," page 357.)

Stopping Rotor Blades Precedes Evacuation

"Ditching a helicopter can be done with little or no groundspeed, which should decrease the resultant decelerative violence," said the U.S. National Search and Rescue Committee. "However, without built-in flotation, the helicopter will sink so rapidly that timely evacuation becomes a major problem. The danger is compounded because the evacuation cannot be started until rotating components have come to a stop, by which time cabin spaces are filling or are filled with water."[5]

Ditching scenarios might include any combination of the following:

- A helicopter without hull-flotation equipment has engine power, but the pilot anticipates a problem such as fuel exhaustion or transmission failure. Life rafts are deployed, and all occupants (except the pilot flying) enter the water as the helicopter is flown in a normal hover at three feet to five feet (1 meter to 1.5 meters). Those in the water inflate their life vests and board the life rafts. The pilot hover-taxis approximately 50 yards [46 meters] downwind and ditches the helicopter, a scenario that creates a risk that the pilot will be unable to reunite with other survivors. Ditching the helicopter away from other survivors in the water reduces the risk of injury to the other survivors from rotor blades and capsizing;

- A helicopter without hull-flotation equipment has inadequate engine power for continued flight. The pilot conducts an autorotative landing; the rotor blades are stopped; the crew deploys the life raft; the occupants evacuate after the cabin has filled with water; and all occupants board the life raft;

- A helicopter with hull-flotation equipment has engine power, but the pilot anticipates a problem such as fuel exhaustion or transmission failure. The pilot lands the helicopter, which remains afloat and upright. The crew deploys the life raft, and all occupants evacuate directly into the life raft as soon as the rotors stop turning; or,

- A helicopter with hull-flotation equipment has inadequate engine power for continued flight. The pilot conducts an autorotative landing, and the helicopter remains afloat and upright. The crew deploys the life raft and all occupants evacuate directly into the life raft as soon as the rotors stop turning.

The pre-takeoff briefing, typically conducted by the pilot, should include the exact method of fastening and unfastening restraints, the location and use of flotation equipment and survival equipment such as pyrotechnic signaling devices, how and when the aircraft would be evacuated in a ditching, the location of normal exits and emergency exits, and the methods of opening the exits.

"For FARs Part 135 [commuter and on-demand operations], the rules require the pilot to conduct a briefing of passengers prior to flight, demonstrating and explaining the use of all safety devices and equipment such as shoulder harnesses, emergency exits, life vests and life rafts," said Sharon Miles, an aviation safety engineer in the FAA Rotorcraft Directorate.[6] "FARs Part 91 [general operating rules] also requires a passenger safety briefing by the pilot."

"The evacuation cannot be started until rotating components have come to a stop."

Because installed equipment can vary even among similar models in an operator's fleet, each briefing should be tailored to provide thorough information on the specific equipment available for the helicopter that will be flown.

"Typically, when life rafts are part of the overwater emergency equipment, they are stored inside the helicopter in the United States," Miles said. "FAA also has approved some life rafts that are installed on the skids and can be deployed from inside the cabin." Door compartments and storage pods attached to the side or underside of the fuselage also are used, and FAA requires all types to be deployable from inside the aircraft, she said.

Beyond preflight briefings, specialized training can improve the likelihood that passengers will survive a ditching. Some helicopter operators require passengers to receive emergency training, although this is not required by some civil aviation authorities such as FAA, Transport Canada and U.K. CAA.

"All occupants remain strapped in their seats until cabin spaces have filled with water."

"For example, when Gulf Coast employees of an oil company fly regularly as helicopter passengers, the company often requires helicopter overwater-safety training for the employees," Miles said (see "Train to Rise to the Top," page 378).

U.S. Army safety-training documents contain the following general ditching procedures, which are based on actual ditching experience in single-main-rotor helicopters without emergency flotation systems.[7]

- "If possible, prior to water contact, jettison doors that open outward. Cabin doors that slide should be opened or windows removed. Care must be taken when jettisoning doors to preclude damage to the main-[rotor blades] or tail-rotor blades;

- "A normal landing should be made at zero groundspeed into the wind and [at a] minimum rate of sink. Excessive tail flare should be avoided; premature water contact of the tail rotor may result in loss of anti-torque control before the main fuselage settles in the water. In the event of ditching due to anticipated fuel starvation or for any reason when ditching is imminent but not immediate, much can be done to protect personnel and survival gear if planned ditching procedures are established and followed. In a planned ditching, the helicopter should be hover-taxied approximately 50 yards [46 meters] downwind after the [passengers,] crew and equipment have been evacuated. A hovering autorotation should then be accomplished to attain minimum rotor speed upon contact with the water. Under any ditching conditions, water spray may reduce visibility;

- "Main-rotor brake (when available) should be applied and the aircraft kept level while rotor [revolutions per minute (rpm)] decreases. As the fuselage settles in the water, [collective] pitch should be pulled until the aircraft tends to roll. At [that same] time, cyclic should be applied in the same direction so water contact will stop the main rotor without violent reactions or flipping the aircraft in the opposite direction. If one side of the aircraft provides better exits, the helicopter should be rolled in the opposite direction [away from the side with better exits] before effective rotor control is completely lost; and,

- "It is important that all occupants remain strapped in their seats until cabin spaces have filled with water. This prevents being swept around inside the cabin with in-rushing water. Each occupant must identify and hold on to a reference until the aircraft has submerged. This minimizes disorientation with respect to the nearest exit, regardless of aircraft attitude after submersion. [Life vests] should not be inflated until positively clear of the aircraft."

The FSF *Helicopter Flight Crew Ditching Checklist* (page 89) is intended as a framework for further discussion of ditching procedures. The checklist was assembled from basic procedures recommended by several helicopter operators, training specialists and water-survival specialists. The focus of the checklist is on float-equipped helicopters that remain afloat following ditchings during offshore operations, but the information also is useful to corporate operators, on-demand operators and others who conduct overwater flights in helicopters.

Passengers Must Prepare Themselves

The time available to prepare for helicopter impact was longer than five minutes in some ditchings, but was less than one minute in others. Because helicopter overwater operations typically are conducted without a flight attendant aboard, passengers must prepare themselves for a ditching. The FSF *Helicopter Passenger Ditching Checklist* (page 90) is intended as a framework for discussion of procedures that will help passengers fend

Continued on page 91

Flight Safety Foundation
Helicopter Flight Crew Ditching Checklist
(Offshore Operations)

Fly the aircraft.

Preliminary

- Transmit a "mayday" and intentions to ditch; select transponder code 7700.
- Maintain the minimum specified torque value.
- Turn into the wind.
- Select the landing area.
- Maintain airspeed for minimum rate of descent.
- Maintain the landing gear up.

Preparation

- Arm the emergency flotation system per flight crew operating manual (FCOM).
- Landing light, as required.
- Emergency lights, as required.
- Tell passengers not to inflate life vests until clear of the aircraft.

Before Ditching

- Manually deploy the emergency flotation system per FCOM.
- Command/signal "brace."
- Reduce groundspeed, drift and rate of descent to a minimum.
- Gently lower the collective after touchdown.

After Ditching

- Shut down the engine(s).
- Apply the rotor brake with great caution (if equipped).
- Announce on the radio frequency in use that the helicopter has been ditched and evacuation has begun.
- Deploy and/or confirm activation of the automatic deployable emergency locator transmitter (if equipped).
- Jettison the doors (if equipped).
- Arm and deploy life rafts when main-rotor blades have stopped.
- Confirm life raft deployment.
- Evacuate passengers, and exit with specified emergency equipment.
- Conduct roll call.
- Cut the mooring/inflation line, as appropriate.
- Confirm that the life raft emergency locator transmitter is activated (if equipped).
- Initiate survival procedures with life rafts or without life rafts as required by conditions.

Note: This information, which focuses on helicopters with emergency flotation systems during offshore operations, was assembled for discussion of ditching procedures and is not intended to supersede operators' or manufacturers' requirements or recommended procedures.

CHECKLIST

Flight Safety Foundation

Helicopter Passenger Ditching Checklist

(Offshore Operations)

Preliminary

- Obey the pilot's instructions.
- Do not distract the pilot.
- Do not inflate the life vest inside the helicopter; prepare the immersion suit for use.
- Secure helmet, if provided.
- Review the location and operation of doors and emergency exits.
- Establish the reference position (handhold).
- Review the location and operation of the emergency locator transmitter and life raft.

Preparation

- Secure all loose equipment.
- Remove eyeglasses if they are not secured in the helmet and secure them in a closed pocket.
- Fasten the seat belt correctly and review release procedures.

Before Ditching

- Confirm the reference position (handhold); be prepared for escape if the helicopter capsizes.
- When commanded by the pilot, assume the brace position; maintain the brace position until landing motion has ceased.

After Ditching

- Obey the pilot's instructions on opening exits, evacuating cabin and boarding life raft(s).
- If pilot is incapacitated, open exits and evacuate after main-rotor blades stop turning.
- Inflate life vest, board the life raft and conduct roll call.
- If life rafts are unavailable, use line to connect all survivors in a single group.

Note: This information, which focuses on helicopters with emergency flotation systems during offshore operations, was assembled for discussion of ditching procedures and is not intended to supersede operators' or manufacturers' requirements or recommended procedures.

CHECKLIST

for themselves before and after impact. The focus of the checklist is offshore operations, but the information also is useful to corporate operators, on-demand operators and others who conduct overwater flights in helicopters.

The first item on the checklist is to obey the pilot's instructions; other checklist items help passengers to be prepared.

Surviving the impact requires proper restraint at all times, and is enhanced by a timely brace command if the occupants have been briefed on the brace command or by a command to "grab your ankles." Some helicopter operators brief passengers on the following brace positions: With shoulder straps, tighten your seat belt and shoulder strap and sit upright, knees together, arms folded across your chest; without shoulder straps, bend forward so that your chest is on your lap, head on knees and arms folded under your thighs (see "Studies Reveal Passenger Misconceptions About Brace Commands and Brace Positions," page 51).

Upon water contact, egress from the helicopter is the next step in the survival process — but probability of escape depends on how long the aircraft floats and whether the aircraft remains upright at the surface. Accident experience has shown that even among trained passengers and crewmembers, the procedures for taking and holding a breath, unfastening seat belts/harnesses, removing headsets or operating an emergency exit under water can be difficult to remember and difficult to accomplish.

One U.S. Army helicopter pilot said that after a ditching following engine failure at 30 feet above the water, he was stunned temporarily by the sudden immersion and a blow to the face. Despite having completed helicopter underwater-escape training, he said that he had difficulty remembering to unfasten restraints while submerged in a dark cockpit and that his emergency underwater-breathing device (see "HEED This," page 365) was nearly depleted before he could egress, inflate his life vest and reach the water surface.[8]

In addition to helicopter-specific ditching procedures, U.K. CAA has published the following broad recommendations about planning and conducting overwater helicopter flights.

"The weather over the sea can be very different from the land (e.g., sea fog)," U.K. CAA said. "The water around the U.K. coast is cold even in summer, and survival time may be only 15 minutes (about the time needed to scramble a [search-and-rescue (SAR)] helicopter). A good-quality insulated [immersion] suit, with warm clothing underneath and the hood up and well sealed, should provide over three hours survival time. … In addition, take a life raft; it's heavy, so recheck weight and balance. … It should be properly secured but easily accessible, as a helicopter will sink faster than an airplane. … You are strongly urged to carry a personal locator beacon [see "The Search-and-rescue System Will Find You — If You Help," page 111] and flares. Remain on an appropriate aeronautical radio station [frequency]. … If the helicopter is fitted with [emergency hull-] flotation equipment, make sure you are familiar with its operation. Minimize overwater time in single-[engine] helicopters. (Public transport helicopters are limited to 10 minutes over water when crossing sea areas around the United Kingdom.)"[9]

He had difficulty remembering to unfasten restraints while submerged in a dark cockpit.

Some helicopters used in commercial offshore transport in the North Sea have public-address systems that are used for briefings and for communication during emergencies. Because passengers typically wear the hood of their immersion suit covering their ears during takeoffs and landings, methods of emergency communication have to be provided that compensate for reduced ability to hear. In some systems, cordless headsets or headsets with snag-resistant safety features have been implemented.

Because of the variability of accident conditions, some elements of any survival system may prove to be unsatisfactory for the actual circumstances. For example, deploying life rafts stowed on the exterior of the helicopter may be preferable in a sudden collision with water, but deploying life rafts stowed inside the cabin may be preferable in a ditching with an emergency flotation system deployed.

A U.K. CAA report said, "We endorse the view … that an externally mounted [life] raft is more likely to be of use in the case of an unexpected and/or violent impact with the sea; under such circumstances, it is highly desirable that the life raft should be released automatically without the need for any action by crew or passengers." Methods could be provided to manually release external life rafts from the cockpit, the cabin or outside the aircraft as required by circumstances, and to enable the crew to drop one of its life rafts to survivors of another helicopter that has been ditched or otherwise has entered the water, the report said.

Sea Conditions Dictate How to Board Life Rafts

Preventing damage to life rafts launched from helicopters requires a strategy for life raft boarding that matches the emergency conditions.

"Traditionally, the dry-shod method (or dry method) has been taught to evacuate the fuselage and enter the life raft," said a 1995 U.K. research report. "The crew and passengers enter the inflated life raft directly from the fuselage, without getting wet. Throughout the evacuation procedure, the life raft is tethered on a short [mooring/inflation line] against the fuselage. Thus, the survivor is not exposed to the attendant dangers of cold-water immersion and drowning; and there is a low risk of separation from the [life] raft. The disadvantages of the dry-shod method are: The [life] raft may be damaged by contact with the helicopter, lost if the helicopter capsizes, or be difficult to enter."[10]

In contrast, during a wet evacuation (also called the swim-away method), one survivor attaches a line to the life raft container, pushes the life raft container to a safe zone (outside the rotor-strike area if the helicopter capsizes), deploys and boards the life raft. Other survivors enter the water, then move along the line to the life raft and board the life raft in the safe zone. With this method, survivors leave the helicopter more quickly, but time to life raft boarding is longer because of the swimming required.

"A wet evacuation should be avoided if possible."

"The current results confirm that dry [evacuation] is the evacuation of choice and windward [the side or direction facing toward the wind] is the direction of choice, followed by dry leeward [the side or direction facing away from the wind]," the report said. (Deploying the life raft so that the wind blows it toward the helicopter can assist the boarding process but increase the risk that the life raft will be lifted from the water and pressed against the aircraft.)

"A wet evacuation should be avoided if possible, but if inevitable, the windward side is again preferable. A wet evacuation presents a number of problems made worse by a high sea state and darkness. These include difficulties in gripping the [mooring/inflation line], swimming away on the leeward side, navigating to the safe zone, communication in the water and, after an exhausting swim, climbing into the life raft. … Given the variable nature of helicopter ditching accidents, the pilot and crew may have very little choice concerning which method to use. Their training must include the options, as well as the advantages and disadvantages and include practice of each [method]."

Significant improvements in emergency exit lighting and life rafts occurred during the 1990s, U.K. CAA said.

"All helicopters being used in support of offshore energy exploitation [require] emergency-exit illumination to be adequate for its purpose when the aircraft is capsized and the cabin partially or completely submerged," U.K. CAA said.[11] "Additionally, some cabin windows are of a suitable size to provide an additional escape route and as required … must be made openable. … Although not a requirement, lighting for these 'escape windows' can be installed, provided it does not reduce the effectiveness of the emergency exit illumination.

"In principle, at least two separate means of [emergency-exit lighting] activation should be provided: by flight crew action, to switch all exit light systems simultaneously; and automatically, when the cabin becomes more than half submerged in water, each emergency exit being provided with its own automatic switch. Where it is impracticable to provide for remote activation of an individual exit lighting — for example, where the emergency exit is inset into a door — a self-contained automatic activation alone will be acceptable. Flight crew compartment emergency-exit lights should only be activated automatically, unless it can be shown that reflections or dazzle will not be a hazard to the flight crew. Lights should operate at their full brightness level for a minimum of 10 minutes after activation. Battery capacity should take account of the need for routine testing of the light system. The system should remain fully operational when submerged to a depth of at least 50 feet [15 meters].

"For passenger-compartment exits, there must be sufficient light to locate the means of release of the exit. This will normally entail the provision of a discrete locator light adjacent to the exit-release means. Brightness should be such that the exits can be identified as such from a distance of at least 20 feet [six meters] in clear water, without any additional light from other sources. … Activation [of escape-window lighting] should be in a similar manner to emergency-lighting activation, except that no manual control need be provided, and each window-lighting system should be completely independent wherever possible.

"Underwater escape through a rectangular aperture of 17 inches by 14 inches (432 millimeters by 355 millimeters) has been satisfactorily demonstrated by persons of a size believed to cover 95 percent of male persons wearing representative survival clothing and uninflated [life vests]. … For windows smaller than approximately 19 inches by 17 inches (483 millimeters by 432 millimeters), down to the minimum acceptable size of 17 inches by 14 inches, placarding and passenger briefing will be necessary to ensure that larger persons do not occupy the adjacent seats. It is recommended that placards should be of the pictorial 'fat man/thin man' type."[12]

During the 1990s, some civil aviation authorities and manufacturers attempted to provide life rafts for helicopters that could be deployed easily and would be resistant to punctures caused by sharp edges and protrusions of a floating helicopter.

"After ditching into water, a helicopter is inherently unstable whether or not it has a flotation system; even a moderate-sized breaking wave may capsize or sink it," one U.K. research report said. "Thus, the potential for loss of life is very real. … The various problems involved in escape from a ditched helicopter include: total loss of the raft because the helicopter rolled on top of it, puncture through friction on the fuselage or a tail-rotor strike, being blown onto its side against the side of the fuselage and [being] impossible to right, survivors having difficulty in boarding, the [mooring/inflation line] securing [the life raft] to the helicopter cut by a sharp edge, and [the life raft being] difficult or impossible to launch."[13]

Extreme caution is required to prevent accidental snagging of a life raft mooring/inflation line that could cause inflation inside the cabin and/or entanglement with the aircraft interior, the report said.

> **"A helicopter is inherently unstable whether or not it has a flotation system."**

Two major factors influence the equipment and training helicopter operators provide to crews and passengers to survive water-contact accidents: the threat of cold shock and hypothermia, and the amount of time that probably would be required for search and rescue.

Survival-related technologies and methods used by European helicopter operators in the North Sea (most flying between offshore oil-production platforms and Denmark, the Netherlands, Norway and the United Kingdom) and in the North Atlantic (most flying between offshore oil-production platforms and Canada) are applicable to most of the world's cold-water environments. After surviving the aircraft impact with water and evacuating the helicopter, passengers and crewmembers floating in open water would be expected to withstand the risks of drowning and hypothermia for a time ranging from 30 minutes to a few hours if they have appropriate immersion suits, life vests and training. Boarding a life raft could extend significantly survival times.

Survival-related technologies and methods of U.S. helicopter operators in the Gulf of Mexico (most flying between offshore oil-production platforms and Texas or Louisiana) are applicable to other areas of the world where water temperatures are warmer. After surviving the aircraft impact with water and evacuating from the helicopter, passengers and crewmembers floating in open water would be expected to withstand the threats of drowning and hypothermia for a period of time ranging from a few hours to several days, if they have appropriate life vests and training. Boarding a life raft could extend to weeks the time available for search and rescue. ■

The bottom line, in our opinion …

- **Properly wearing restraints counteracts the effects of in-rushing water that could cause occupants to strike objects, ingest water or become too disoriented to evacuate.**
- **Every crewmember and passenger must know how to brace for impact, to find the primary/secondary exits by touch and to operate the exits.**
- **Never inflate a life vest inside the helicopter because the bulk and buoyancy can prevent escape, and the vest could be punctured.**
- **Procedures for helicopter ditching must protect cockpit/cabin occupants from turning main-rotor blades yet enable evacuation as quickly as possible.**
- **Correctly wearing cold-water immersion suits and boarding life rafts significantly extends survival time.**

Notes

1. Dutch Transport Safety Board. *Final Report 97–74/A–25 PH–KHB, Sikorsky S-76B, 20 December 1997, Near Den Helder.* During final approach to an oil-production platform in the North Sea in dark-night conditions, the helicopter entered a steep descent that was not recognized immediately by the crew. The aircraft struck the water, inverted, rapidly filled with seawater and began to sink about 10 minutes later. The aircraft emergency flotation system was not activated and life rafts were not deployed. The two pilots and six passengers evacuated. Both pilots and five passengers received no injuries or minor injuries; one passenger died. Rescue by the crew of a supply vessel was completed after approximately one hour. The accident report said, "The accident most probably was initiated by a large power reduction during the turn to final to platform L-7A thereby creating the onset for a high rate of descent, which went unnoticed by the crew. When the crew realized the situation, the application of collective power reduced the sink rate but came too late to prevent the helicopter hitting the water. … A number of passengers reported that the [helicopter underwater-escape training (HUET)] had helped in evacuating the helicopter."
2. U.S. Army. "How to Crash a Helicopter." U.S. Army Primary Helicopter Center, Fort Wolters, Texas, U.S. File no. 1–403–2. <users.adelphia.net/~luv2hang/crash.htm>
3. Harris, Joel. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. March 13, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Transport Canada. *Airworthiness Manual,* Chapter 537, "Airworthiness Standards, Appliances," Section 537.205, "Helicopter Passenger Transportation Suit Systems." Oct. 29, 1998. The standards are applicable to "an operations specification for hypothermia protection of rotorcraft occupants engaged in certain offshore operations." The standards were published in 1988 by the Canadian General Standards Board as Standard CAN/CGSB–65.17–M88, "Helicopter Passenger Transportation Suit Systems."
5. U.S. National Search and Rescue Committee. *United States National Search and Rescue Supplement to the International Aeronautical and Maritime Search and Rescue Manual.* Appendix D, "Emergency Assistance to Aircraft Other Than Search and Rescue." D–9, D–10. May 2000.
6. Miles, Sharon. Interview by Rosenkrans, Wayne, and e-mail communication. Alexandria, Virginia, U.S. April 24, 2003, and Dec. 10, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
7. U.S. Army. "Basic Ditching Techniques and Procedures." *Flightfax* Army Aviation Risk-management Information. Volume 27 (February 1999).
8. Whalen, David B. "Ditching at Sea." Excerpted in *Flightfax* Army Aviation Risk-management Information. Volume 27 (February 1999). (The original article was published in *Flightfax* in May 1992.)
9. U.K. Civil Aviation Authority (CAA). *Helicopter Airmanship.* General Aviation Safety Sense Leaflet 17B. 2000.
10. Brooks, C.J.; Potter, P.L.; Hognestad, B.; Baranski, J. "Liferaft Evacuation From a Ditched Helicopter: Dry Shod vs. Swim Away Method." *Aviation, Space, and Environmental Medicine.* Volume 68, January 1997.
11. Safety Regulation Group, U.K. CAA. "Helicopter Emergency Escape Facilities." *Airworthiness Information Leaflet AIL/0124,* Issue 2. July 18, 2002.
12. U.K. CAA. *Report of the Review of Helicopter Offshore Safety and Survival.* Civil Aviation Publication 641. February 1995 (reprinted May 2002).
13. Tipton, M.J. "Immersion Fatalities: Hazardous Responses and Dangerous Discrepancies." *Journal of the Royal Navy Medical Service.* Volume 81, 1995.

Offshore Helicopter Operators' Emergency Systems Incorporate Rescue Planning

Flotation, location and communication drive operational decisions in environments where up to 95 percent of flight time occurs over water.

— FSF EDITORIAL STAFF

Preparations by some helicopter operators for overwater operations have evolved to include improved aircraft equipment, emergency flotation systems, methods of aircraft/engine maintenance, satellite-based methods of flight tracking, communication and distress reporting via commercial satellite, regular simulator training for ditching, periodic helicopter underwater-escape training, and water-survival training for use of life vests, cold-water immersion suits (also known as survival suits, exposure suits, helicopter passenger suits, aircrew immersion suits and helicopter offshore transport suits) and life rafts.

Ditching should be a last resort for a helicopter crew, said Colin Brown, head of quality and safety for CHC Scotia, and Peter Cork, flight safety

> **"Our regulatory responsibility is to provide life [vests] and life rafts."**

officer for CHC Scotia, a North Sea helicopter operator.[1]

"Many advances currently help us to avoid going down that route of a ditching," Brown said. "We first have to take into consideration reliability — monitoring what the pilots and the aircraft are doing — to maintain the high reliability that we have had in the last 20 years in North Sea operations. For example, health and usage monitoring system [HUMS] and helicopter operations monitoring programs [HOMP] enable us to look at operational data on a daily basis so that we can pinpoint engineering issues or operational matters that ordinarily may go unnoticed or may be unreported by the crew."

Helicopter operators meet regulatory requirements, but oil companies are included in safety decisions, too.

"We look after our crews and guarantee the safety of passengers in providing the air transport service while the oil companies increasingly take the initiative in specifying safety equipment for their own passengers," Brown said. "Our regulatory responsibility is to provide life [vests] and life rafts. Our clients move in their own ways, such as providing personal locator beacons [PLBs; see "The Search-and-rescue System Will Find You — If You Help," page 111] and rebreather systems [see "HEED This," page 365]. They can put in different sorts of survival equipment, provided that the equipment does not impede escape from the aircraft."

CHC Scotia flights are coordinated and monitored by an operations control center that would assist in a distress alert for any overdue aircraft, he said.

"We would realize that we have an aircraft down somewhere if either an emergency call had been made or arrival of the aircraft at the landing site was overdue by 20 minutes," Cork said. "Even if the crew fails to get out a distress message, we have emergency procedures that are initiated after specified periods of time. The local air traffic control center staff invariably is the first to know about an aircraft in distress, and they would activate the appropriate emergency procedures. As part of the overall response to an aircraft emergency, company helicopters — if they are being flown in the general area — also can be tasked to conduct a preliminary search. This search initially would be centered on the last known position, with the area of the search expanded concentrically from that position. The U.K. Maritime and Coastguard Agency coordinates all rescue operations using whatever resources are available."

Operators of North Sea helicopters work together and with search-and-rescue (SAR) authorities to be prepared for overwater emergencies and to respond to ditchings and other life-threatening water emergencies, he said.

"We are well covered by our national SAR services — invariably, less than an hour passes before recovery operations begin, and recovery times in the U.K. sectors of the North Sea are rarely longer than one hour," Brown said. "By tradition, emergency services from other helicopter operators are also mutually available when required. We have to think about 24-hour SAR capabilities when we conduct all flight operations, and all of our corporate customers must produce safety cases that factor in these SAR capabilities. If we must ditch an aircraft near an offshore installation, we know that SAR authorities or oil companies will have safety vessels that are equipped for sea rescue within one nautical mile or two nautical miles [two kilometers or four kilometers] of the landing site. Many changes came into effect after the helicopter accident at the Cormorant Alpha oil platform." (See "Accident Experience Influences Helicopter Overwater Operations," page 78.)

Brightly Colored Chevrons Help Searchers Find Aircraft

One aspect of SAR responders' ability to visually find a helicopter in the water depends to some extent on the contrast provided by its color scheme.

"A dark-colored aircraft is very difficult to see on a bright sunny day even when upright, and because of the helicopter's predisposition to roll over on its side or to invert when ditched, the operator also needs to consider high-visibility paint schemes for the underside of aircraft as an important aid to location," Cork said. "Marking the helicopter with large chevrons in white, orange, red or lime green is recommended as a best practice. The company scheme used by each operator should be common knowledge among operators and SAR authorities."

Reflective areas on the aircraft exterior — combined with retroreflective tape on all life vests, immersion suits and life rafts — significantly increase conspicuity when SAR responders use searchlights in darkness and low visibility. (Retroreflective materials are engineered to reflect light in the direction of its source and are most effective when the ambient light is low.)

"Our aircraft also carry an [automatic deployable emergency locator transmitter (ADELT)] that is mounted externally in the tail area," Brown said. "The ADELT can be deployed automatically or manually and is designed to automatically transmit a distress alert on 406 MHz [megahertz], 121.5 MHz and 243.0 MHz. Each aircraft also has, mounted on the cockpit voice recorder, a sonar beacon [pinger] that would be used to find the aircraft if it came to rest at the bottom of the sea. The ping is emitted about every three seconds for 30 days."

All aircraft have been equipped with the emergency-exit-illumination system (EXIS) to help survivors to identify all exits in darkness and during underwater egress, he said.

At CHC Scotia, crews receive annual refresher training in aircraft-specific emergency drills and safety equipment carried. Underwater escape and survival training using third-party expertise in aircraft/simulator ditching drills and practice in underwater escape is provided every three years. Passengers typically receive training from their employer or a third party that has survival expertise on properly wearing the immersion suit (equipped with a life vest, rebreather, light and whistle), underwater escape and water survival.

Best practices have been shared and safety initiatives have been launched through collaboration of the oil-company committees and the marine-aircraft committees of the U.K. Offshore Operators Association, U.K. Defence Evaluation and Research Agency (DERA), Cranfield University (Bedfordshire, England) and other organizations. Ditching survivability has been a major subject of shared interest, Brown said.

"We have been involved in underwater-escape trials prior to the introduction of new immersion suits and in one trial that required getting out of the smallest aperture — called an opera window — in the rear passenger compartment of the Sikorsky S-76," he said. "This review has benefited escape capability from that type of aircraft. The S-76 recently has gone through modification of the opera window with a new removable-seal window. The passenger removes the seal, then pushes out the window.

"Another industry policy of U.K. operators in the North Sea is not to allow any occupant to be more than one [seat] away from an escape point; that is, a person cannot be two [or more] seats from a window. This means that some aircraft [configurations] of five passengers abreast would not be used in the North Sea."

"… A person cannot be two [or more] seats from a window."

The company uses a variety of aircraft equipment and survival equipment during North Sea operations. The immersion suits worn by crewmembers are constructed of relatively lightweight, Gore-Tex fabric that is suitable for daily wear while working in the cockpit and for extending survival time in cold water. Each pilot's life vest also has been equipped with a small, manually activated emergency radio beacon to broadcast distress signals on 121.5 MHz and 243.0 MHz — and with a 406-MHz PLB, which incorporates a 121.5-MHz signal for homing.

U.K. helicopters over the North Sea are required to carry two life rafts per aircraft, each with the capacity to carry all crewmembers and passengers.

In Denmark's Faroe Islands, 96 percent of helicopter operations by Atlantic Airways are conducted over water, and these operations include inspection of North Sea fisheries at distances up to 200 nautical miles (370 kilometers) from shore, said Hans Erik Jacobsen, manager of the Helicopter Department of Atlantic Airways.[2] The department also has equipment, procedures and trained personnel to provide offshore SAR services.

The Faroe Islands are situated in a very narrow current of the Gulf Stream with average ocean-surface temperatures of 6 degrees Celsius (C, 43 degrees Fahrenheit [F]) to 9 degrees C (48 degrees F) — not as cold as ocean areas closer to Iceland or Scandinavian countries, he said. Nevertheless, the water is cold enough to challenge rescuers who typically enter the water to assist survivors.

"Most common for rescuers are thick-fabric dry suits so that the rescuer is able to survive in cold water for several hours without problems," Jacobsen said. "We use these just in case we have to leave the rescuer at sea to wait to return to shore in another helicopter. Attached to each crewmember life vest are a beacon, signal rockets and a handheld radio transceiver for voice communication on 121.5 MHz and 243.0 MHz. Based primarily on recent discussion among our rescuers, our plan is to implement 406-MHz personal locator beacons for all crewmembers and for everyone who is flying offshore with us."

> **"The pilot must control the aircraft all the way down — which is much easier said than done."**

Crew training comprises both SAR training as rescuers and training to survive a ditching or other water-contact accident.

"Training includes simulated rescues at sea with pickups out of the sea and taking people off vessels," he said. "Our number-one fear is hypothermia, so when we discussed survival equipment, we decided to provide to the hoist [winch] operator the same equipment that was chosen as good enough for the rescuer to use in the water." (See "Is There a Doctor Aboard the Life Raft?" page 187.)

Typically, a company SAR helicopter has two pilots, one rescue swimmer or open-sea diver and one winch operator who is cross-trained as a rescue swimmer.

"We all go through underwater-escape training through [Norwegian Underwater Technology Center (NUTEC)] every second year," he said. "We train for underwater escape without an emergency breathing device, and do wet drills using lifeboats and life rafts at the same time. NUTEC also provides in the Faroe Islands one week of recurrent SAR training and emergency medical training for our rescuers annually or every six months. This covers how to rescue people from the water."

Helicopter Simulators Enable Autorotations to Sea Surface

Atlantic Airways helicopter pilots receive recurrent flight training and instrument flight rules training in simulators at the FlightSafety International center in Hurst, Texas, U.S. The training includes ditching procedures and practice (see "Imagine the Worst Helicopter Ditching — Now Get Ready for It," page 85.)

"Part of this is a lot of training on how to enter autorotation down to land on the sea surface," Jacobsen said. "Visibility in clouds, in daylight and dark-night conditions can be manipulated by instructors so the crew either breaks out of clouds just before impact or does not see anything down to the sea. It is very difficult to autorotate to a successful ditching in these conditions. The pilot must control the aircraft all the way down — which is much easier said than done — while remembering to make the mayday call, to deploy the emergency flotation system and to complete other emergency-checklist procedures. Pilots also practice overwater hoist operations and approaches, landings and takeoffs from vessels and oil platforms in the simulator. All this training is very good for pilots and very important for safe conduct of our flights."

The department operates one Bell Helicopter Textron 212 — used primarily for transporting passengers to and from remote islands and villages, and for sling work [i.e., lifting loads with a hook or sling on an external line] — and one Bell Helicopter Textron 412, primarily used in SAR operations for the Maritime Rescue Coordination Center Faroe Islands. The SAR aircraft has a four-axis autopilot with hover-lock, which assists the crew in remaining over a SAR scene and in using automation to conduct approaches to targets.

"The reason for selecting this configuration was to increase safety during night-rescue operations," he said. "The crew is capable of hanging still in the air using the autopilot."

On both helicopters, the emergency flotation systems are armed for automatic inflation or manual inflation by the pilots whenever the helicopter is flying over water at an airspeed less than 60 knots.

"If the aircraft ends up on the water surface, and the crew has not manually deployed the flotation system, saline switches on the belly automatically will inflate the flotation bags," he said. "The likelihood of ending up in the water is remote. If we fly an overwater distance that is more than 10 minutes offshore — typically to an offshore destination or for fishery inspection or fish surveillance — all passengers wear waterproof immersion suits of Gore-Tex material, which require a separate life vest, or immersion suits in which the life vest is included. For flights only between islands — which are about three minutes apart — passengers do not use immersion suits because 24-hour shore-based lifeboat services are in close proximity and have the ability to launch quickly their rescue vessels."

At Atlantic Airways, one of the pilots is responsible for conducting the passenger pre-takeoff safety briefing, he said. Nevertheless, how much attention helicopter passengers give to the briefing can vary as much as passenger attention to the safety briefing on transport jets. Jacobsen said that the problem can occur regardless of whether crewmembers conduct the briefing or use a video briefing.

"I noticed while visiting another operator that most passengers were sleeping during the briefing — and I was told that passengers who travel routinely often say that they are tired of the briefing," he said. "When the helicopter is floating on the water, the most important messages for passengers are where the emergency exits are located, not to open the cabin door [as required by procedures for a specific aircraft] and how to push out the emergency-exit window and step over into the life raft that has been inflated outside the window. We also cover how to remove the emergency windows for underwater escape. Briefings also cover how to enter a life raft."

Public-address systems, which are mandatory, have been installed in each helicopter to enable pilots to give loud-volume commands to passengers during an emergency, he said.

"We do a lot of island-hopping and all these passengers are frequent fliers," he said. "Although there is no oil industry within the Faroe Islands, if we have seismic-ship stations or oil-exploration rigs that are stationary for eight weeks or 10 weeks, we transport the same offshore passengers back and forth and land on the same ships in our waters for a few weeks at a time. The employers normally provide safety training to their offshore employees. For our local passengers who do the fishery inspections, the coast guard and other authorities here provide additional training.

"We try to encourage fishery inspectors to take helicopter underwater-escape training to increase their chances of survival — but when we deal with people outside the helicopter business, it is not easy to convince them of the necessity of this training. They do not understand how slim are the chances to survive if they end up in the water and they have not been trained to escape from the helicopter."

> **"… Slim are the chances to survive if … they have not been trained to escape from the helicopter."**

In the 1970s, rapid growth of helicopter transport to support offshore-oil activities in the Gulf of Mexico — and various accidents involving water landings — prompted U.S. helicopter operators to address a variety of risks that were being identified, said Mark Fontenot, director of training for Air Logistics in New Iberia, Louisiana, U.S.[3]

"In the early days, we developed our own training with videos from the U.S. Coast Guard," Fontenot said. "Soon we had to start looking

"Ditchings happen more often than we would like."

at the survival aspects for the crew and passengers in a ditching, and we started doing helicopter underwater-escape training in the mid-1970s to the late 1970s. We made our own small dunkers [mechanical devices that enable pilots to practice holding their breath, releasing restraints, operating exits and escaping from a helicopter-cockpit mock-up after the device has been inverted in a swimming pool]. Over a period of about 15 years, we got away from doing this training on our own."

Currently, Air Logistics and other operators in the Gulf of Mexico typically use underwater-escape training provided by other organizations.

"This helicopter-specific emergency-evacuation program begins with water safety and water survival information and practice in a small-scale device," he said. "Then trainers use a very large helicopter underwater-escape trainer with the front end configured as a pilot station and the back of the cabin configured for passengers as a specific type of aircraft."

Variations in regulatory requirements and client requirements influence some decisions about safety equipment used, Fontenot said.

"Ditchings happen more often than we would like," he said. "Much about the equipment choices is economically driven — involving factors of extra weight and expense — or is federally required. For example, in the Gulf of Mexico, operators typically do not have EXIS lighting — which is now required in the North Sea — unless a contract specifies this lighting. If the client wants it, we put it in the aircraft."

Air Logistics helicopters have a standardized emergency flotation system installed on the outside of the skids. The majority of systems are inflated from a nitrogen cylinder in the aircraft. The pilot arms the system during specified phases of flight, and pulls a trigger or pushes a button to fire a squib (pyrotechnic charge) to open the inflation valve.

"The flotation system enables the pilot to land the helicopter upright in the water, allowing time to stop the rotor and to egress into the life raft," he said. "If seas are not very high and the pilot lands correctly, the helicopter does not roll over. Usually, people board the life raft and are recovered by a vessel."

Upright helicopters most often are towed to an oil platform, where a crane is used to hoist the aircraft either to the platform or to the deck of a ship. In some situations, the helicopter may be towed to shore or a larger helicopter may transport the ditched aircraft from the water surface to shore, he said.

Every day, pilots conduct a flotation-system check that includes a test of electrical circuits. Maintenance technicians periodically inspect other components. They do not fire the squib, but they unpack and inflate the flotation bags with compressed air, check their serviceability and then deflate and repack the flotation bags.

Each crewmember uses a constant-wear life vest equipped with a 121.5-MHz beacon, a 121.5-MHz radio transceiver, a strobe-type survivor-locator light, sea-dye marker and a large yellow plastic trash bag to make a person less conspicuous to sharks while floating in the water (some specialists said that the color yellow is attractive to sharks, however, because its brightness contrasts with the dark ocean; see "What's Eating You? It's Probably Not a Shark," page 211). Each passenger wears during flight a life vest approved by the U.S. Federal Aviation Administration (FAA). Each life raft has a variety of signaling devices, such as smoke devices, flares and mirror, he said.

"Our area of operations is over water 95 percent of the time, and one aspect of our pilot training is specific to our environment," Fontenot said. "Like one other operator on the Gulf Coast, we require, for new-hire pilots and on a recurrent-training basis, that pilots complete our engine-out autorotation training to the water in one of two aircraft that have fixed utility flotation systems. Even though these aircraft have fixed utility flotation systems, pilots can practice arming a system simulating deployment and getting correct indicator lights. We teach techniques of ditching into the wind, as over land, and practice arming the system and inflating the flotation bags. We have done this for about 20 years because we have benefited from this training."

Offshore helicopter operators in the Gulf of Mexico typically are based near the coast and conduct flights at altitudes between 500 feet and 5,000 feet.

The majority of flights involve operating under visual flight rules in uncontrolled airspace below 1,200 feet with no air traffic control radar coverage unless the aircraft at this altitude is within 20 miles to 40 miles (37 kilometers to 74 kilometers) of Houston, Texas, or Galveston, Texas, Fontenot said. Helicopter operators typically provide their own local weather observations to each other, he said.

"Currently, about 8,000 people and 500 to 600 helicopters work in the Gulf of Mexico every day," Fontenot said.

Air Logistics maintains a private flight-following facility based on a combination of very high frequency amplitude modulation (VHF AM) aeronautical voice communication, manual position logging by flight-following staff, a satellite-based tracking service, position-reporting procedures and coastline-crossing procedures. Aircraft often are beyond and/or below FAA radar surveillance.

"For many years, we have required our pilots to report crossing coastlines and to make a position report every 15 minutes along the route of flight," Fontenot said. "We learned the hard way to do this so that we could narrow the search area in the event of an accident. Before pilots take off from bases that are 10 minutes from the coastline, for example, they type into our system a flight plan and activate the flight following with their base staff before crossing the coastline. We have radio operators in strategic areas to track the flight so that the majority of aircraft appear on a log that shows times, positions and miles to the destination.

"We used to have to search along the whole route of a 100-mile flight. When the pilot makes 15-minute position reports at a typical 120-knot airspeed, we have a 30-nautical-mile [56-kilometer] segment of the route to search."

Commercial Satellite-based Flight Following Speeds Rescue of Survivors

Technological advances being adopted by Air Logistics and other helicopter operators in the Gulf of Mexico simplify the process of tracking and responding to a ditched aircraft, and determining that an aircraft has lost communication but has continued the flight as planned. They integrate global positioning system (GPS) positions with automated satellite-based communication and reporting.

"Our company and another operator have begun installing the satellite-based flight-tracking system on some aircraft," he said. "The system uses a satellite transmitter/receiver on the aircraft and a GPS receiver, and automatically transmits position and altitude to a commercial satellite. The satellite downloads this data to a communication center in Delaware, U.S., which then transmits the data over the Internet to a host computer in our flight-following facility, where we can view the flight information plotted on a computer-screen map of the Gulf of Mexico. We have set up our flight-following system to receive GPS position updates every three minutes."

The map is divided into numbered blocks measuring three nautical miles (six kilometers) by three nautical miles, and depicts the flight-planned route of each aircraft. Position reports by voice are required of pilots flying aircraft with the automatic tracking system. One reason is that cessation of the automatic burst of data from the aircraft triggers an alarm, and pilots must be able to report that a false alert has occurred and enable flight-following personnel to continue monitoring the flight without automation.

"Currently, about 8,000 people and 500 to 600 helicopters work in the Gulf of Mexico every day."

"If a pilot has an in-flight malfunction, an emergency button can be used to transmit the aircraft location while the pilot also makes a radio call," Fontenot said.

Helicopter operators in the region anticipate that FAA will implement automatic dependent surveillance–broadcast (ADS-B) as a method of separating helicopter traffic over the Gulf of Mexico. ADS-B uses avionics on the aircraft flight deck and electronic equipment on the ground for airborne separation assurance and ground-based surveillance of airspace without radar. They also have supported research leading to improvements in air traffic surveillance, radio communication and weather reporting — including automated weather-observation stations and communications facilities that would be installed by FAA on privately owned oil platforms in the Gulf of Mexico, he said.

Helicopter operators work closely with the Coast Guard to report when one of their aircraft has been ditched in the Gulf of Mexico; nevertheless, company helicopters usually can reach the scene more quickly than Coast Guard helicopters or vessels, he said.

"Typically, there is not much we can do at the scene, however, before the Coast Guard arrives," Fontenot said. "We do not have equipment or training to conduct the rescue, but we typically can report to our flight-following facility the block number of lost contact, whether the aircraft has landed OK and whether people are in the aircraft or in a life raft. Our aircraft will stay over the scene until it needs fuel, and we get out of the way when the Coast Guard is on scene. People in the water usually cannot communicate with us by two-way radio."

When another operator's aircraft is missing in the Gulf of Mexico, helicopter crews in the area typically maintain a lookout — and may divert from their route to conduct a preliminary search — but they do not become involved in the official search unless requested, he said.

Based on experience shared by many helicopter operators in the Gulf of Mexico in recent years, the time required to find crewmembers and passengers after a ditching averages one hour to two hours, he said. ■

The bottom line, in our opinion ...

- **Completing checklist procedures during an autorotative landing to the sea surface — even in darkness and low visibility — can be experienced effectively in a simulator.**
- **Large chevrons in white, orange, red or lime green help searchers to see helicopters whether they are upright or inverted in the water.**
- **Seating configurations must provide rapid accessibility of an exit to each occupant under the most difficult evacuation conditions.**
- **Collective efforts of helicopter operators can shorten SAR-response time and contribute to improved over-water safety through research.**

Notes

1. Brown, Colin; Cork, Peter. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 30, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
2. Jacobsen, Hans Erik. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. May 2, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
3. Fontenot, Mark. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 17, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

Helicopter Hull-flotation Systems Reduce the Risk of Rapid Sinking

In benign conditions, pilots can conduct a ditching with low risk of aircraft damage. Some emergency flotation systems also make possible a precautionary water landing and a water takeoff.

— FSF EDITORIAL STAFF

Optional ditching certification for helicopters and separate certification for helicopter flotation systems help to make aircraft performance during descent and after water contact as predictable as possible. Essentially, both processes are intended to provide occupants enough time near the surface to exit to a life raft. In its report on one helicopter water-contact accident, for example, the U.K. Air Accidents Investigation Branch said in 1992 that hull flotation is so important in survival that automatic systems should be considered despite the slight risk of inadvertent in-flight deployment.[1] Absence or failure of a flotation system — or insufficient time to deploy the system as in this accident — increases the risk that occupants will not be able to exit before the helicopter sinks.

"Although they are primarily designed to provide flotation following an intentional ditching, [flotation bags] must also be useful as additional buoyancy following a collision with the sea," the report said. "According to witnesses, [the accident helicopter] remained at the surface for one or two minutes, generally inverted and awash. Inflated hull-flotation bags would have extended this time and, perhaps more significantly, [would] have caused the hull to float higher in the water, thus aiding the escape by occupants. Escape is only feasible within a few meters of the surface, and therefore any delay in the sinking of the cabin is bound to be beneficial. In an accident scenario, it is unreasonable to rely on flight crew [deployment] of the emergency [flotation system], and therefore an automatic system is highly desirable. The manufacturers remain concerned at the possible hazard of inadvertent deployment and would wish to incorporate adequate safeguards."

In response, a 1995 report by the U.K. Civil Aviation Authority (CAA) said that the best compromise is to provide an automatic system that would activate upon water contact when armed but would alleviate concern about inadvertent in-flight deployment by incorporating an arming switch as used on manual-only systems.[2]

Certification helps to ensure that after landing on water in specified conditions, the helicopter will stay afloat for a sufficient period of time for all occupants to be evacuated safely, said Sharon Miles, an aviation safety engineer in the Rotorcraft Directorate of the U.S. Federal Aviation Administration (FAA).[3] Current FAA regulations do not require helicopters to be ditching-certificated, but contain specific requirements for helicopters that are operated over water, she said. Consequently, helicopters may be equipped with emergency flotation systems but not be ditching-certificated.

Some small helicopters that operate under U.S. Federal Aviation Regulations (FARs) Part 27, *Airworthiness Standards – Normal Category Rotorcraft,* are not certificated for ditching but comply with specific portions of the ditching-certification requirements to install emergency flotation systems for use in an emergency landing on water and to allow an evacuation of the occupants after an emergency landing on water, Miles said.

For certification purposes, FAA defines ditching as "an emergency landing on the water, deliberately executed, with the intent of abandoning the rotorcraft as soon as practical." During testing of ditching performance, FAA assumes that the helicopter "will be intact prior to water entry with all controls and essential systems, except engines, functioning properly." The demonstration of compliance with flotation and trim requirements must reflect "reasonably probable water conditions" of sea state 4, a moderate sea with significant wave heights of four feet to eight feet (one meter to two meters). U.K. CAA has additional requirements related to sea state because of North Sea operations, which involve a more severe operating environment than the typical water environment for U.S. helicopter operations, Miles said.

Standards Do Not Specify Minimum Flotation Time

Helicopter-ditching certification standards — which have been harmonized by FAA and the European Joint Aviation Authorities (JAA) in most regulations — do not contain a specific length of time that a helicopter must remain afloat but require that the time be sufficient for all occupants to be evacuated safely. If a helicopter has a seating capacity of more than 44 passengers, however, or a seating capacity of 10 or more passengers per emergency exit, or no main aisle per specific requirements, transport category certification standards (Part 29) require a test to demonstrate emergency evacuation of the helicopter within 90 seconds, Miles said. Ditching certification does not override the certification requirements for those helicopters.

"Safety of occupants is the primary concern of these regulations," Miles said. "Some helicopter manufacturers also want to maximize the opportunity to recover the aircraft, but regulations do not consider the aircraft recovery aspect, only occupant safety. Ditching-certification requirements include emergency exits above the helicopter water line; emergency exits on each side of the helicopter; and enough openings in the top, bottom or end of the helicopter to enable occupants to evacuate the helicopter in the event of a rollover — unless the manufacturer can show that a rollover will not occur in the required sea-state conditions.

"FAA/JAA regulations for ditching certification do not explicitly specify the sea state, but as part of compliance principles, FAA has a policy about sea state, wind and temperature conditions that is used during the certification demonstration. Compliance can be demonstrated through model testing or by FAA acceptance of results of computer-based modeling, on a case-by-case basis, when the manufacturer can demonstrate that the model is accurate."

Most helicopter ditchings involve autorotation; in some events, autorotation is not an option because of the circumstances of the emergency, such as insufficient time for the pilot to respond to the emergency, Miles said. Pilots are trained in the use of the flotation systems, the emergency procedures for a ditching scenario and the optimal method of ditching the specific helicopter.

The skid-mounted flotation bags of emergency flotation systems are packed in covers so that they create little aerodynamic drag.

"The typical intact airplane has a lot of under-body structure and built-in buoyancy — factors that are just not present for helicopters," Miles said. "Nevertheless, helicopter operators generally have had good results during overwater emergencies in which the emergency flotation system was activated properly. Even when rollovers have occurred, most helicopters remained upright long enough for the occupants to evacuate safely because buoyancy in various sea states has met the certification requirements. In other cases, however, the emergency flotation system has not been activated prior to entering the water, and this has caused a catastrophic event. Some of these accidents involved failure of the pilot to activate the system because of insufficient time for response."

The high vertical center of gravity (CG) of the typical helicopter is an important determinant of what occurs on the water surface, she said.

"Most of the aircraft mass is above the water, and with this relatively high vertical CG and no stabilizing help from wide-span wing structure, helicopters tend to be less stable than airplanes in the water," said Miles. "The problem is not necessarily how the pilot landed the helicopter or where the pilot landed the helicopter."

Various conditions affect the helicopter's resistance to rollover following a ditching, she said.

"Generally, on a calm sea, the helicopter can be relatively stable on the water, and the idea is to keep the aircraft as stable as possible," said Miles. "With wave action, the helicopter is more susceptible to rollover. Mainly, wave action — waves and breaking waves— is responsible for rollover. Breaking waves are created when a wave is too heavy to support itself and the top of the wave falls toward the upstream side. In a scenario where wave action and wind overtake the helicopter, the helicopter may be overcome by the wave action and subsequently roll over on its side or upside down. Waves and breaking waves — and some swells — could act differently in causing rollover in that the helicopter may 'ride the waves' until the critical vertical CG is exceeded and the helicopter subsequently rolls over. Testing is generally associated with waves to certain specified heights, and certification of the flotation system is based on stability for those wave heights."

The manufacturer typically demonstrates evacuation of the helicopter in a calm-seas environment; variations of sea state are not included, said Miles.

"In model testing, we look for the aircraft to stay upright in the water, and the manufacturer must demonstrate that the aircraft will stay afloat for some period of time," Miles said. "If the manufacturer provides a flotation system as standard equipment or as emergency equipment, information about occupant egress must be included in the flight manual, preflight passenger briefings for specific flights and maintenance-manual instructions for the flotation systems installed on the

> **"Most of the U.S. helicopters with fixed utility flotation systems are operated in Alaska."**

helicopter. Part of the design requirements is an in-flight evaluation of aircraft performance by a flight test pilot and a design engineer when the emergency flotation system is added for the first time. Each flight test varies according to the approvals sought by the applicant. Performance capability and handling qualities with the system installed must be demonstrated during actual flight testing and approved by FAA through the approval of the aircraft flight manual. On the operating side of regulatory oversight, each pilot then must be trained in every aspect of flight, including the correct use of the emergency flotation system."

FARs and Joint Aviation Requirements include the following airworthiness requirements for ditching certification of a helicopter as an optional standard for manufacturers:

- Ability to land and remain upright after water contact with a forward velocity of zero knots to 30 knots in specified wave conditions and in likely roll attitudes and yaw attitudes; with the rotorcraft pitch attitude in autorotation in specified side-wind conditions; after asymmetrical rotorcraft landing; with immersion before and after full inflation of the emergency flotation system; with the most severe wave heights for which approval is desired (a minimum of sea state 4 should be considered);

- Demonstration of auxiliary-float loads or emergency-float loads should be determined by full immersion or specified methods of counteracting side wind, asymmetrical rotorcraft landing, water-wave action, rotorcraft inertia, and probable structure damage and punctures;

- Demonstration of rotorcraft water entry, adequate flotation and trim, and upright position for safe and orderly occupant egress and occupant survival; and,

- Provision of emergency exits for egress when upright and for egress when inverted.

Helicopters used in overwater operations generally have one of two basic categories of inflatable flotation systems: fixed utility flotation systems or emergency flotation systems (also called ditching floats or popout floats by some aircraft operators). Typically, fixed utility flotation systems are used not only as emergency/ditching systems but also in amphibian-type operations. Helicopter operators that select fixed utility flotation systems typically use these systems at all times because they routinely conduct takeoffs and landings from water, or they otherwise require this capability to anticipate possible offshore landings, such as during fishing operations off ships.

"Most of the U.S. helicopters with fixed utility flotation systems are operated in Alaska," Miles said. "Many helicopters operating in or from the lower 48 states carry inflatable emergency flotation systems only for use during an overwater emergency."

Flotation systems for current models of helicopters typically have an inflatable design whether they are the fixed utility type or the emergency type, said Dave Parrott, director of engineering for Apical Industries, a U.S. manufacturer of flotation systems for several types of helicopters.[4]

"Fixed utility flotation systems are based on a simple system that is always inflated in flight; their flotation bags are thicker and more durable than emergency flotation systems," Parrott said. "Bolted onto the skid gear, fixed flotation systems are inflated from a maintenance-shop air compressor before flight and have no integral inflation system. Fixed utility flotation systems might be used, for example, by operators of tuna-fishing vessels where the helicopter always lands on the deck of a ship and the operator is not concerned about achieving the maximum forward speed. Other advantages are less initial cost and maintenance cost.

"Emergency flotation systems use a thinner inflatable material that is rolled and packed into an aerodynamic cover on each skid. Many different types are available, but normally this is a 'nontakeoff' set of floats to be used only during an emergency situation. Over the years, several 'takeoff systems' that also can be deployed for normal landing on water and normal takeoff from water also have been developed, so operators currently use the terms 'nontakeoff system' or 'takeoff system.'"

The company designs most current emergency flotation systems to remain inflated with helium or nitrogen until a vessel can tow the floating helicopter or another helicopter can pick up the floating helicopter, he said.

"Under the most common circumstances — an autorotation to landing with the flotation bags inflated — the helicopter essentially could stay afloat for weeks," Parrott said. "Emergency flotation systems can be lighter in construction if their only purpose is to give the occupants enough time to egress into a life boat or a life raft. After ditching, however, a majority of helicopters are towed by boat — typically for about 30 nautical miles [56 kilometers]."

Multiple Flotation Chambers Help Prevent Sinking

The design of an inflatable helicopter flotation system begins with calculation of the full forward CG location and the full-aft CG location. These data help to determine the basic design and the number of isolated flotation chambers required for buoyancy and stability. Multiple chambers protect against sinking if one chamber is punctured.

"We deflate the largest compartment of the emergency flotation system with the helicopter at maximum gross weight, and verify that the helicopter does not roll over in the resulting attitude," Parrott said. "We design flotation bags ideally to keep the fuselage a few inches out of water. Otherwise, the more water entering the fuselage, the tougher it will be to recover the aircraft — and if salt water enters electrical components, they will be pretty well unsalvageable. Keeping the fuselage out of the water is not a regulatory requirement but is a capability driven by operator requirements. FAA, for example, wants to see a system that keeps the helicopter upright even if close to the water surface, so the system is designed first to keep the helicopter upright, then to help the operator to retrieve the ditched helicopter in usable condition."

In the United States, FAA requires a minimum buoyancy of 1.25 times the gross weight of the helicopter and demonstration of sufficient buoyancy and stability after ditching. The company's designs use 1.5 times maximum gross weight as the required buoyancy to keep the fuselage higher above the water, Parrott said.

Approved operating speeds of helicopters with flotation systems depend on several factors. Helicopters with fixed utility flotation systems installed have lower speeds because of additional aerodynamic drag, but the flotation bags of emergency flotation systems are packed so that they produce little aerodynamic drag. Safe speeds for deploying emergency flotation systems and for operating with the system deployed are determined by flight testing.

"For each helicopter type, a never-exceed speed (V_{NE}) normally applies to the flotation-system deployment — such as do not inflate above 60 knots or 90 knots — then the helicopter can be flown with the system deployed at a higher speed," Parrott said. "Emergency flotation systems really are not designed for sustained high forward speed. They are designed to get the aircraft onto water and to float there safely."

When seeking regulatory approval of a new flotation-system design, the company uses a helicopter of the required type to conduct in-flight testing of inflation, autorotation with the system deployed and landing on water.

"Most of our designs are approved to allow takeoff after a water landing because of customer requirements," Parrott said. "With this system, the pilot may land in water because a warning light came on, but after investigation of the problem, the helicopter could be flown to the nearest repair station."

> **"Emergency flotation systems really are not designed for sustained high forward speed."**

Intervals for required operator inspections of flotation bags, gas hoses and gas-cylinder gauge pressures typically are six months or 12 months; typically this involves unsnapping the aerodynamic cover, checking the condition of the packed flotation bags and replacing the cover as specified in the flight manual supplement. Usually, disassembly of the entire system — unpacking, checking and repacking flotation bags, hydrostatically testing the cylinder and rebuilding valves — and reassembly will be conducted every three years during the manufacturer's system-recertification inspection, he said.

One customer's requirement led Apical to design and obtain certification for a new system for some helicopters in which a life raft is packed on the exterior surface of the emergency flotation system in containers that are mounted on the skids.

"The pilot inflates the system, lands on water, shuts down the aircraft and remotely inflates the life rafts outside the cabin from a separate activation system and gas reservoir," Parrott said.

Generalizations about how and when helicopter operators carry emergency flotation systems are difficult because practices depend on many variables, such as whether the helicopter is operated regularly over water.

"Typically, the emergency flotation system installed on the skids forms part of the normal helicopter configuration — especially where a lot of operation is over water as in coastal areas of Texas and Louisiana; in the central part of the United States, many helicopters are equipped with this kit considering the typical operational use," Miles said. ■

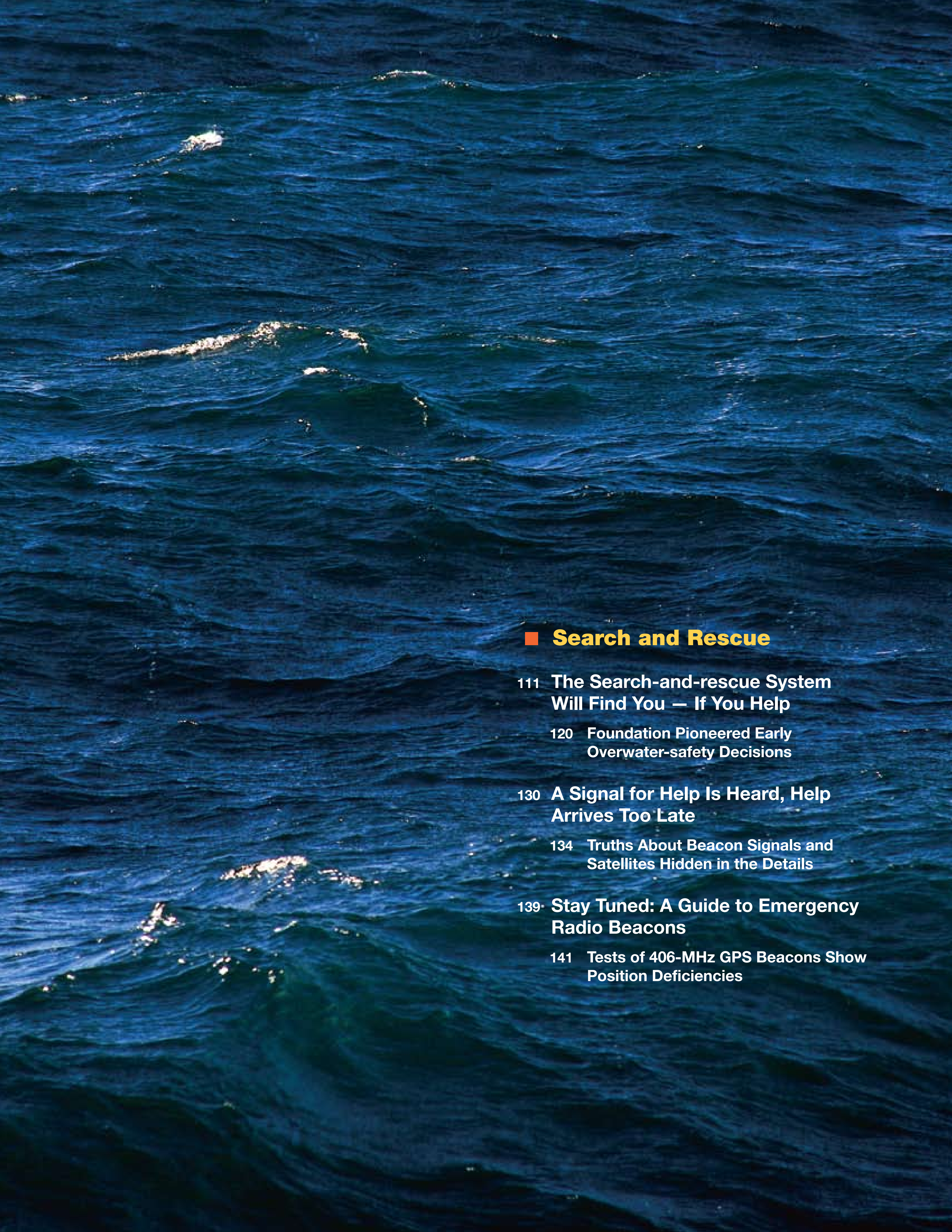
The bottom line, in our opinion …

- **An emergency flotation system keeps the helicopter upright to provide occupants the best configuration for evacuation; recovering the aircraft will be secondary.**
- **Absence of an emergency flotation system dramatically increases the risk that occupants will be unable to evacuate before the helicopter sinks.**
- **Some emergency flotation systems can be used for normal landing on water and normal takeoff from water.**
- **Ditching certification of the helicopter typically requires emergency exits above its water line and on each side, and openings in the top, bottom or end that enable occupants to escape after a rollover.**

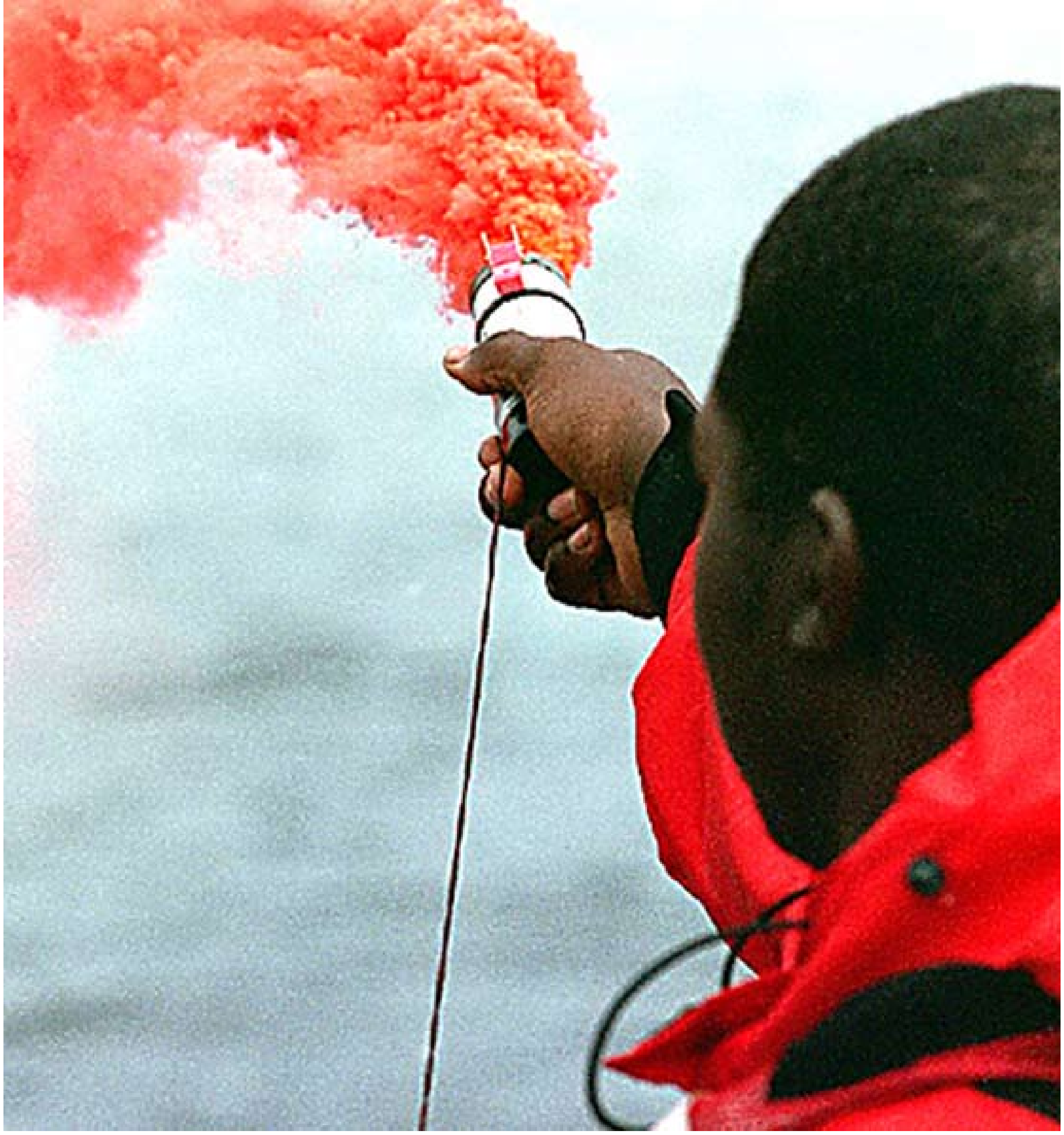
Notes

1. U.K. Air Accidents Investigation Branch. *Report on the Accident to AS 332L Super Puma, G–TIGH, Near the Cormorant 'A' Platform, East Shetland Basin, on 14 March 1992.* April 26, 1993. The helicopter struck the sea following a takeoff from an oil platform. One crewmember and 10 passengers were killed; one passenger was seriously injured; and one crewmember and four passengers received minor injuries or no injuries. The aircraft was destroyed. Causal factors were: "The [commander's] failure to recognize the rapidly changing relationship between airspeed and groundspeed, which is a fundamental problem associated with turning downwind in significant wind strengths. The commander, who was the handling pilot at the time … inadvertently allowed the airspeed and then the height to decrease while turning away from a strong gusting wind. Despite the application of maximum power, the helicopter was incapable of arresting its established descent within the height available. Incipient vortex-ring state and downdrafts may have contributed to this problem, as may the height of the wave crests. Several human factors, including possibly some fatigue and frustration, exacerbated by a demanding flying program in which the commander was managerially responsible, may have degraded the crew's performance to an extent that the normal safeguards of two-crew operation failed."
2. U.K. Civil Aviation Authority. *Report of the Review of Helicopter Offshore Safety and Survival.* Civil Aviation Publication 641. February 1995 (reprinted May 2002).
3. Miles, Sharon. Interview by Rosenkrans, Wayne, and e-mail communication. Alexandria, Virginia, U.S. April 24, 2003, and Dec. 10, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Parrott, Dave. Interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 25, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

Search and Rescue



Search and Rescue



A red flare is an international signal of distress.

The Search-and-rescue System Will Find You — If You Help

A complex array of resources can be marshaled for SAR. Just as important — long before anyone becomes a survivor — will be the prepared aircraft operator and aircraft crew.

— FSF EDITORIAL STAFF

For a rescue coordination center (RCC), a ditching or other aircraft water-contact accident is a life-threatening emergency of the highest priority. Key differences in responding to an aircraft in distress[1] vs. a marine vessel in distress are the source of the distress alert and the working assumption that survivors of an aircraft accident require rapid medical assistance, said Lt. Cmdr. Paul Steward, liaison officer to the Cospas–Sarsat International Satellite System for Search and Rescue and implementation officer for the Distress Alerting Satellite System (DASS), Office of Search and Rescue, U.S. Coast Guard.[2,3]

("Distress alert" refers to any notification received by search-and-rescue [SAR] authorities, such as a pilot declaring mayday to air traffic control [ATC] or the signal from an emergency radio beacon. An RCC is an organization — established by a country or a group of countries in the same geographic area — that takes responsibility for organization of SAR services and for coordinating SAR operations within a specific region.)

"RCC personnel understand that an aircraft does not float indefinitely, that survivors will be in the water, and that survivors are likely to be exposed to a lot more trauma and injuries than people aboard a marine vessel that is sinking," Steward said. "The longer that people are exposed to the elements, the greater the likelihood that injury or death will ensue. So there is a greater emphasis on the time factor compared with a marine vessel that has broken down or that is taking on water, for example."

Beacons are designed to enable global communication of distress and determination of the survivors' position. In the absence of a "mayday" or a report of an overdue aircraft, the difficulty of finding survivors in the ocean can be insurmountable if no beacon has been deployed, the beacon has not been activated or the beacon has malfunctioned. The probability that SAR authorities will receive the signal from a beacon, however, was increased dramatically by Cospas–Sarsat, which was declared to be operational in 1985 (see "Truths About Beacon Signals and Satellites Hidden in the Details," page 134).

Cospas–Sarsat is important to civil aircraft operations over water because the system enables SAR authorities to locate survivors of a ditching or other water-contact accident in areas where ATC facilities do not have radar coverage. Basic familiarity with Cospas–Sarsat helps aircraft operators to conduct flight planning, to select optimal types of survival equipment, to prepare ground personnel for overwater emergencies and to know what to expect from the RCC while awaiting rescue.

Using a worldwide data-distribution plan, Cospas–Sarsat automatically sends distress alerts based on beacon signals via computer network to the responsible RCC according to the geographic location of the distress. If the position of a 406-megahertz (MHz)[4] beacon cannot be determined immediately, the first distress alert is sent to the SAR authorities of the country in which the beacon has been registered. A 406-MHz GPS (global positioning system) beacon is designed to incorporate position data in its signal. The source of position data may be an internal GPS receiver or external navigation equipment (for example, an aircraft GPS navigation receiver or a flight-management computer).

The U.S. National Oceanic and Atmospheric Administration (NOAA), the Coast Guard and the U.S. Air Force operate Cospas–Sarsat, and NOAA operates the U.S. Mission Control Center (MCC) in Suitland, Maryland, U.S. As of Oct. 30, 2003, 27 other Cospas–Sarsat MCCs are operated by Algeria, Argentina, Australia, Brazil, Canada, Chile, China, France, Hong Kong (China), India, Indonesia, Italy, Japan, Nigeria, Norway, Pakistan, Peru, Russia, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Taiwan (China), Thailand, United Kingdom and Vietnam. The U.S. National Aeronautics and Space Administration (NASA) provides technical support to Cospas–Sarsat by launching satellites, investigating system problems and developing technological improvements.

The underlying satellite-system technology was developed in 1979 under a memorandum of understanding among agencies of Canada, France, the Union of Soviet Socialist Republics (now the Commonwealth of Independent States) and the United States; 37 countries and two independent SAR organizations currently participate in the program. In October 2003, Cospas–Sarsat points of contact worldwide[5] included MCCs, RCCs, regional joint search-and-rescue centers, rescue sub-centers and other organizations.[6] (Proprietary real-time flight-following systems currently used by some aircraft operators — combining GPS receivers and satellite-based communication equipment — also may incorporate distress-alerting capabilities independent of Cospas–Sarsat.)

While Cospas–Sarsat helps to save lives, the system also delivers an avalanche of false alerts[7] every day to the world's RCCs. Responding to a false alert with unnecessary deployment of SAR resources has the following effects, Steward said:

- SAR professionals are placed at unnecessary risk of harm;
- SAR professionals and assets, such as SAR aircraft and SAR marine

A U.S. Coast Guard 52-foot (16-meter) motor lifeboat in a wave in the northwest Pacific Ocean.

vessels, that are launched or diverted are not available to respond to other distress alerts; and,

- Expenditure of funds while responding to false alerts affects every SAR authority's ability to pay for operations in life-threatening emergencies.

In 2001, the Coast Guard estimated the following aircraft/vessel operating costs, not including the costs of personnel:[8]

- A Lockheed Martin HC-130 Hercules airplane costs US$9,332 per hour;
- A Dassault HU-25 Falcon airplane costs $6,174 per hour;
- A Sikorsky HH-60 Jayhawk helicopter costs $7,885 per hour;
- A Eurocopter HH-65 Dolphin helicopter costs $5,173 per hour;
- A cutter costs $3,000–7,000 per hour;
- A patrol boat costs $1,200 per hour; and,
- A small boat costs $500–1,500 per hour.

Although beacons are important survival tools, SAR authorities recommend that aircraft operators avoid complete reliance on any one method of communicating distress; develop realistic expectations by becoming aware of SAR limitations; provide optimal survival equipment, procedures and training; and compensate with ground personnel and backup plans wherever failures could occur. Immediate, proactive intervention by the aircraft operator's ground personnel is an essential element in a successful SAR response (see "A Signal for Help Is Heard, Help Arrives Too Late," page 130). Such preparations should include readiness to identify and to assist the RCC, and to closely monitor its response.

In recent years, relatively few ditchings involving professional flight crews and large aircraft have required a SAR response by the Coast Guard compared with ditchings involving nonprofessional pilots and small aircraft, said Dan Lemon, chief of the Coordination Division, Coast Guard Office of Search and Rescue.[9]

"An accident in which a business aircraft ditches and becomes a Coast Guard SAR case has occurred every two years or three years," he said. Coast Guard SAR-case data, which are collected for purposes of operational analysis rather than aviation safety analysis, do not contain separate categories for business/corporate aircraft, commuter/on-demand aircraft or helicopters.

To be realistic, aircraft operators should assume — for safety planning — that up to 24 hours could elapse before rescuers arrive at the scene of a water-contact accident in areas of the world where RCCs have well-developed SAR systems.

"It is hard to imagine taking longer than 24 hours — in most cases, survivors would be rescued a lot more quickly," Lemon said. "If the aircraft is ditched in a remote area, the time to rescue might be longer than 24 hours."

Some aircraft operators should visualize how they would cope with a rescue delay of up to a week, however, said Paul D. Russell, a maritime safety specialist and accident investigator, and a retired Coast Guard captain with more than 5,000 flight hours in fixed-wing and rotary-wing aircraft.[10]

Coast Guard training and procedures consider the risks to the survivors and the risks to SAR personnel in determining when and how to respond to a distress alert. Deaths of seven Coast Guard rescuers while conducting two SAR operations during the past six years underscore the risks, Steward said.

ATC and SAR authorities typically work together closely.

"We will be feeding back to ATC what we are doing for a number of reasons — first for air traffic separation because we will have our aircraft in the air searching," said Lt. Cmdr. Jay Dell, who replaced Steward as Cospas–Sarsat liaison officer and DASS implementation officer in the Coast Guard Office of Search and Rescue. "The SAR aircraft, the SAR mission coordinator or the air station of the search aircraft will keep ATC informed about search activities and the positions and altitudes of SAR aircraft. ATC then will issue an advisory to all other aircraft in the area to assist, to provide information on sightings of survivors or to remain clear of the SAR operations area, as required by circumstances."[11]

Because of their unique capabilities, SAR helicopters may be used to rescue survivors of an aircraft water-contact accident. Their relatively limited endurance and speed, however, reduce their radius of action. Radius of action means the maximum distance that the SAR aircraft or SAR marine vessel can travel away from its base along a given course with a normal mission load and return without refueling, allowing for all safety and operating factors. Helicopters usually arrive at the distress scene before marine vessels that must travel the same distance, and can be operated above heavy seas and in rough weather conditions. Their low-speed maneuverability and hovering capability enable rescuers to quickly recover survivors. While on scene, rescuers typically can raise survivors with a winch to the helicopter, and some helicopters can be used to conduct amphibious landings and takeoffs.

One of many pervasive myths about SAR response is that helicopters will be used to conduct every offshore rescue. In reality, the response will involve a SAR helicopter only when the accident occurs relatively close to shore (within the helicopter's radius of action) and when it is available.

The Coast Guard, for example, does not operate air-refuelable aircraft but, in some scenarios, may request assistance from similar air-refuelable military aircraft, crewed by personnel trained for SAR operations. When greater distances are involved, the response may require use of fixed-wing search aircraft and a Coast Guard cutter. For open-ocean searches at very long distances from shore, diverting a commercial ship may be the fastest method or the only method of rescuing survivors. In addition to distance from shore, adverse weather conditions can delay any rescue by hours or days.

Adverse weather conditions can delay any rescue by hours or days.

Data Show Dimensions of Challenges to SAR Authorities

The following data reflect the scope of international SAR activity:

- From 1982 through 2002, Cospas–Sarsat assisted in the rescue of more than 15,700 people in about 4,500 maritime, aviation and inland SAR cases worldwide;[12]

- In 2002, Cospas–Sarsat was the *only source of the distress alert and position* in 372 maritime, aviation and inland SAR cases worldwide, in which 1,411 people were rescued (approximately one SAR case per day);

- Data from 337 SAR cases — in which the Coast Guard responded to civil aircraft in distress during fiscal years 2000, 2001 and 2002 — showed that 50 cases (14.8 percent) were categorized as ditchings and 143 cases (42.4 percent) were categorized as other aircraft water-contact accidents. Of the 337 cases, 15 (4.5 percent) occurred more than 50 nautical miles

(93 kilometers) from shore, 124 (36.8 percent) occurred on inland waterways and 86 (25.5 percent) occurred on land. Use of a beacon to communicate distress was recorded in 12 of the 337 cases. These data, which are collected for purposes of SAR operational analysis rather than aviation safety analysis, do not contain separate categories for business/corporate aircraft, commuter/on-demand operations or helicopters. The Coast Guard annually reports about 40,000 incidents in which its resources are "used to aid any person and property.";[13]

- The Coast Guard requests 200 times to 400 times a year that commercial ships — usually among the 13,000 ships that participate in Amver (the acronym for Automated Mutual-assistance Vessel Rescue), a voluntary worldwide ship-reporting system — search/rescue people at sea;

- In 2002, Amver tracked an average of 2,760 ships per day, participated in 349 SAR cases and diverted 243 ships from 37 countries to conduct searches for 115 ships, to rescue 191 survivors and to assist 28 marine vessels; and,

- No assistance by Amver ships to survivors of ditched aircraft was reported in 2002; Amver data showed assistance to three ditched aircraft in 1996, two ditched aircraft in 1997, no ditched aircraft in 1998 and two ditched aircraft in 1999.

Type of Beacon Influences Response by Rescuers

Among the most important incentives for providing 406-MHz beacon technology for overwater operations are the differences in the size of the typical search area and the differences in RCC search policies. The required search area will be smallest when a 406-MHz GPS beacon has been activated and largest when a 121.5-MHz beacon has been activated (Figure 1, page 116).

One example of differences in search policies is that the absence of confirming information directly influences the decision by the SAR mission coordinator at a Coast Guard RCC to conduct a search.

"In any scenario involving only a distress alert from a 121.5-MHz beacon, we will not launch a visual search based on the first satellite pass," Steward said. "We will not launch a visual search to the first composite position — which is calculated from the second satellite pass over the beacon — unless we have other indications of distress: the report of a 'mayday,' the report of an overdue aircraft, a flare sighting, etc. It will not be until the second composite position is known — based on the third satellite pass — that we will launch our SAR response."

SAR response to the distress alert from a 121.5-MHz beacon may be minimal.

"For the distress alert from a 121.5-MHz beacon far out in the Pacific Ocean, we would not necessarily send an aircraft to search, but we would send a notice to all Amver ships passing through the area to keep a lookout," said Lemon. "Crews of these ships would not necessarily conduct a search, they would just tell us if they see anything."

In contrast, the Coast Guard policy is to respond to the first distress alert received from any 406-MHz beacon by beginning search preparations and, when the beacon position is confirmed, by initiating the search without delay unless the distress alert has been confirmed to be false.

"From information provided by a person listed as an emergency contact in an owner-registration database of 406-MHz beacons, we can create a track line to search and estimate by time, based on

SAR response to the distress alert from a 121.5-MHz beacon may be minimal.

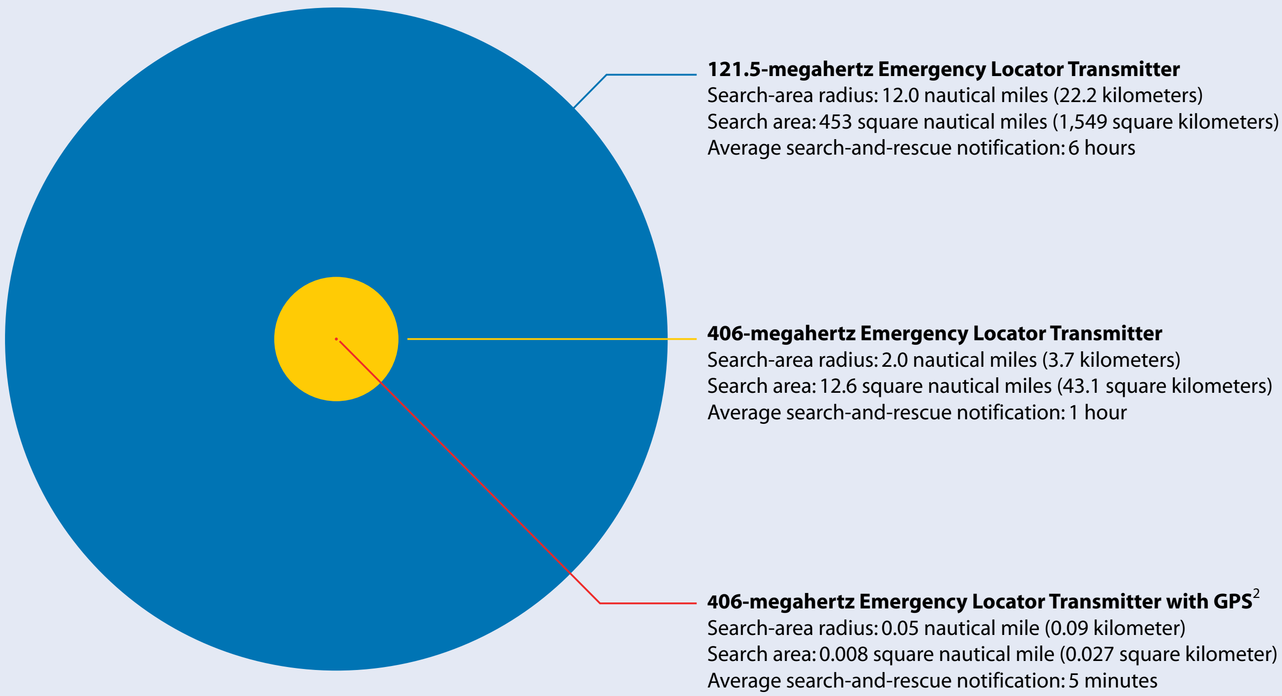
when the 406-MHz signal was received, where along that path the aircraft may be located," Steward said. "By knowing the type of aircraft and average speed, we can begin a search at that point with the knowledge that we will get position confirmation from the second pass of a polar-orbiting satellite."

Policies on conducting visual searches in response to distress alerts from 121.5-MHz beacons vs. 406-MHz beacons vary among RCCs in different parts of the world, however.

"We have chosen to respond to the first signal from 406-MHz beacons despite the high false-alert rate, but there is no international requirement that this be done," Lemon said. "For whatever reasons, not all countries do this. Our normal procedure — if the scenario involved a signal from a 406-MHz beacon far out in the Pacific Ocean — is that an Amver vessel probably would be diverted to go to the location and look around. If we did not find an Amver ship nearby, we probably would launch an aircraft and at least assess the situation."

To find survivors after arriving in the search area, crews of SAR aircraft typically use direction-finding equipment to home to the beacon. SAR equipment, training and capabilities vary widely, however. The Coast Guard, for example, has a wide array of advanced-technology SAR

Figure 1
Search Areas Determined by Technology of Emergency Radio Beacons[1]



Cospas = Cosmicheskaya Sistyema Poiska Avariynich Sudov (Russian words that mean "space system to search for marine vessels in distress")
GPS = Global positioning system SAR = Search and rescue Sarsat = Search and Rescue Satellite-aided Tracking

[1]Emergency radio beacons include emergency locator transmitters (ELTs), emergency position-indicating radio beacons (EPIRBs) and personal locator beacons (PLBs). Signals from these beacons are detected by the Cospas–Sarsat International Satellite System for Search and Rescue and are relayed to rescue coordination centers. Cospas refers to a SAR-instrument package built by the Union of Soviet Socialist Republics and carried on participating Russian satellites that are operated now by the Commonwealth of Independent States. Sarsat refers to Canadian/French-built SAR-instrument packages carried on participating satellites that are operated currently by the United States. Cospas–Sarsat also receives distress alerts from SAR instruments aboard satellites operated by India and by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) with the European Space Agency.

[2]Some 406-megahertz (MHz) EPIRBs and 406-MHz PLBs use position information from GPS receivers. Some 406-MHz ELTs use position information from a GPS receiver or other aircraft navigation equipment.

Source: U.S. National Oceanic and Atmospheric Administration

equipment — such as vision-enhancement devices — but aircraft operators should not assume that all SAR authorities have similar equipment. Among advanced equipment, forward-looking infrared cameras are passive systems that detect thermal radiation — such as the body heat of survivors — and generate live video images. They normally are preferred for night use.

Night-vision goggles also may be used by crewmembers of SAR aircraft or SAR marine vessels. The effectiveness of these devices depends, in part, on ambient light sources (including moonlight and starlight); the speed of the SAR aircraft or SAR marine vessel; the height of observers above the water; sea state and size; illumination and reflectivity of the search object (e.g., retroreflective tape on survivors and life rafts significantly increases the chances of detection by reflecting light toward the source so that the materials appear to be much brighter than their surroundings); and use of lights and pyrotechnics by survivors when searchers are within visual range.

When the crew of a SAR aircraft has the survivors in sight but is not in radio communication with them, procedures call for the crew to indicate to survivors that they have been sighted by flashing a signaling lamp or a searchlight, or by firing two signal flares (usually green) a few seconds apart. Another method to confirm the sighting of survivors is for the crew of a SAR airplane to fly over them at a lower altitude with landing lights illuminated or with wings rocking.

Policies and procedures for dropping survival equipment vary among rescue organizations, and may affect what, if anything, is dropped. Factors in the decision include whether other life rafts have been launched successfully and without significant damage; whether the survivors' life raft has become unserviceable; whether survivors in the life raft are overcrowded; and whether any survivors are in the water.

"Most often, these drops occur when survivors are far from an initial response by the Coast Guard or other resources and we have to use an HC-130 Hercules aircraft," said Dell. "Survivors absolutely should not make assumptions about how much longer they must wait for rescue.

"The first thing that the crew of the responding aircraft will try to do is establish communication and determine the overall situation. Using a radio transceiver dropped to survivors, they will tell survivors what is contained in packages that have been dropped and how to use specific equipment. Even if the crew of the first search aircraft to arrive cannot establish communication with survivors in a life raft, they will attempt to maintain 'top cover' over the scene to keep track of position and reassure survivors that they are working to assist them."

The fixed-wing SAR aircraft typically will keep the distress scene in sight; survey the distress scene; plot the location; communicate to the RCC's SAR mission coordinator details of the location, visible survivors, rescue risks/opportunities, actions taken, further requirements and overall situation; and mark the distress scene with a sea-dye marker, smoke float and/or datum marker buoy, which measures current and wind drift and transmits these data to SAR authorities, as appropriate. With the crew of a fixed-wing SAR aircraft coordinating on-scene activities and

An HC-130 has the range to conduct a search far offshore.

By staying together, survivors provide a bigger search object on the water.

SAR helicopters conducting rescues of survivors in daylight conditions and good visibility, marking the distress scene may be unnecessary.

The *International Aeronautical and Maritime SAR (IAMSAR) Manual* says that the SAR mission coordinator may direct the SAR aircraft crew that finds the survivors to remain on scene until relieved by another SAR aircraft or marine vessel, forced to return to base (e.g., by weather or low-fuel condition) or the rescue has been completed.[14] While on scene, SAR airplanes function as a radio communication center and airborne radar beacon/target, and provide radio signals for direction-finding and homing[15] by other SAR aircraft and SAR marine vessels.

Many Factors Challenge Searchers at Distress Scene

Computer-aided search-planning software enables the SAR mission coordinator of an RCC to quickly establish an initial search area and to expand the search area, based on objective criteria. Nevertheless, any time that SAR authorities conduct an open-ocean search, visually identifying a life raft or a person in the water is extremely difficult.

"Even if our aircraft fly over the entire search area, the probability of detecting the survivors still is not close to 100 percent without a beacon homing signal," Lemon said. "Nevertheless, we have found people when conditions were remarkable because the search area was so big and the search object was so small."

The *IAMSAR Manual* said, "Having a very precise search-object position is useful but does not eliminate the need for SAR unit homing capabilities. This is especially true if the SAR unit does not have precise navigation equipment or if operations take place at night or in other low-visibility conditions."

The size of a SAR search area depends on many factors, including the accuracy of the beacon position, the time elapsed before searchers arrive on scene and environmental factors such as ocean currents, waves and winds. The amount of time that searchers will require to conduct an air search of an open-ocean area depends largely on the sweep width (i.e., how far the search crew can see objects in the water from one side to the other side of the search aircraft).

The choice of sweep width will be based partly on the search target that searchers expect. The number of sweeps required to cover the area using an appropriate search pattern, multiplied by the time required to fly each sweep at the SAR aircraft speed, gives the time required to conduct a search one time.

"If we have a fixed-wing search aircraft in good visibility conditions, the crew typically would not take time to fly a search pattern on arrival because the crew often can see the whole area in one flyover — unless they are looking for one person in the water without a life raft, which would require searching at a lower altitude," Lemon said. "With a cutter or a helicopter at a normal search altitude of 500 feet, we would start from the best position we have. Searching from a known position is very fast unless we have low visibility. At night or in foggy conditions, searching is a whole different ballgame — this is when a homing signal can be very valuable even when we have an updated GPS position from a 406-MHz GPS beacon.

"With a 406-MHz GPS beacon and GPS-equipped search aircraft, searchers can go right to the beacon, except that they have to take into account that if a half hour elapsed in transit, the target could have drifted. If searchers do not have an updated GPS position when they arrive, they could be a little bit off the actual location. Although the crews of our SAR aircraft probably would see survivors of a ditched aircraft, searchers on the bridge of a ship could require a few passes in a shallow-circle pattern to see survivors. For the crew of a ship, a search area based on a 406-MHz GPS beacon position is much better than a search area based on a 406-MHz beacon without position data."

In the United States, the beacon type encoded in a 406-MHz signal determines which SAR organization is first to receive the distress alert. Any distress alert from an emergency position-indicating radio beacon (EPIRB) automatically goes to a maritime RCC operated by the Coast Guard. Any distress alert from a 406-MHz ELT or personal locator beacon (PLB; a compact beacon designed to be carried by an individual on land, but also used on water) automatically goes to the U.S. Air Force RCC, which coordinates all U.S. inland SAR cases (except aircraft water-contact accidents in a few inland bodies of water, to which the Coast Guard responds).

"If the location initially is not known, the U.S. Air Force will look at the owner registration data and try to ascertain where the aircraft is and who the owner is in response to the distress alert," Steward said. If the U.S. Air Force RCC determines that the distress aircraft is in a maritime SAR region, the distress alert will be forwarded to the Coast Guard.

"If an EPIRB is activated and the location initially is not known, the distress alert will go directly — with no delay — to a Coast Guard RCC that is responsible for maritime SAR," Steward said. "We coordinate very closely with the U.S. Air Force RCC, but there will be an extra step until they realize that the distress alert is from an aircraft over water and that they need to send the distress alert to a Coast Guard RCC. That may mean a delay of two minutes to half an hour, but when we are talking about life saving, minutes matter."

Similar delays can occur when the distress aircraft has been ditched in an inland body of water and a Coast Guard RCC is first to receive the distress alert from a 406-MHz EPIRB, he said. Differences in 406-MHz beacon-type encoding do not affect the significance attached to the distress alert by the Coast Guard or the U.S. Air Force, however, said Dell.

"For example, a PLB could be activated in the middle of the Pacific Ocean, but just because PLBs currently are encoded for land use does not mean that we will respond differently," Dell said.

The cessation of a beacon's signal after the first distress alert has been received from survivors of a water-contact accident would not affect a search that has been launched by the Coast Guard, Lemon said.

"Typically, that the signals stopped would not change our response, because people inadvertently turn off beacons and beacons stop transmitting for various reasons," Lemon said. "For example, aircraft can sink with the ELT, beacons can be damaged by fires, and antennas easily can get broken off on impact. If one of the RCCs got two or three distress alerts and then the alerts stopped, we still would investigate the distress alert."

Continued on page 122

"When we are talking about life saving, minutes matter."

Foundation Pioneered Early Overwater-safety Decisions

International safety systems for transoceanic flight and other overwater operations received significant attention in the 1950s, said Gloria W. Heath, an aerospace consultant who has been involved with many aspects of overwater safety in aviation.[1] In the early 1950s, Heath recognized that differences in civil aircraft pilot training, technology and search-and-rescue (SAR) systems — compared with prewar operations — warranted attention by airlines, manufacturers, pilots and regulators.

"There was not much civil transoceanic travel by airplane until the 1950s," Heath said. "Before World War II, the only airplanes used for transoceanic commercial passenger service had been seaplanes. Pilots in the 1950s knew that under some circumstances they would have to 'alight' on the water — ditching was the well-known term," Heath said. "I asked then what Flight Safety Foundation was going to do to lead in this situation, and I took the initiative by getting in touch with the U.S. Coast Guard. I asked them to start a training program for former military pilots and nonmilitary pilots who would be flying land airplanes over the ocean. Coast Guard seaplane instructors took these pilots out over the water to educate them about how they could gauge swells, currents and the speed and direction of wind on the water, enabling them to evaluate the factors required to conduct a ditching with the least damage to the airplane."

During this period, SAR capabilities at sea were enhanced by Coast Guard ocean stations, marine vessels positioned at sea for routine communication with crews of aircraft on transoceanic flights. ("We have not had ocean stations since the 1970s," said Lt. Cmdr. Jay Dell of the Coast Guard. "They were replaced by better capability to respond.")[2]

Heath also pursued methods of safe ditching by interaction with the U.S. National Advisory Committee for Aeronautics (NACA, predecessor of the U.S. National Aeronautics and Space Administration). NACA built scale models of airplanes that would be flying over oceans and tested the ditching performance of the models in water tanks (see "Ditching Certification — What Does It Mean?" page 66).

"NACA worked to determine the best landing configurations for ditching and how manufacturers could make design modifications and hull reinforcements," she said. "NACA published several reports on results of testing models that

Gloria Heath, in winter flying gear, before a 1943 primary training flight in a Boeing Stearman for the U.S. Women Airforce Service Pilots.

Gloria Heath

were ditched with flaps down, flaps up, wheels down, wheels up, etc. There was a question of the validity of scale-model tests against real-world performance, but there also were a number of ditchings to study."

In the following decades, Heath led or participated in several initiatives that became the basis of the current SAR system worldwide. These included Amver (the acronym for Automated Mutual-assistance Vessel Rescue, a voluntary worldwide ship-reporting system operated by the Coast Guard), and the International Convention for the Safety of Life at Sea (SOLAS), which includes common safety standards and procedures for marine vessels.

She was an early advocate of the use of emergency locator transmitters (ELTs) in general aviation and worked to interest owners in equipping their aircraft with ELTs.

"The Foundation was very instrumental in getting the first ELT requirement into effect through the U.S. Federal Aviation Administration, which greatly simplified searching for aircraft at the time," she said.

As director of SAR-ASSIST after leaving the Foundation, she was a pioneer in developing survival equipment, locating survivors, advocating acoustic beacons for underwater location of flight data recorders and cockpit voice recorders, and using chemical-luminescence strips to mark emergency-exit pathways in transport aircraft. She also was chairman of the Committee on Safety and Rescue Studies of the International Academy of Astronautics, which — in the course of studying satellite-based rescue systems for astronauts and cosmonauts — recognized the potential use of satellites to send all kinds of distress/disaster alerts from anywhere on Earth to international authorities.

The committee's SAR-related recommendations — which became reality in the Cospas–Sarsat International Satellite System for Search and Rescue — also inspired United Nations conferences on peaceful methods of using remote-sensing satellites, weather satellites and communication satellites to predict and mitigate natural disasters through better infrastructure, warning systems and response capabilities, she said. ■

— FSF Editorial Staff

Notes

1. Heath, Gloria. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 24, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Heath was the first employee of Aircraft Engineering for Safety (AES), and she helped Jerome F. "Jerry" Lederer (FSF president, emeritus, until his death Feb. 6, 2004) merge AES with Flight Safety Foundation in 1947. In 1948, she was FSF project manager of the first formal course in aircraft accident investigation to be conducted in the United States, Lederer said. In 1965, she left the Foundation to become a consultant to the Cornell-Guggenheim Aviation Safety Center. She later served as a member of the FSF Board of Governors. Currently, she is actively involved in the Foundation as an FSF governor, emeritus. Heath influenced many systems that enable survival in water-contact accidents. As assistant director of the Cornell-Guggenheim Aviation Safety Center and as director of SAR-ASSIST, Heath has been an aerospace scientist and consultant. Her career began as a pilot in the Women Airforce Service Pilots, U.S. Army Air Force, in World War II.

2. Dell, Jay; Cospas–Sarsat liaison officer and Distress Alerting Satellite System (DASS) officer, Office of Search and Rescue, U.S. Coast Guard, U.S. Department of Homeland Security. Interview by Rosenkrans, Wayne. Washington, D.C., U.S. July 2, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. The Cospas–Sarsat International Satellite System for Search and Rescue currently includes satellites provided by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) with the European Space Agency, India, Russia and the United States. Cospas is the acronym for the Russian words Cosmicheskaya Sistyema Poiska Avariynich Sudov, which means "space system to search for marine vessels in distress," and refers to a SAR-instrument package carried on Russia's polar-orbiting satellites. Sarsat, the acronym for Search and Rescue Satellite-aided Tracking, refers to Canadian/French-built SAR-instrument packages carried on U.S. polar-orbiting satellites.

Regarding circumstances in which suspension of search operations must be considered, the *IAMSAR Manual* said, "The decision to suspend a search involves humanitarian considerations, but there is a limit to the time and effort that can be devoted to each SAR case. … The decision to suspend operations should be based on an evaluation of the probability that there were survivors from the initial incident, the probability of survival after the incident, the probability that any survivors were within the computed search area, and the effectiveness of the search effort as measured by the cumulative probability of success." Some RCCs use computer software to assist in determining the probability of survival based on factors such as the survivor's age, weight, height, clothing with/without a survival suit, type of survival suit, air temperature, water temperature and the height of seas (see "Is There a Doctor Aboard the Life Raft?" page 187).

Amver System Enables SAR Response From Marine Vessels

If SAR authorities believe that a ship is the best rescue option, they may turn to Amver. For example, if the crew of a business aircraft ditches in the South Atlantic Ocean or the South Pacific Ocean, the closest ship might be only 250 nautical miles (463 kilometers) away, Lemon said. Coast Guard fixed-wing aircraft can drop emergency supplies but cannot conduct the rescue. The Dassault HU-25 Falcon can search using a radius of action of 800 nautical miles (1,482 kilometers), and the Lockheed Martin HC-130 Hercules has a radius of action of 1,600 nautical miles (2,963 kilometers).

The Sikorsky HH-60 helicopter has a radius of action of 300 nautical miles (556 kilometers) and the Eurocopter HH-65 helicopter has a radius of action of 150 nautical miles (278 kilometers).

"The primary rescue units in the middle of the ocean are commercial ships — not Coast Guard cutters or Coast Guard helicopters," Lemon said. "A commercial ship would take more than 16 hours to travel 200 nautical miles [370 kilometers] to get to the scene at 12 knots."

In practice, using commercial ships to assist survivors of a ditching has been rare, said Dell. The reason is that most water-contact accidents have occurred relatively close to shore.

As the world's only voluntary ship-reporting system operated exclusively for SAR on a global basis, Amver enables the SAR mission coordinator of an RCC to identify participating ships in the area of distress and request assistance from the crews of the best-suited ship or ships. Participation has been limited to ships of more than 1,000 gross tons on a voyage of 24 hours or longer, said the Coast Guard, which operates Amver. In recent years, cruise ships, research vessels and fish-processing vessels also have participated.

> **"The primary rescue units in the middle of the ocean are commercial ships."**

Movements of participating ships from more than 140 nations are plotted continuously with a computer system, using plans and reports sent by vessel operators. Position data are displayed graphically as a "surface picture" on computer terminals in some RCCs — or sent by Internet e-mail or faxed by request to SAR mission coordinators in other RCCs.

"Crews of participating ships log into the Amver system when they depart a port," Steward said. "They submit sail plans, position reports, arrival reports and deviation reports so we know where Amver ships are or will be in the next two-hour period. We typically contact a nearby Amver ship via high-frequency (HF) radio or satellite communication. In seven years, I have never known an Amver vessel to say no to a Coast Guard request to respond to a distress scene."

RCCs also can call upon captains of Amver ships if survivors of a water-contact accident require emergency medical treatment far from land.

"A lot of merchant ships have physicians," Steward said. "If we are on a cutter in the middle of the ocean or our SAR-helicopter crew has picked up someone who needs immediate medical attention, we also may divert one of the Amver ships with a physician to provide medical assistance."

Any RCC in the world can use Amver, and use of the system increased during the 1990s so that diverting an Amver vessel to aid vessels in distress became routine, Lemon said.

Amver also exchanges ship-reporting data with several similar systems operating in specific nations or specific areas of the world, such as SECOSENA in Argentina, AUSREP in Australia, SISTRAM in Brazil, ECAREG and NORDREG in Canada, U.S./Canada Vessel Traffic Services Area (CVTS Offshore), CHILREP in Chile, SHIPPOS in Denmark, GREENPOS and KYSTKONTROL in Greenland, INSPIRES in India, AREA in Italy, JASREP in Japan and SINGREP in Singapore.

RCCs Swap Information but Operate Autonomously

In many countries, the entity responsible for the RCC and maritime SAR response is a ministry of transportation, navy, air force or coast guard. No RCC has authority to oversee or to direct the decisions of the RCC in another country, however, Steward said.

"RCCs are not reporting to any higher central authority that is monitoring everything," Lemon said. Rather, relationships among the staffs of RCCs around the world are based on the principles of SAR information exchange among equals and on professional courtesy, he said.

Global SAR principles and methods have become simpler to understand during the past five years. SAR authorities worldwide have been adopting common standards and procedures jointly developed by the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) and published in the *IAMSAR Manual*.

The *IAMSAR Manual* says, "A basic, practical and humanitarian characteristic of having a global SAR system is that it eliminates the need for each [nation] to provide SAR services for its own citizens wherever they travel worldwide. Instead, the globe is divided into SAR regions, each with [an RCC] and associated SAR services, which assist anyone in distress within the SAR region without regard to nationality or circumstances."[16] ICAO Annex 12, *Search and Rescue*, defines a SAR region as "an area of defined dimensions, associated with an RCC, within which SAR services are provided."

Many nations and regions with advanced SAR capabilities provide detailed information to aircraft operators through publications and Internet sites. Some nations where SAR capabilities are minimal may provide information to aircraft operators only by request. ICAO recommends that aircraft operators communicate directly with SAR authorities for the most current information. Nevertheless, other information sources used within the SAR community can be compared for a general impression of the SAR environment along a specific route.

"We strive constantly to keep valid lines of communication and points of contact within all countries," said Dell. "That is a very difficult task and very indefinite in terms of ensuring that a timely, appropriate response can be initiated by any given country."

Aircraft operators should expect the SAR response to a water-contact accident to be based on procedures and methods in the *IAMSAR Manual* and in regional/national supplements published by SAR authorities. The Coast Guard recommends that aircraft operators use the *IAMSAR Manual*, Volume 3, and provide to pilots quick-reference procedures that incorporate *IAMSAR Manual* information.

SAR authorities worldwide have been adopting common standards and procedures.

"Volume 3 would give any aircraft operator a good overview and a very good start in what they need to know to develop overwater-safety procedures," Steward said. "It gets everybody — not just the rescuers — on the same page, including what survivors can expect. It is a good idea for aircraft operators to check out the route and know who will be responsible for SAR response on the overwater segments. When flying well off a coast — or anywhere there may not be the best SAR response — the aircraft operator may need additional survival equipment, including drinking water, warm clothing and hats, and food because of the rescue time factor."

Several noncommercial information sources are available — in addition to commercial flight-planning services — for learning about the SAR capabilities of nations along an overwater route. SAR regions, and the nation that has accepted SAR-coordination responsibility for each SAR region, can be identified on charts in regional ICAO air navigation plans. Some RCCs cannot coordinate open-ocean searches and do not have access to SAR aircraft or SAR marine vessels that can conduct open-ocean rescues, however.

"The SAR sections of the air navigation plans should be understood as plans and not reality," said Brian Day, technical officer, Air Traffic Management Section, ICAO. "It is beyond ICAO's resource capacity to maintain a current list of all 189 member states' assets. The usefulness of air navigation plans is very limited in showing the extent of these SAR assets to operators that are determining how they should support their operations from a SAR perspective."[17]

For general research by aircraft operators, Day directs attention to an Internet site — <http://www.sarcontacts.com> — created and maintained by RCC Halifax, Nova Scotia, Canada, and EMS Technologies with support and funding from the Canadian Coast Guard and the Canadian National SAR Secretariat.

"Operators may find this database of international SAR agencies and RCCs useful as a tool in safety planning," Day said.

For emergency planning by aircraft operators, charts in the SAR sections of ICAO air navigation plans also show the short-range search areas over oceans that can be covered by SAR helicopters and

The first RCC to receive a distress alert either must respond or hand off the case to an RCC that's better suited to respond.

the extra-long-range search areas over oceans that can be covered by SAR fixed-wing aircraft from various points on land. "These are purely ICAO plans for maritime search capability — not rescue capability," said Lemon.

IMO has been developing a database of the resources available to the world's RCCs, Lemon said. To help aircraft operators plan overwater operations, he recommended the IMO Internet site <www.imo.org> for updates about global SAR plans.

Nations with relatively advanced SAR capabilities benefit from the trend toward cooperative methods. For example, Canada, the United Kingdom and the United States collectively have defined methods of responding to SAR cases where SAR regions and responsibilities meet in large expanses of the Atlantic Ocean.

"The United States has 15 SAR agreements with other countries," Lemon said. "U.S. responsibilities comprise 10 maritime SAR regions, one SAR region for the State of Alaska and one for the continental United States. Another 22 SAR regions of other countries border those of the United States. In our oceanic SAR regions, we handle three-fourths of the North Pacific Ocean and about half of the North Atlantic Ocean. The Coast Guard handles all maritime SAR cases and aeronautical SAR cases that occur over water in these regions."

More maritime SAR regions exist worldwide than aeronautical SAR regions because aeronautical SAR regions have been combined for efficiency, which was made possible by the increasing range of aeronautical radio communication. A number of nations with well-developed RCCs and extensive experience routinely provide SAR coordination — sometimes far from their SAR regions — and help to identify SAR resources from outside the region where the distress alert occurs.

"For example, Norway coordinates many of the maritime SAR responses in the Indian Ocean, France coordinates many responses off the coasts of Africa, and the United Kingdom coordinates some SAR cases in the South Atlantic Ocean," Lemon said. "The South Atlantic Ocean is a vast expanse of ocean with practically no land areas. Some countries in South America and Africa have limited resources to respond to an aircraft ditching or distant maritime SAR case."

International flight operations often are conducted through maritime SAR regions. IMO has divided the world's oceans into 13 maritime SAR areas, in which nearby countries have defined and accepted responsibility for maritime SAR regions. ICAO regional air navigation plans show the aeronautical SAR regions and maritime SAR regions for most of the world.

Complex relationships and agreements govern operations by SAR authorities of one country in the territorial waters of another country. Typically, the humanitarian nature of the work is recognized and provisions have been made for immediate action when the distress scene is known and lives are at stake.

"Searching and rescuing are totally different ballgames when the situation involves territorial waters where another country has sovereign control," Lemon said. "In a purely rescue situation — when we know that if we do not go in, nobody else will, and people will die — we notify the country but do not waste time requesting permission to save survivors. We balance the concern for sovereignty and the concern for lifesaving.

"On the other hand, if the situation is an overdue aircraft that may be in distress, but a search is required because we are not sure where the aircraft is, we normally request permission to search another country's territorial waters because we do not know whether people actually are in distress or whether we could help them."

This general practice is based on U.S. interpretations of international law; explicit agreements with some countries enable many searches for SAR purposes to be conducted in another country's territorial waters without requesting permission.

Planning Compensates For Extreme Disparities in SAR Capabilities

Failure to consider SAR capabilities along overwater routes in some areas of the world can leave an aircraft operator unprepared for scenarios that can occur after a water-contact accident. The reason is that extreme disparities exist among SAR capabilities despite the universal intention to render humanitarian assistance.

"Currently, maritime SAR is not fully implemented around the world — some maritime SAR systems exist on paper only," said Lemon. "This is mainly a problem among developing nations that have limited resources. The reality is that there are fewer resources in the southern hemisphere, for example, than in the northern hemisphere — fewer countries, fewer commercial ships and fewer aircraft. Survivors of an aircraft ditching probably would have to wait longer to be rescued in the southern hemisphere. The Coast Guard can contact quickly just about any RCC — but not all of them, such as those in nations that have not developed their SAR capabilities very well. We are working with IMO to do assessments and to find at least enough funding to get the RCC functions going."

Many international organizations have been working to improve SAR capabilities in some of the least-capable SAR regions, however. The relevance of this work to any particular aircraft operator depends on the geographic location of its overwater flight operations.

"Some aircraft are in radar range and radio range all the time and are monitored by air traffic control," Day said. "Other aircraft are likely to conduct flights in environments that are less well monitored. Operators faced with a paucity of navigation aids and/or ordinary communication facilities are most at risk."

Africa currently is the primary focus of international SAR improvement through combined efforts of African nations, non-African nations, ICAO, IMO and the Cospas–Sarsat Secretariat. Some African SAR regions have had serious deficits for decades, a situation that has prompted external financial support and technical assistance in recent years.

> **"Some maritime SAR systems exist on paper only."**

"Various authorities currently are focusing on the improvement of

"Unlike the provision of air traffic services, SAR is perceived to cost money, not make money."

SAR services in areas of the world that are either historically deficient or presently critical," Day said. "But absence of adequate investment in SAR services by some governments sometimes reflects long-held beliefs.

"Unlike the provision of air traffic services, SAR is perceived to cost money, not make money. The economic implications deserve closer consideration, however. Historically, conducting an open-ocean search was the major cost factor. Extensive research has shown that the value of lives and equipment saved over time far exceeds the cost of the SAR services that reclaimed them. Some intangible benefits largely defy quantification; these include benefits to tourism, trade and commerce and the goodwill that arises from obvious attention to humanitarian issues."

Recent international consensus about improving English-language proficiency in aeronautical communication — including distress situations — also is expected to positively influence SAR capabilities. ICAO will require, beginning in November 2008, a specified level of English-language proficiency for air traffic controllers and for flight crews that operate internationally. The requirements are based on international recognition of the value of a language for ATC communication that can be used in addition to an ATC facility's national language.

"Aeronautical voice telephony is the primary means of communication, even with the introduction of controller-pilot data link communication," Day said. "Improving proficiency in English will place a huge economic demand on nations and airlines, but the benefits will be extremely positive. RCCs indirectly will have a requirement to communicate rapidly and reliably with ATC and, in some cases, with pilots.

"ICAO cannot impose the same degree of requirement on the SAR domain as on the ATC domain. But it stands to reason that the same imperative for improved communication in English rests with RCCs during communication between RCCs, during communication between an RCC and ATC and during communication between an RCC and a pilot."

Behind the Scenes, Local Policies Govern Searches

Under international SAR conventions, any nation that assumes responsibility for a SAR region commits in principle to providing a fully capable RCC or equivalent services. In some cases, nations establish rescue subcenters under the RCC of another nation to provide SAR services within their SAR regions, the *IAMSAR Manual* said.

The manual says that governments will delegate to their RCCs the authority to directly coordinate SAR responses with RCCs of other regions and nations. Usually, delays that would be caused by communicating through diplomatic channels can be avoided, Lemon said. Sometimes an RCC receives a distress alert and retains the coordination function after determining that there is no suitable RCC for handing off the SAR case in the SAR region where the distress has occurred, he said.

"The 'first RCC' principle holds that the first RCC to receive a distress alert is responsible for responding to the SAR case until it can arrange for response by an RCC that is closer or better suited to take over the SAR case," said Lemon. "If there is none, the first RCC keeps the SAR case even though the distress alert might have come from outside its SAR region. When this principle is followed, a SAR case does not fall through the cracks [i.e., fail to receive a response because of confusion about which RCC is responsible]."

Clear communication from one RCC to another is essential in the handoff process.

"Some nations have chosen to use SAR-region boundaries as indicators of sovereign right — which is a complete misapplication of the concept of SAR regions," Day said. "The most operationally enlightened view is that SAR regions would become invisible to aircraft operators and would not limit the SAR response."

Next-generation GPS Satellites Integrate New SAR Functions

New U.S. satellite technology for detecting signals from 406-MHz beacons — called the Distress Alerting Satellite System — has been designed to add SAR-instrument packages to future constellations of GPS satellites in medium-Earth orbits. The European Commission/European Space Agency, Russia and the United States all are working with Cospas–Sarsat on similar technology. In the United States, for example, two DASS-equipped GPS satellites are in a demonstration and evaluation phase. If DASS is fully implemented as planned, a 406-MHz beacon anywhere on Earth's surface will be in view of four satellites, and within 10 minutes, SAR authorities will be able to determine twice as accurately as with current technology the location of all types of 406-MHz beacons. DASS also may enable RCCs to confirm that a distress alert is genuine, to know the circumstances of survivors and to tell survivors the status of SAR assistance, Lemon said.

"Technically, there is no reason that we cannot have two-way text communication between an RCC and survivors except that beacons will have to be designed to take advantage of this capability," he said. "The advertised time frame for fully operational DASS is 2015, but I believe the change could be quicker. For Cospas–Sarsat to agree to let DASS become part of its system, test results must demonstrate that this technology works globally."

The Coast Guard also is among SAR authorities seeking improvements in worldwide SAR response to aircraft involved in a ditching or other water-contact accident that occurs in the vicinity of an airport (as well as accidents on land). Airports currently do not receive directly distress alerts from ELTs, and the nine-minute time for processing distress signals detected by satellite significantly exceeds current standards for on-airport response by aircraft rescue and fire fighting (ARFF) services.

"The problem with an aircraft going down just off an airport is how to know immediately that it went down and its position," Lemon said. "If all ATC knows is that the aircraft went off radar, it could take ARFF and the Coast Guard a relatively long time to find it. At the request of the Air Line Pilots Association, International, the U.S. National SAR Committee is considering the potential role of 406-MHz ELTs with position encoding and other technologies so that distress alerts not only go through satellites to an RCC but instantly go to ATC and ARFF authorities at the local airport." ■

The bottom line, in our opinion …

- **Some SAR systems exist on paper only. Others vary widely in the resources available to conduct visual searches from aircraft and to conduct open-ocean rescues.**
- **Aircraft operators should have familiarity with the RCCs that might become responsible for coordinating efforts to find and rescue survivors of a ditching along their overwater routes.**
- **Automated systems forward satellite-detected distress alerts to the appropriate RCC, where people become responsible for whatever action is — or is not — taken.**
- **Finding survivors in the open ocean usually is less difficult than conducting the rescue.**
- **Aircraft operators have a vital interest in globally harmonized SAR procedures and in international initiatives to upgrade substandard resources.**

Notes

1. The term "declaring an emergency" — while not part of the official phraseology of the International Civil Aviation Organization (ICAO) — is widely understood to mean that a pilot (or air traffic controller or aircraft operator) is formally notifying air traffic control that an aircraft is in distress. "Distress" in ICAO phraseology means "a condition of being threatened by serious and/or imminent danger and of requiring immediate assistance." Distress is communicated by the word "mayday" repeated three times in voice radio communication; the letter group "SOS" telegraphed in Morse code; rockets, shells, rocket-launched red flares or cartridge-launched red flares (fired one at a time at short intervals) or a red parachute flare (ICAO Annex 10, *Aeronautical Telecommunications*, Volume 2, 5.3, "Distress and Urgency Radiotelephony Communication Procedures").
2. Steward, Paul. Interview by Rosenkrans, Wayne. Suitland, Maryland, U.S. April 9, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Steward retired from the U.S. Coast Guard in June 2003. Although search-and-rescue (SAR) authorities of other countries also play an essential role in responding to aircraft water-contact accidents, limited FSF editorial resources and close proximity to Coast Guard personnel were the primary reasons that the staff focused on the policies and practices of the Coast Guard, which has headquarters in Washington, D.C., U.S. The Coast Guard is part of the U.S. Department of Homeland Security. SAR authorities in many other countries also share expertise and conduct humanitarian activities that are essential to global SAR efforts, and aircraft operators should contact SAR authorities in their respective countries for more information.
3. The Cospas–Sarsat International Satellite System for Search and Rescue currently includes satellites provided by the European

Organization for the Exploitation of Meteorological Satellites (EUMETSAT) with the European Space Agency, India, Russia and the United States. Cospas is the acronym for the Russian words Cosmicheskaya Sistyema Poiska Avariynich Sudov, which means "space system to search for marine vessels in distress," and refers to a SAR-instrument package carried on Russia's polar-orbiting satellites. Sarsat, the acronym for Search and Rescue Satellite-aided Tracking, refers to Canadian/French-built SAR-instrument packages carried on U.S. polar-orbiting satellites.

4. Cospas–Sarsat Secretariat. "Cospas–Sarsat Data Distribution Plan." Issue 4, Revision 5. October 2002. 3–8. Frequencies in the range of 406.0 MHz to 406.1 MHz are reserved for beacons designed to transmit distress alerts in the Cospas–Sarsat program. Most current 406-MHz distress beacons operate on 406.025 MHz or 406.028 MHz. In 2004, radio beacons that use an additional channel — 406.037 MHz — will be available.

5. The following countries are formally associated with the Cospas–Sarsat program as providers of ground receiving stations or as user nations: Algeria, Australia, Brazil, Chile, China, Denmark, Germany, Greece, India, Indonesia, Italy, Japan, Madagascar, Netherlands, New Zealand, Nigeria, Norway, Pakistan, Peru, Saudi Arabia, Singapore, Spain, South Africa, South Korea, Sweden, Switzerland, Thailand, Tunisia and United Kingdom. Independent organizations in Hong Kong and Taiwan, China, also provide ground receiving stations. Three specialized agencies of the United Nations — ICAO, the International Maritime Organization (IMO) and the International Telecommunications Union (ITU) establish requirements and/or standards for SAR equipment and use.

6. In October 2003, Cospas–Sarsat SAR points of contact worldwide included the following mission control centers (MCCs), rescue coordination centers (RCCs [MRCCs for maritime; ARCCs for aeronautical]), joint search-and-rescue centers (JSRCs), rescue sub-centers (RSCs) and organizations: Rinas Tirana International Airport (Albania), Ascension Island Air Operations (Ascension), RCC Australia (Australia, Adelie Land, Christmas Island, Cocos [Keeling] Island, St. Paul and Amsterdam), RCC Kabul (Afghanistan), Algeria MCC, Luanda RCC (Angola), MRCC Fort de France (Anguilla, Antigua, Dominica, Guadeloupe, French Guiana, Martinique, Montserrat, Saint Kitts and Nevis, Saint Lucia), Argentina MCC, RCC Vienna (Austria), Radiocommunication Center (Azerbaijan), MRCC Lisboa (Azores, Madeira, Portugal), Civil Aviation Authorities (Bangladesh), Central American Corporation for Air Navigation Services (COCESNA; Belize, Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua), San Juan RSC (British Virgin Islands, Dominican Republic, Grenada, Netherlands Antilles, Puerto Rico, Saint Vincent and the Grenadines, Trinidad and Tobago, and U.S. Virgin Islands), Miami RCC (Bahamas, Barbados, Cayman Islands, Cuba, Haiti, Jamaica, Turks and Caicos Islands, United States), RCC Bahrain, Brazil MCC, RCC Bruxelles (Belgium), Cotonou Airport (Benin), Bermuda RCC, La Paz RCC (Bolivia), Banja Luka RCC (Bosnia and Herzegovina), MRCC Varna (Bulgaria), MRCC Cape Town (Botswana, Burundi, Lesotho, South Africa), Brazil MCC, RSC Ouagadougou (Burkina Faso), RSC Douala (Cameroon), Canada MCC, RCC Sal (Cape Verde), RSC Bangui (Central African Republic), Department of Civil Aviation (Bhutan), RCC N'Djamena (Chad), Chile MCC, China MCC, Hong Kong MCC (China), Office of Search and Rescue Group (Colombia), MRCC La Réunion (Comoros, Crozet Archipelago, Kerguelen Islands, Mayotte, La Réunion), ACC Brazzaville (Congo), RCC Wellington (Cook Islands and New Zealand), RCC Abidjan (Cote d'Ivoire), MRCC Rijeka (Croatia), JRCC Curaçao (Aruba, Netherlands Antilles), RCC Larnaca (Cyprus), Air Navigation Services (Czech Republic), Kinshasa RCC (Democratic People's Republic of the Congo), RCC Karup (Denmark, Faroe Islands, Greenland), RSC Djibouti, RSC Bata (Equatorial Guinea), Ecuadorian Air Force (Ecuador), SAR Center (Egypt), ACC Asmara/RCC Asmara (Eritrea), MRCC Tallinn (Estonia), Falkland Islands RCC, RCC Nadi (Fiji), RCC Turku (Finland), France MCC (Andorra, Gibraltar and France), RCC Tahiti (French Polynesia), RSC Libreville (Gabon), RSC Banjul (Gambia), MRCC Georgia (Commonwealth of Independent States), RCC Münster (Germany), National Disaster Management Organization (Ghana), RCC Piraeus (Greece), RCC Conakry (Guinea), RSC Bissau (Guinea-Bissau), Civil Aviation Department (Guyana), Budapest Air Traffic Control Center (Hungary), GUFUNES Telecommunication Center (Iceland), India MCC, Indonesia MCC, RCC Tehran (Iran), RCC Baghdad (Iraq), Irish Coastguard (Ireland), Tel Aviv Ben-Gurion Airport (Israel), Italy MCC, Japan MCC, RCC Amman (Jordan), Nairobi RCC (Kenya), Marine Guard (Kiribati), Republic of Korea MCC, RCC Kuwait, MRCC Riga (Latvia), RCC Roberts (Liberia), RCC Zurich (Liechtenstein and Switzerland), ARCC Vilnius (Lithuania), RSC Luxembourg, Macao Marine Department (Macao), RCC Antananarivo (Madagascar), Lilongue RCC (Malawi), Maldives Airports Authority, RSC Bamako (Mali), Malta RCC, RCC Honolulu (Marshall Islands, Micronesia, Northern Mariana Islands and Palau), Civil Aviation (Mauritania), RCC Mauritius, Mexican Navy (Mexico), MRCC Gris Nez (Monaco), ARCC Mongolia, RCC Casablanca (Morocco), Maputu RCC (Mozambique), NAMSAR (Namibia), RCC Nauru, Department of Civil Aviation (Nepal), Netherlands Coast Guard (Netherlands), Norway MCC, RCC Nouméa (New Caledonia, Wallis and Futuna), RCC Niamey (Niger), Nigeria MCC, Norway MCC and JRCC Stavanger (Norway), RCC Muscat (Oman), Pakistan MCC, Aeronáutica Civil (Panama), Peru MCC, RCC Port Mooresby (Papua New Guinea), Asunción RCC (Paraguay), Peru MCC, Manila RCC (Philippines), Pitcairn Police (Pitcairn Island), Warsaw RCC (Poland), RCC Abu Dhabi (Qatar), Civil Aviation Authority Flight Operations (Romania), Russia MCC, Kigali RCC (Rwanda), Samoa National Surveillance Center, Saudi Arabia MCC, RCC Dakar (Senegal), ACC Belgrado (Serbia and Montenegro), Seychelles RCC, RSC Freetown (Sierra Leone), Singapore MCC, Bratislava MCC (Slovakia), Harbor Master Office (Slovenia), MRCC Honiara (Solomon Islands), South Africa MCC, Spain MCC, Colombo RCC (Sri Lanka), Department of Civil Aviation (Surinam), RSC Matsapha (Swaziland), ARCC Göteborg (Sweden), Taipei MCC (Taiwan, China), Dar es Salaam RCC (Tanzania), Thailand MCC, RCC Bangkok (Thailand), RSC Lome (Togo),

Tonga Defence Services (Tonga), Tunis ACC (Tunisia), RCC Ankara (Turkey), ARCC Funafuti (Tuvalu), Entebbe RCC (Uganda), Odessa MRCC (Ukraine), Emirates RCC (United Arab Emirates), U.K. MCC (United Kingdom of Great Britain and Northern Ireland), U.S. MCC (United States), Carrasco RCC (Uruguay), Vanuatu Meteorological Services, RCC Maiquetia (Venezuela), Vietnam MCC, RCC Sanaa (Yemen), Lusaka RCC (Zambia) and Harare RCC (Zimbabwe).

7. IMO and ICAO. *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual*. Document 9731–AN/958. Volumes 1–3. 1998, 1999. "False alerts are any alerts received by the SAR system which indicate an actual or potential distress situation, when no such situation actually exists," the *IAMSAR Manual* says. "The term 'false alarm' is sometimes used to distinguish a false alert known to have originated from an equipment source intended to be used for distress alerting. Causes of false alerts include equipment malfunctions, interference, testing and inadvertent human error. A false alert transmitted deliberately is called a hoax. It is essential that SAR personnel treat every distress alert as genuine until they know differently."

8. The Coast Guard uses cutters — marine vessels 65 feet (20 meters) or greater in length having adequate accommodations for crew to live aboard — and small boats on the water, and airplanes and helicopters in air operations. Cutters usually have a motor surf boat and/or a rigid-hull inflatable boat aboard. Fixed-wing aircraft — Lockheed Martin HC-130 Hercules turboprops and Dassault HU-25 Falcon jets — operate from large air stations and small air stations. Helicopters — the Eurocopter HH-65 Dolphin and Sikorsky HH-60 Jayhawk — operate from flight-deck equipped cutters, air stations and air facilities. Boats — all marine vessels 12 feet to 64 feet (four meters to 20 meters) in length — usually operate near shore and on inland waterways. They include motor lifeboats; motor surf boats; large utility boats; surf rescue boats; port security boats; aids-to-navigation boats; and a variety of smaller, nonstandard boats including rigid inflatable boats.

9. Lemon, Dan. Interview by Rosenkrans, Wayne. Washington, D.C., U.S. June 24, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

10. Russell, Paul D. Interview by Flight Safety Foundation editorial staff. Alexandria, Virginia, U.S. May 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. In the U.S. Coast Guard, Russell conducted more than 200 water landings and served in various positions, including commander of two air stations, chief of the Aviation Training Center Training Division and chief of SAR operations in the Northwest Region, before retiring in 1984 with the rank of captain. He is chief engineer, aviation system safety, Boeing Commercial Airplanes, and a maritime safety and accident investigator for Safety Services International.

11. Dell, Jay. Interview by Rosenkrans, Wayne. Washington, D.C., U.S. July 2, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

12. Cospas–Sarsat Secretariat. *Cospas–Sarsat Information Bulletin No. 16* (August 2003). U.S. National Aeronautics and Space Administration Goddard Space Flight Center; U.S. National Oceanic and Atmospheric Administration; U.S. National Environmental Satellite, Data and Information Service. *Cospas–Sarsat Search and Rescue System*. Publication no. LG 2000-XX-XXX-GSFC, 2000. <www.sarsat.noaa.gov> and <poes.gsfc.nasa.gov/sar/sar.htm> Commercial satellite-based systems also are used for distress alerting. For maritime distress, for example, Inmarsat, based in London, England, is a global mobile satellite communication operator that provides telephone, fax and data communication using a constellation of five geostationary satellites (i.e., satellites that maintain a fixed position above a point on Earth with orbital speed equal to Earth's rotation).

13. Schaefer, Richard. Office of Search and Rescue, U.S. Coast Guard. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. Sept. 5, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

14. IMO, ICAO. *IAMSAR Manual.* Volume II, *Mission Co-ordination*. Chapter 6, "Rescue Planning and Operations."

15. Most 406-MHz emergency locator transmitters (ELTs) and emergency position-indicating radio beacons (EPIRBs) include a 121.5-MHz auxiliary homing transmitter that enables SAR aircraft and SAR vessels to locate the radio beacon using direction-finding equipment. ICAO and the International Maritime Organization (IMO) require homing capability, which is not part of the performance specifications of Cospas-Sarsat. Similarly, civil aviation authorities' requirements for automatic activation of ELTs by impact forces and maritime authorities' requirements for automatic activation of EPIRBs by immersion are not part of the performance specifications of Cospas–Sarsat. Current-generation direction-finding equipment carried by SAR aircraft and SAR marine vessels can home to these beacons using both the 406-MHz frequency and the separate 121.5-MHz homing signal, but this equipment has not been widely adopted. Therefore, aircraft operators should ensure that ELTs and EPIRBs include a 121.5-MHz signal for homing by searchers using standard direction-finding equipment and meet the applicable requirements of national authorities.

16. IMO, ICAO. *IAMSAR Manual.*

17. Day, Brian. E-mail communication and telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 2, 2003, and July 4, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

A Signal for Help Is Heard, Help Arrives Too Late

When search-and-rescue authorities reported that they had detected the signal from a 406-megahertz emergency radio beacon, many people assumed — incorrectly — that a visual search had been launched.

— FSF EDITORIAL STAFF

The headline in a sailing magazine left no room for doubt — "EPIRB: If you set it off, they will come!"[1] Like mariners who believe that activating the emergency position-indicating radio beacon (EPIRB) guarantees a swift rescue at sea, aircraft operators who conduct overwater flights can become too reliant on the aviation version of the emergency radio beacon — the emergency locator transmitter (ELT).

The expectation of rescue is understandable because among 365 worldwide search-and-rescue (SAR) cases in 2001 that involved beacons detected by satellites, only three involved failure to find any of the people in distress.[2] But one of these cases revealed a stark reality: SAR authorities in some parts of the world — unlike those in the United States, for example — do not consider the distress alert from a 406-megahertz (MHz) beacon, the most current and preferred technology, to be sufficient reason to launch a visual search.

Sixty-eight (19 percent) of the SAR cases involved aircraft. In five (7 percent) of the aircraft cases, a 406-MHz beacon was activated. In 63 (93 percent) of the aircraft cases, a 121.5-MHz beacon (or military beacon) was activated. In 18 (26 percent) of these aircraft cases, the signal from the beacon was the only distress alert (see "The Search-and-rescue System Will Find You — If You Help," page 111).

The SAR case that provided hard lessons learned involved a 406-MHz EPIRB carried by the experienced two-person crew of the sailboat *Leviathan*. The beacon was activated for six hours on June 8 and June 9, 2001, in the Indian Ocean, beginning on June 8 at 1958 coordinated universal time (all times UTC).[3] With no information that confirmed genuine distress, however, SAR authorities in the area conducted only a communication search (i.e., calling the missing crew on maritime radio frequencies and broadcasting a pan-pan[4] about the safety of the sailboat via marine radio and satellite-based communication with the crews of commercial ships and military ships in the area). The regional SAR authorities — unaware that *Leviathan's* crew had reported rough weather conditions before failing to meet predetermined radio schedules — assumed that a false alert had occurred, probably by inadvertent activation of the beacon. Other sailboat crews conducted efforts to determine *Leviathan's* condition, but they were unaware that the sailboat's beacon had been activated only a few hours after the crew had reported rough weather conditions. Neither the other sailboat crews nor SAR authorities had complete information about *Leviathan's* situation.

More than 11 days after *Leviathan's* beacon was activated, the regional SAR authorities and the U.S. Coast Guard were provided additional facts, and the U.S. Coast Guard coordinated a visual search. Neither *Leviathan* nor its crew was found.

When any maritime search is delayed, the probability of finding survivors decreases unless signals from the beacon continue until searchers arrive at the distress site. Without an ongoing signal to update position information, winds and ocean currents cause search targets to drift at sea, said Dan Lemon, chief of the Coordination Division, Office of Search and Rescue, U.S. Coast Guard.[5]

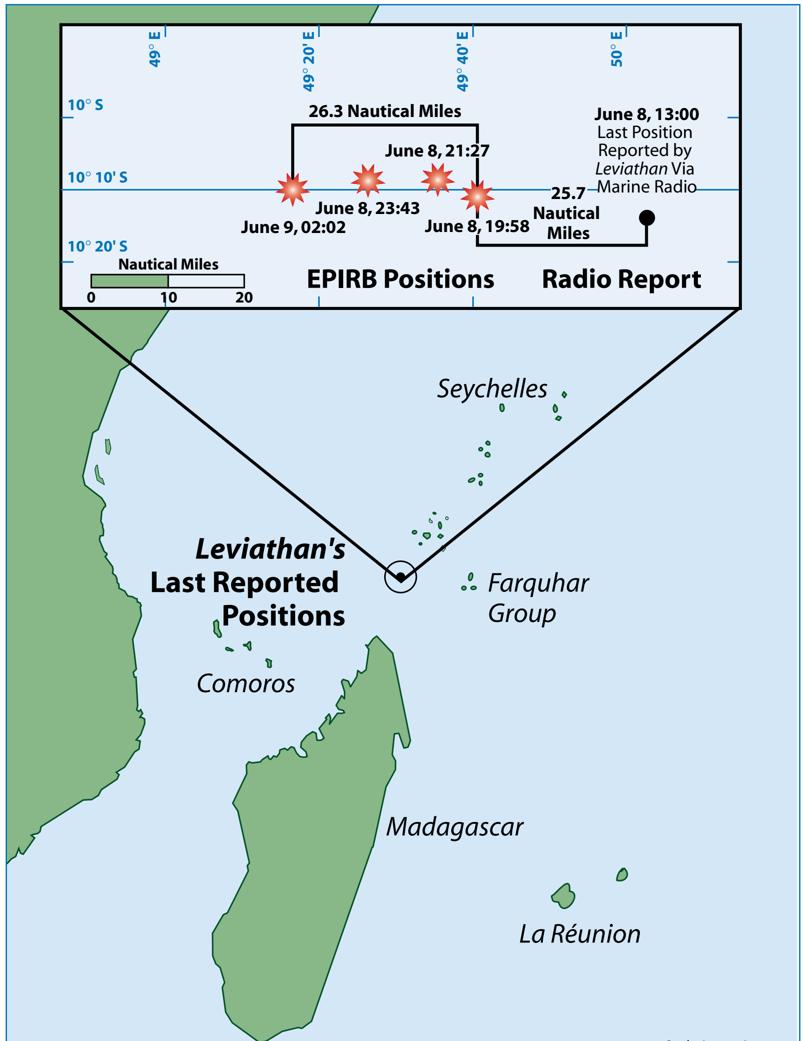
Weather Conditions Deteriorated

The story unfolded as follows:

- *Leviathan* was a 32-foot (10-meter) Down East cutter en route from Chagos Archipelago to Île de Mayotte, both in the Indian Ocean, during the second year of a four-year circumnavigation of the world. The crew recently had purchased the beacon and had encouraged other sailors to carry a beacon. No life raft was aboard the boat, which carried an inflatable dinghy. *Leviathan's* crew was cruising loosely as part of a group of four sailboats (i.e., crews typically would be out of visual range of one another). They were communicating with one another via marine radio at a scheduled time each day;

- On June 7, *Leviathan's* crew reported that they would continue to the island of Mayotte (the southernmost island in the Comoros chain) in deteriorating weather conditions. The cruising group's other crews, who were trailing *Leviathan* by 40 nautical miles to 60 nautical miles (74 kilometers to 111 kilometers), elected to anchor at nearby Farquhar Island;

- At 1300 on June 8, *Leviathan's* crew communicated by marine radio with the other crews, and they agreed to a twice-a-day radio schedule. *Leviathan's* crew reported that they were in big seas and 45-knot winds, but they did not report that they were in distress.[6] While such weather conditions would be demanding and uncomfortable for the crew, the conditions would not suggest a life-threatening emergency to experienced sailors in a sturdy boat;



EPIRB = Emergency position-indicating radio beacon

- At 1958, six hours and 58 minutes after the last radio communication from the crew, a satellite detected the first of four signals from *Leviathan's* beacon (see map).[7] The first signal provided insufficient position data to SAR authorities, which is a normal technological limitation of the Cospas–Sarsat[8] International Satellite System for Search and Rescue (see "Truths About Beacon Signals and Satellites Hidden in the Details," page 134). One hour and 29 minutes later, when the *Leviathan* beacon's signal was detected by a second satellite pass at 2127, SAR authorities were able to confirm its position in the Indian Ocean about 142 nautical miles (262 kilometers) north of Antsiranana, Madagascar (the nearest city on the large island; local time for Madagascar is UTC plus three hours) and about 330 nautical miles (612 kilometers) from Mayotte. Two hours and 16 minutes later, a third signal was relayed by a satellite at 2343; and two hours and 19 minutes later, the fourth and last signal was detected by a satellite at 0202 on June 9. The last beacon position was approximately 52 nautical miles (96 kilometers) west of *Leviathan's* position at the time of its crew's last radio call. The beacon signals then ceased for unknown reasons. Incorporating a hydrostatic-release mechanism and a water-activated switch, the EPIRB carried on *Leviathan* was designed to automatically float free and activate if the sailboat sank; the beacons also could be activated manually (see "Stay Tuned: A Guide to Emergency Radio Beacons," page 139);

- Personnel of U.S. Coast Guard Rescue Coordination Center (RCC) Alameda (California, U.S.; local time for California is UTC minus seven hours during daylight saving time) simultaneously received copies of the first two distress alerts concerning *Leviathan* as a routine procedure because of the beacon's U.S. registry. At 2015 on June 8, they told the *Leviathan* crew's emergency contact in the United States — identified in the U.S. 406-MHz beacon-registration database — that the signal from the beacon had been detected;

- RCC La Réunion — located about 700 nautical miles (1,296 kilometers; local time for La Réunion is UTC plus four hours) southeast of the beacon's position — received data about these distress alerts via the Toulouse, France, Mission Control Center of Cospas–Sarsat. RCC La Réunion's first step was to relay these data to RCC Seychelles (where local time is UTC plus four hours), about 485 nautical miles (898 kilometers) northeast of the beacon's position, and to RCC Antananarivo (Madagascar), about 565 nautical miles (1,046 kilometers) south of the beacon's position;

- RCC Antananarivo — in whose SAR region the beacon was located — did not respond to telephone calls about this case from other RCCs. As a result, RCC La Réunion maintained responsibility for the case, as would be expected under international SAR guidelines;

- At 0302 on June 9, RCC La Réunion and RCC Seychelles began broadcasting messages in French on 2182 kilohertz, an international maritime emergency frequency. The messages asked all vessels in the area — including French military vessels at Mayotte preparing for training exercises — to look out for *Leviathan* and to report any information to SAR authorities;

- At 0345 on June 9, *Leviathan's* crew did not check in on the predetermined radio schedule. Awareness that *Leviathan's* beacon had been activated — combined with a missed radio schedule and the report of high winds and heavy seas — would have caused the cruising group's crews to assume that a genuine distress was likely. Nevertheless, they were unaware that *Leviathan's* beacon signal had been detected seven hours and 47 minutes earlier. (Unless otherwise agreed, a missed radio schedule would not signal an emergency. Crews may miss schedules as they cope with the demands of operating a boat — especially in rough weather conditions — and unexpected problems such as depleted battery power, a damaged antenna or equipment failure.)

  That same day, the missed radio schedule was reported to a maritime-oriented amateur radio net that assisted cruisers in the Indian Ocean and along the East African coast by providing weather forecasts and safety information. The Kenya-based net was run by an amateur radio operator ("ham"), who said — incorrectly — that a boat could not be reported missing until 10 days had passed. (The U.S. Coast Guard later said that no such waiting period exists under international guidelines for SAR responses.) Other hams and maritime-oriented amateur radio nets were made aware of *Leviathan's* missed radio schedule. (Many cruisers obtain amateur radio licenses to enable them to exchange messages with families, friends and fellow hams, as well as to take advantage of the resources of a wide variety of volunteer radio nets.);

- At 2000 on June 9, when called by telephone, the *Leviathan* crew's emergency point of contact told personnel at RCC La Réunion that her most recent communication with *Leviathan's* crew had occurred two months before June 8. This person could tell SAR authorities only that the *Leviathan* was believed to be en route to the Madagascar area;[9]

- On June 11, the cruising group's crews said that they became aware that SAR authorities were conducting "lookout" broadcasts for *Leviathan* but they were not aware that its beacon signal had been detected;[10]

- On June 15, the cruising group's crews learned from hams that *Leviathan's* beacon had been activated on June 8; they were now certain that the vessel had been in distress. By June 17, they had learned that no visual search had been conducted for the vessel;[11]

- After conducting the communication search from June 9 to June 15, the duty officer at RCC La Réunion suspected a false alert because only four positions were received from the beacon and the signal had ceased after a few hours, he said. When plotted on a chart of the area, the beacon positions also seemed consistent with a sailboat traveling on a normal course at a normal speed. A theory to explain these distress-alert data — which RCC La Réunion called "false alert by wrong manipulation" — was that the beacon probably had been activated inadvertently, then deliberately deactivated by *Leviathan's* crew because there was no distress. The duty officer at RCC La Réunion operated under this theory until June 18. Later, he said that about 99 percent of distress alerts from 406-MHz beacons in the area had proven to be false alerts;[12, 13] and,

- After they were unable to persuade personnel at RCC La Réunion to conduct a visual search, the cruising group's crews on June 18 persuaded personnel at RCC Cape Town, South Africa, to relay to RCC Alameda their information that the *Leviathan* crew had reported rough weather conditions before failing to make predetermined radio schedules. Personnel at RCC Alameda, who had assumed that RCC La Réunion was coordinating an appropriate response, then communicated with personnel at RCC La Réunion about the status of this case. E-mail messages about *Leviathan* also received the attention of French government officials, who relayed information to the duty officer at RCC La Réunion. The duty officer at RCC La Réunion later said that he "understood the reality of the situation" (i.e., that the *Leviathan* was missing and that the distress alert probably had been genuine).

"The crews of sailboats that had been with *Leviathan* got the ball rolling for us to become involved," said Lt. Thomas Stuhlreyer of the U.S. Coast Guard. "At that point, it was clear from RCC La Réunion that nothing beyond communication searches had been carried out. The call [prompted] people at RCC Alameda to begin working with the U.S. Department of Defense on the air search."[14]

Based on the new information, RCC Alameda coordinated a visual search on June 20, 21 and 22 using a U.S. Navy P-3C Orion airplane from Diego Garcia, a U.S. military base about 1,000 nautical miles (1,852 kilometers) from the last known position of *Leviathan's* beacon. This search was suspended when no sign of the boat or crew was found.

SAR Policies Vary

Exactly what happened to *Leviathan* and its crew was not determined by SAR authorities. The U.S. Coast Guard provided insights into the SAR response, however.

Despite wide adoption of international guidelines that encourage consistent practices among SAR authorities, variations exist in policies. Most importantly, criteria may differ for launching a search after receiving a distress alert from a beacon. Moreover, SAR authorities, aircraft operators or families may assume incorrectly that SAR authorities in another country are launching a search when, in fact, the indications of distress required by local SAR authorities to launch a search have not been received.

How the U.S. Coast Guard becomes involved in a case outside its SAR regions is based on general principles rather than procedures, Stuhlreyer said. Providing assistance outside these regions is common, but becoming involved when the case is as far away as the Indian Ocean is fairly unusual, Stuhlreyer said. Involvement with SAR activities of other nations depends typically on how much assistance they request.[15]

"When another RCC is responsible for the SAR case, it is their ball," he said. "If a case similar to *Leviathan* happened now, we would get information from the emergency contact [for the U.S.-registered 406-MHz beacon], then follow up by calling the regionally responsible RCC to make sure that the nearest RCCs are aware of the distress alert, that an RCC has assumed responsibility and that they have all our information. We also try to find out if they need assistance. There has to be a clear handoff of every case between RCCs; when standard phraseology is used, there is no doubt about who has accepted responsibility.

"We got this confirmation [of the activation of a U.S.-registered beacon] at the same time as French SAR authorities at RCC La Réunion. From our initial checks with them, we found out that they were taking this SAR case for action although the distress alert was in the Madagascar search-and-rescue region. From that point, this was their [RCC La Réunion's] case. We knew they had it, and there was no further follow-up by RCC Alameda. This is how the system is supposed to work. We don't report back to other RCCs, so it is easy to see why we were not in on what RCC La Réunion was doing."

Unlike RCC Alameda, which received information about the first two beacon positions, RCC La Réunion received all four beacon positions, said Cmdr. Michael Hicks of the U.S. Coast Guard.[16]

"They said that they were conducting some preliminary communication searches, and we made the assumption then that they were the 'first RCC' [i.e., they would maintain responsibility for this case unless a different RCC — such as one with more suitable resources — accepted responsibility by formal transfer]," Hicks said. "That contributed to some confusion."[17]

The U.S. Coast Guard had received no further information about the *Leviathan* case until the call from RCC Cape Town. While a P-3C Orion was en route to begin the air search, RCC Alameda received information that the crew of a French navy vessel had spoken with the crew of *Leviathan,* he said. This information proved to be false.

Personnel at RCC Alameda discussed the status of this case with personnel at RCC La Réunion.

Continued on page 135

Truths About Beacon Signals and Satellites Hidden in the Details

Know this: All emergency radio beacons are not equal! Depend on a 406-MHz beacon with built-in position reporting as the best type for alerting search-and-rescue resources.

In the exaggerated and misinformed claims of some equipment sales personnel, activating an emergency radio beacon guarantees that search-and-rescue (SAR) authorities will receive instantaneous notification of the beacon's signal and an equally fast calculation of position. Buyer beware, because caveats are many in the world of beacons and satellites. Under optimum conditions with the appropriate equipment, notification of a distress alert and position information can occur in less than 10 minutes. In other cases, hours could pass before an accurate position of the activated beacon is determined. Moreover, 121.5-megahertz (MHz) beacon analog signals are vastly inferior to 406-MHz beacon digital signals, making the 121.5-MHz beacon the least desirable for emergencies. (See Figure 1, page 116, for more information about notification times and search areas based on the type of beacon signal.)

Four meteorological satellites (one maintained by India, two maintained by the United States and a European satellite that was declared operational in January 2004) are in geostationary equatorial orbits (synchronized with the Earth's rotation so that the satellites appear fixed above the Earth). They are in constant view of at least one of 12 ground receiving stations, and each satellite views a vast section of Earth between approximately 70 degrees north latitude to 70 degrees south latitude. These satellites carry SAR instrument packages, and a 406-MHz signal from a beacon activated in view of one of these satellites is received immediately and relayed to a ground receiving station. After processing of the data by a ground receiving station, the data are forwarded to a mission control center (MCC) for additional information and data refinement, before forwarding the notification of a distress alert to the appropriate rescue coordination center (RCC). The RCC will determine appropriate action to take such as launching — or not launching — an air search.

These geostationary satellites receive signals only from 406-MHz beacons; because they have no motion relative to the Earth, Doppler-shift processing cannot be used to calculate the position of activated beacons. Thus, awareness of a distress condition is not synonymous with knowing the position of the distress beacon. If a 406-MHz beacon has been registered by its owner, SAR resources can begin mobilization with corroborating information from the emergency contact, such as the approximate flight track of an aircraft, until a more accurate position can be calculated. If the beacon is equipped to provide accurate position data in its signal, SAR authorities immediately will receive that data, too. Otherwise, a ground receiving station only can calculate an accurate position based on beacon data received during two separate passes of a polar-orbiting satellite(s), and that data will be relayed via the MCC to the RCC.

Eight polar-orbiting satellites (three maintained by Russia and five maintained by the United States) change their views constantly and are often out of view of their 42 ground receiving stations. The system requires four of these satellites to be operational at any given time to provide SAR coverage of the high latitudes; typically, 60 minutes to 90 minutes elapse between polar-orbiting satellite passes over a specific location, with the shortest intervals near the poles and the longest intervals near the equator. These intervals, coupled with the time required for data to be stored and transmitted later to a ground receiving station, can result in much more than an hour of cumulative delays from two satellite passes before an accurate position can be calculated by the ground receiving station and then relayed to the RCC.

Polar-orbiting satellites receive signals from 406-MHz beacons and 121.5-MHz beacons. The 406-MHz data are stored until a ground receiving station is in view. If a ground receiving station is in view simultaneously with the reception of a 121.5-MHz signal, that information (and the 406-MHz data) will be forwarded to the ground receiving station. If a 121.5-MHz signal is received and no ground receiving station is in view, that 121.5-MHz information will not be stored or forwarded by polar-orbiting satellites; *authorities will have no knowledge of the signal*. For example, mid-ocean areas of the southern hemisphere and southern Africa are not in view simultaneously with ground receiving stations.

Among beacons, a 406-MHz beacon with accurate position-data reporting provides the fastest notification of distress and an accurate position. When this type of beacon is activated, its position will be updated once every 20 minutes. For example, if an emergency locator transmitter (ELT; a beacon designed for aviation use) is interfaced with an external global positioning system (GPS) receiver and is activated aboard an aircraft during descent from altitude in preparation to ditch, the last position downloaded from the GPS receiver will be transmitted by the ELT for 20 minutes. After 20 minutes, the ELT will accept an updated position, which in turn will be transmitted for 20 minutes. Moreover, despite the greater inherent accuracy of GPS (less than 10 meters [33 feet]), beacon-data constraints result in the transmission of less accurate position information ranging from about 120 meters (394 feet) to 7.4 kilometers (four nautical miles). Nevertheless, rapid notification of SAR authorities and confirmation of a position are far more important than extreme accuracy of position.

In addition to the ELT, the family of 406-MHz beacons includes the emergency position-indicating radio beacon (EPIRB), which is designed for maritime use, and the recently introduced personal locator beacon (PLB), which is designed for use on land (and also used on water) by individuals. Using the same distress frequencies, these beacons differ mainly in packaging and activation methods. When any of these beacons incorporates accurate position data in its signal, it provides the fastest notification of distress and an accurate position.

An automatic fixed ELT will remain attached to a sinking aircraft after a ditching and, like the other types, will *not* broadcast a usable signal after sinking. Therefore, regardless of regulatory requirements, at least one additional 406-MHz beacon such as a survival-type ELT or automatic deployable ELT (ADELT) should be aboard the aircraft during overwater operations. An EPIRB and/or a PLB (each with or without internal GPS receivers) also can be carried aboard the aircraft and used. No matter which type of 406-MHz beacon is activated, SAR authorities will receive the distress alert. ■

— FSF Editorial Staff

"The staff at RCC La Réunion said that they had assumed the *Leviathan* EPIRB signal was a false alert, and it appeared to us that they were not going to take action," said Hicks. "Although the probability of success was very low, we believed that we should at least make our best attempt to locate the vessel. One factor we look at is whether or not there is a chance that someone still may be alive. This crew had been in radio communication and then was out of communication. We also learned then that the crew had reported encountering bad weather. On the chance that they might be adrift and unable to communicate, we applied our drift model and looked for the highest-probability area to search. Finding a SAR aircraft to conduct a search in the Indian Ocean was not a trivial matter. There aren't any U.S. Coast Guard assets at the ready to search in many parts of the world. The nearest usually will be a U.S. Department of Defense asset; those assets are something we can try to get on a case-by-case basis. In the Indian Ocean, many countries are much less equipped to conduct large open-ocean searches, however, than countries such as Australia, Canada, Japan, Russia and the United States."

Personnel at RCC Alameda attempted to communicate with their counterparts at RCC Antananarivo to determine what SAR resources they might have for this case.

"No one answered the telephone, or the contact information was incorrect, and I do not believe that we ever talked to anyone in Madagascar," Hicks said. "It was apparent that this RCC was not going to do anything. The fact that we could not talk to them factored into our reasons to conduct an air search. When we know that insufficient action or no action has been taken, we have authority to [conduct SAR operations in international waters]. We took action based on what was known at the time."

Absence of any response by an RCC to a distress alert is unusual, Lemon said.

"The U.S. Coast Guard tried unsuccessfully to contact RCC Antananarivo, and our people were very frustrated," Lemon said. "The ones who should have been responding to that SAR case, and did not, caused some delays which, I believe, may have been the critical factor in not finding those people."

Having all available information soon after a distress alert influences search decisions, Hicks said.

"Better communication from the start would be the key to confirming that another RCC is taking the proper actions," Hicks said. "We urge anyone who has concerns about the safety of a vessel or aircraft to immediately tell the nearest SAR authorities. For example, for U.S.-registered aircraft and marine vessels, the U.S. Coast Guard should be contacted. Our RCCs also should know how to call directly the RCCs in other countries, although the flow of communication and the SAR responses will vary depending on where the distress occurs."

Stuhlreyer said that anyone who carries a 406-MHz beacon should know that even though it is the most current technology, it represents a method of last resort to communicate distress. *No beacon should be depended upon to replace two-way communication as the primary means of signaling distress.* This principle has been emphasized strongly in international SAR guidance for aircraft operators and other users of the global SAR system.

Anyone who is monitoring the safety of a marine vessel or aircraft will need not only a plan of communication but a plan of action for situations in which distress may be indicated by absence of communication, but distress is uncertain. The plan should designate who will initiate a communication search and the threshold of action (such as elapsed time) for how and when communication with SAR authorities will begin. Personnel monitoring the safety of an aircraft or vessel also should be alert for elements of a radio message that convey possible danger although distress has not been declared.

"If there is a lesson in this SAR case for aircraft pilots, it is that activating an ELT, EPIRB or PLB does not guarantee that SAR personnel will arrive, because capabilities vary around the world," Stuhlreyer said. "The remoteness of a region has an

Beacon-registration data … must be kept as up-to-date as possible.

effect on ability to respond — some areas are a lot harder to get to than others."

Another lesson is that beacon-registration data and information about the specific flight operation must be kept as up-to-date as possible.

"In this SAR case, people who were contacted did not have specific information about the sail plan," Stuhlreyer said. "I would recommend leaving a copy of the flight plan or the sail plan with the emergency point of contact who is listed in the database."

By querying the 406-MHz owner-registration database, RCC personnel rapidly can identify the associated aircraft or marine vessel, owner information (name, address, telephone numbers) and emergency-contact information.

The emergency contact named in the database should know, or should be able to determine quickly, the following information that will aid SAR operations:

- All communication equipment available to the aircraft occupants;
- Flight-plan data, expected arrival times and the crew's normal practices in overwater operations, and other relevant schedule information. This includes the number of people aboard the aircraft (passengers, pilots, flight attendants and other crewmembers);
- Accurate description of the aircraft (especially color, including a photo or digital image of the aircraft for the RCC that can be faxed or sent by Internet e-mail);
- Name, age and gender of each aircraft occupant; and,
- Survival equipment carried on the aircraft (such as life vests, life rafts, signaling devices, protective clothing, first aid supplies and drinking water) and training of aircraft occupants to use the equipment.

This should be only the beginning of the emergency contact's involvement with SAR authorities. Ground personnel designated to speak for the missing crew and passengers must be well prepared with detailed information about training, experience, equipment and other overwater-survival preparations. They must be assertive in their initial communication and follow-up communication with SAR authorities. They should focus on providing and receiving factual information. The aircraft operator should be prepared to do whatever is required to maintain communication with the RCC throughout the SAR response to a distress alert.

What the aircraft operator tells RCC personnel about the crew and passengers of the ditched aircraft can influence the assumptions and decisions made by the RCC's SAR mission coordinator.

"When the aircraft is operated by a company, the company often will establish an emergency operations center to work directly with the Coast Guard," Lemon said. "The primary emergency contacts first should be people who can be contacted 24 hours a day and who can provide useful information. If we know that a person on the aircraft is a professional and trained in survival, we are more likely to assume that the person has done the right things."

When the 406-MHz beacon is unregistered — or registration information is inaccurate — the RCC's response to a distress alert may involve life-threatening delays. Absence of accurate beacon-registration data can prevent RCC personnel from determining that a distress alert is a false alert or knowing the number of people who may be at risk.

"For example, if a satellite receives the signal from an unlocated, unregistered 406-MHz beacon, there is not much that SAR authorities can do until the beacon's position is determined[if the beacon does not provide the position from an internal global postioning sytem (GPS) receiver]," said Lt. Cmdr. Paul Steward, liaison officer to the Cospas–Sarsat International Satellite System for Search and Rescue and implementation officer for the Distress Alerting Satellite System, Office of Search and Rescue, U.S. Coast Guard. "The distress alert is not ignored, but it is categorized as 'unlocated, unregistered' and stored by its unique identification code, which tells only the nation of registry, the manufacturer and the type of beacon. Two passes by polar-orbiting satellites later will provide the beacon's position data, and at that point, the distress alert will be sent by geographic reference to the responsible RCC." The RCC's response will depend on resources available.[18]

Nevertheless, if the aircraft operator believes that the aircraft is in distress and can provide information that enables RCC personnel to calculate an approximate position, a SAR aircraft or SAR marine vessel may be launched with the expectation of receiving the satellite-aided position while en route to the distress scene.

The personnel of RCC Alameda reviewed the *Leviathan* case to distill any lessons learned.

"If this scenario happened today, we largely would follow the same steps, but we probably would follow up more frequently on subsequent days — checking in with the responsible RCC on a more regular basis — whether they request assistance or do not request assistance from the U.S. Coast Guard," Stuhlreyer said.

The *Leviathan* case does not reflect the normal exchange of information among RCCs, Lemon said. Nevertheless, the case was especially disconcerting to cruisers who conduct long-distance voyages in boats and may communicate infrequently with the person who has been designated in the U.S. 406-MHz beacon-registration database as their emergency point of contact. *Moreover, anyone who may have to rely on a beacon for rescue should understand the system's limitations.*

For example, the U.S. Coast Guard policy is to require additional information before conducting an open-ocean visual search if the signal from a 121.5-MHz beacon — the older and less-preferred technology — has been detected only during one satellite pass or only during two satellite passes.[19] Crews of commercial vessels will be asked to keep a lookout, but typically they will not be requested to divert to the scene to conduct a visual search until the Coast Guard receives a beacon position based on three satellite passes.

"In the vast majority of SAR cases, RCCs work together well despite weaknesses due to resource limitations in some nations," Lemon said. "We typically have an effective response — but that is not always the situation. Some cases occur in remote areas where there are no SAR resources. We need to work even harder through the International Civil Aviation Organization and the International Maritime Organization to get RCC capabilities built up so that there is someone who knows what to do to answer the phone in these areas."

The crew of an aircraft involved in a ditching or other water-contact accident ideally will be able to communicate their distress and position to air traffic control (ATC). If the aircraft in distress is detected by SAR authorities only because of the 406-MHz signal from a beacon, SAR authorities typically would be able to confirm genuine distress with ATC because of a flight plan, loss of radar contact and/or flight-following procedures. If no flight plan has been activated with ATC, however, and no one else can confirm quickly that a water-contact accident is probable, the responsible RCC in some parts of the world might not respond because the situation fails to meet its criteria for a visual search, or because they have insufficient resources to respond and do not request assistance from other RCCs.

Unfortunately, help came too late to find *Leviathan's* crew. ■

The bottom line, in our opinion …

- **Update beacon-registration 24-hour contacts — who should know how SAR functions — and ensure that they have current information about the aircraft, survival equipment, crew and passengers.**
- **When first notified about a distress alert, beacon-registrants must confirm which RCC has accepted responsibility and confirm how to contact the RCC.**
- **Establish routine confirmation of flight plans and arrivals, whereby failure to report is a possible indication of distress and should activate procedures for locating the aircraft.**
- **Communicate early and directly with SAR authorities when concerned about the safety of an aircraft.**
- **Be an assertive survivors' advocate to influence RCC decisions about conducting and suspending a visual search. Ask questions. Get answers. Follow up.**

Notes

1. Emory, Dennis S. "EPIRB — If You Set It Off, They Will Come!" *Blue Water Sailing.* November 2002.
2. Cospas–Sarsat Secretariat. "List of SAR Events Assisted by Cospas-Sarsat, January–December 2001." Annex C to *Cospas–Sarsat Report on System Status and Operations, January–December 2001.* This count comprises all search-and-rescue (SAR) cases involving genuine distress that were detected by satellites in the Cospas–Sarsat International Satellite System for Search and Rescue; commercial satellite systems also are used for distress alerting. One report from the French Mission Control Center said that a 406-megahertz (MHz) distress alert from an emergency radio beacon carried on the U.S.-registered sailing vessel *Leviathan* was received by satellite on June 8, 2001, from a location in the Indian Ocean. The report said, "Vessel is missing. No SAR operation conducted by local authority." Two people were involved; they were not rescued, the report said. On Feb. 8, 2001, a 406-MHz emergency position-indicating radio beacon (EPIRB) aboard the *Sandia*, a maritime fishing vessel, was activated in the North Atlantic Ocean; SAR aircraft and SAR vessels searched for four days but

did not find the three crewmembers. On March 21, 2001, a 406-MHz EPIRB aboard the *Nam Yang Ho*, a maritime fishing vessel, was activated in the East China Sea; an oil slick was found, but searchers did not find the six crewmembers.

3. EPIRBs transmit distress alerts on 406 MHz (with five-watt radio-frequency output power) and transmit a separate 121.5-MHz signal (0.025-watt radio-frequency output power) for homing by SAR aircraft and SAR marine vessels within the search area. All 406-MHz beacons are electronically similar, with differences in packaging, activation mechanisms, data-encoding protocols and capability to encode global positioning system data in the signal.

4. "Urgency" in phraseology of the International Civil Aviation Organization (ICAO) means "a condition concerning the safety of an aircraft or other vehicle, or of some person on board or within sight, but which does not require immediate assistance." In addition to the term "pan-pan" repeated three times in voice radio communication, repeated switching on and off of the landing lights or repeated switching on and off of navigation lights (in such manner as to be distinct from flashing navigation lights) communicates urgency in ICAO procedures. ICAO said that an urgency signal will "mean that an aircraft wishes to give notice of difficulties which compel it to land without requiring immediate assistance." (ICAO Annex 10, *Aeronautical Telecommunications,* Volume 2, 5.3, "Distress and Urgency Radiotelephony Communication Procedures.")

5. Lemon, Dan. Interview by Rosenkrans, Wayne. Washington, D.C., U.S. June 24, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

6. Nicholson, Darrell. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. Oct. 7, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Copies of fax memorandums sent by Maritime Rescue Coordination Center (RCC) La Réunion to U.S. Coast Guard RCC Alameda, California, U.S., were provided to FSF editorial staff by Nicholson, a senior editor of *Cruising World*.

7. While activated, a 406-MHz EPIRB transmits a signal containing a half-second burst of data once every 50 seconds. In this SAR case, two polar-orbiting satellites detected signals from the *Leviathan* EPIRB when the satellites passed over the Indian Ocean. These signals were processed and routed automatically to SAR authorities as messages showing one distress alert per satellite pass, based on when the satellite detected the EPIRB signal (called the time of closest approach). A 406-MHz emergency locator transmitter (ELT) or personal locator beacon (PLB) essentially functions in the same manner. All 406-MHz beacons transmit a unique identification code that enables SAR authorities to identify the owner, emergency contact person and other information in a nation-specific beacon-registration database.

8. Cospas–Sarsat Secretariat. Cospas–Sarsat Information Bulletin No. 16 (August 2003). The Cospas–Sarsat International Satellite System for Search and Rescue currently includes satellites provided by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) with the European Space Agency, India, Russia and the United States. Cospas is the acronym for the Russian words Cosmicheskaya Sistyema Poiska Avariynich Sudov, which means "space system to search for marine vessels in distress," and refers to a SAR-instrument package carried on Russia's polar-orbiting satellites. Sarsat, the acronym for Search and Rescue Satellite-aided Tracking, refers to Canadian/French-built SAR-instrument packages carried on U.S. polar-orbiting satellites.

9. Griffiths, Jenni. "Without A Trace." *Cruising World*. December 2002. 64–70. Griffiths and Darrell Nicholson conducted research on the *Leviathan* case and provided some of their documents to assist Flight Safety Foundation in fact-checking for this article.

10. Nicholson.

11. Nicholson.

12. Nicholson.

13. The U.S. Coast Guard policy is to initiate a SAR response to all distress alerts from 406-MHz beacons unless they are confirmed to be false alerts.

14. Stuhlreyer, Thomas. Interviews by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Oct. 8, 2003, and Oct. 14, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Lt. Stuhlreyer is chief, Pacific Area, District 11 Command Center, U.S. Coast Guard. He supervised RCC Alameda in fall 2003.

15. U.S. Coast Guard assistance was not requested, and RCCs in one country have no obligation, except as a professional courtesy, to inform RCCs in other countries about their operational decisions or the status of a case, Lemon said.

16. Hicks, Michael. Interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Oct. 16, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. In June 2001, Cmdr. Hicks was chief, Pacific Area, District 11 Command Center, U.S. Coast Guard. He supervised RCC Alameda. At the time of the interview, he was commander of the U.S. Coast Guard International Ice Patrol, based in Groton, Connecticut, U.S.

17. The duty officer of RCC La Réunion, in one fax message to the U.S. Coast Guard on June 21, 2001, said that this RCC was not directly in charge of assistance in the *Leviathan* case but had been working with RCC Seychelles since the first distress alert. Officials at RCC La Réunion did not respond to an e-mail query and repeated telephone queries from FSF editorial staff about responsibility for this case.

18. Steward, Paul. Interview by Rosenkrans, Wayne. Suitland, Maryland, U.S. April 9, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Steward retired from the U.S. Coast Guard in June 2003.

19. Lemon.

Stay Tuned: A Guide to Emergency Radio Beacons

Civil aviation authorities and search-and-rescue authorities strongly encourage all aircraft operators to upgrade to 406-megahertz technology — especially for overwater operations.

—FSF EDITORIAL STAFF

Beacons include ELTs, EPIRBs and PLBs, such as the one displayed by Lt. Cmdr. Paul Steward.

Emergency radio beacons include emergency locator transmitters (ELTs) carried on aircraft, emergency position-indicating radio beacons (EPIRBs) carried on marine vessels and personal locator beacons (PLBs), which are designed to be carried by people for use on land (but also are used on water).

Beacons generally are differentiated by the primary frequency on which they transmit a distress signal: 121.5 megahertz (MHz) or 406 MHz.[1] The 121.5-MHz beacons are dinosaurs whose days are numbered because of a very high false-alert rate and limited compatibility with satellite-based search and rescue (SAR).

One cause of false alerts is radio-frequency interference. The 121.5-MHz signal — heard as a siren-like tone — often cannot be distinguished from other radio-frequency sources, such as bank automatic-teller machines, pizza ovens and stadium scoreboards. False alerts also are caused by beacon malfunctions, unapproved beacon tests, beacon tests conducted at unapproved times, mishandling of beacons, inadvertent human error and deliberate beacon activation.[2]

Only about 20 percent of the 121.5-MHz signals detected by the Cospas–Sarsat International Satellite System for Search and Rescue are from beacons — and almost all of the 121.5-MHz distress signals are false alerts. For each emergency that SAR forces are alerted to by a 121.5-MHz distress signal, there are 1,000 false alerts, which waste time and resources.[3]

Because of this, SAR forces do not respond as quickly to a 121.5-MHz distress signal — or to a distress signal transmitted on 243.0-MHz, a SAR frequency for military aircraft that is used as an auxiliary frequency by many ELTs.

"Compared to the almost instantaneous detection [and confirmation] of a 406-MHz [distress signal], SAR forces' normal practice is to wait for either a confirmation of a 121.5/243.0-MHz alert by additional satellite passes or through confirmation of an overdue aircraft or similar notification," said the U.S. Federal Aviation Administration (FAA).[4] "SAR forces can initiate a response to a 406-MHz alert in minutes, compared to the potential delay of hours for a 121.5/243.0-MHz [alert]."

Largely because of the high volume of false alerts, Cospas–Sarsat in February 2009 will cease its satellite-based detection of distress signals transmitted on 121.5-MHz and on 243.0 MHz. Although 121.5 MHz will remain an international aeronautical distress frequency and 121.5-MHz beacons will be usable after February 2009 in countries that have not prohibited them, any aircraft operator that has not transitioned to 406-MHz technology will become dependent on signal detection only by pilots of overflying aircraft, air traffic control (ATC) facilities or SAR forces that monitor 121.5 MHz.

Showing Who and Where You Are

Among the advantages of 406-MHz beacons is their ability to transmit the distress signal as a digital message. The data in the message can help SAR forces identify the source of the alert, confirm that the alert is genuine and pinpoint the location of the beacon when the first signal is detected (if position information also has been transmitted).

The signal from each 406-MHz beacon includes identification data that are unique to the beacon (see "A Signal for Help Is Heard, Help Arrives Too Late," page 130). If the beacon is registered, SAR personnel can access information that helps them to quickly determine whether an alert is genuine or false.[5]

"If you need to use your ELT, the reason is that your life is in jeopardy."

Some 406-MHz beacons have built-in global positioning system (GPS) receivers or can be equipped to receive and transmit position data from on-board GPS receivers or other navigation equipment (see "Tests of 406-MHz GPS Beacons Show Position Deficiencies," page 141).

Rescue coordination center (RCC) personnel assume for operational purposes that position data received from a 406-MHz GPS beacon via the Cospas–Sarsat system typically will enable them to begin a visual search with a search-area radius of 0.05 nautical mile (0.09 kilometer), which compares to a search-area radius of 2.0 nautical miles (3.7 kilometers) when a 406-MHz beacon's position is determined with polar-orbiting satellites (see "Truths About Beacon Signals and Satellites Hidden in the Details," page 134).[6] During searches, crews of SAR aircraft typically find every 406-MHz beacon that is activated in a distress situation.[7]

Worldwide in 2002, about 690,000 121.5-MHz beacons were carried by aircraft and marine vessels, and about 314,000 406-MHz beacons were carried by aircraft, marine vessels and individuals (see "The Search-and-rescue System Will Find You — If You Help," page 111).

Despite the benefits of 406-MHz ELTs, relatively few have been installed in aircraft.

"We tell pilots to keep in mind when choosing an ELT, 'If you need to use your ELT, the reason is that your life is in jeopardy,'" said U.S. Coast Guard Lt. Cmdr. Paul Steward. "Nevertheless, in the U.S. beacon-owner-registration database of 406-MHz beacons, only 4 percent are ELTs — a very low percentage."[8]

During the 1990s, many U.S. aircraft operators did not buy 406-MHz ELTs because the benefits were not considered to be worth the higher cost compared with 121.5-MHz ELTs. A 121.5-MHz automatic fixed ELT — the type aboard most aircraft — costs about US$200 to $500. A 406-MHz automatic fixed ELT costs about $1,600 to $3,600, and the interface device that most ELTs require to use GPS or other navigation equipment costs $1,000 to $1,500. (The costs are higher for ELTs with six-axis crash sensors designed for use in helicopters.)

All 406-MHz beacons have self-test switches that enable the user to check for specific malfunctions, but 406-MHz signals and transmitted data must be tested with specialized equipment under carefully controlled conditions to prevent a false alert. In the United States, the Coast Guard provides facilities to test beacon signals and data; manufacturers and commercial services also test and certify that beacons conform to standards.

Continued on page 143

Tests of 406-MHz GPS Beacons Show Position Deficiencies

U.S. search-and-rescue (SAR) authorities found that 22.6 percent of emergency radio beacons tested in 2003 — all designed to take advantage of the global positioning system (GPS) — failed to encode any position in their signals. In two tests of one beacon model, the first positions broadcast to a satellite were inaccurate by more than 27 nautical miles (50 kilometers), the test report said.[1] (All subsequent positions encoded by this model, updated at 20-minute intervals, were accurate to 0.05 nautical mile [0.09-kilometer]; see "Stay Tuned: A Guide to Emergency Radio Beacons," page 139.)

When buying 406-megahertz (MHz) GPS[2] emergency locator transmitters (ELTs), emergency position-indicating radio beacons (EPIRBs) or personal locator beacons (PLBs) to encode position data from a GPS receiver in beacon signals, aircraft operators and other consumers assume that this technology is superior to non-GPS 406-MHz beacons. When they operate correctly, 406-MHz GPS beacons do enable a rescue coordination center[3] to confirm an accurate distress location and to launch a rescue as quickly as possible (see "The Search-and-rescue System Will Find You — If You Help," page 111).

From this test, however, aircraft operators have no way of knowing the relative performance, which models to exclude from consideration or whether manufacturers have corrected the deficiencies because the U.S. Air Force, U.S. Coast Guard and U.S. National Oceanic and Atmospheric Administration (NOAA) withheld identification of these beacon models to encourage manufacturer participation. Specific test results for each beacon — comprising EPIRBs, PLBs and one ELT — were disclosed only to the respective manufacturers.

During the test, 56 beacons from four manufacturers were used in 84 activations; some beacon models were activated more often than others during some test phases, and some models were not activated for every test phase (e.g., the PLBs were not activated at sea). The report contains combined results for seven models activated in optimal conditions and non-optimal conditions.

"The availability of encoded location varied significantly by beacon model," the report said. Overall, three beacon models failed to encode position data in 37.8 percent of activations, and the other four beacon models failed to encode position data in 5.1 percent of activations. In 28.6 percent of activations, beacons required more than five minutes to encode position data.[4] Accuracy of encoded position exceeded 0.5 nautical mile (1.0 kilometer) in 13.3 percent of 60 activations, exceeded 2.7 nautical miles (5.0 kilometers) in 3.3 percent of these activations and exceeded 5.4 nautical miles (10.0 kilometers) in 3.3 percent of these activations.

Standards of the Cospas–Sarsat International Satellite System for Search and Rescue require that beacons equipped with an internal navigation device provide within 30 minutes a position that does not exceed the correct beacon position by 5.0 kilometers. All type-approved beacons currently must conform to these standards under optimal operating conditions.

Obstructions — trees — between the beacon antenna and the sky significantly affected position availability, so the report recommended that users ensure a clear view of the sky in all directions for the best performance. As long as the GPS receivers received signals from GPS satellites that were adequate to encode a position, obstructions between the beacon antenna and the sky were not a factor in accuracy of position.

The test was prompted by distress-alert data from Cospas–Sarsat member nations.[5] These data appeared to show that only about one-third of distress alerts from 406-MHz GPS beacons contained encoded locations. The exact circumstances were unknown, however, said Lt. Cmdr. Paul Steward, Cospas–Sarsat liaison officer and implementation officer for the Distress Alerting Satellite System (DASS), Coast Guard Office of Search and Rescue.[6]

"In 2001, we found that some beacons transmitted a GPS position within two minutes and some beacons took up to 20 minutes to attain a position and to transmit the position," said Lt. Cmdr. Jay Dell, Cospas–Sarsat liaison officer and implementation officer for DASS, Coast Guard (see "Truths About Beacon Signals and Satellites Hidden in the Details," page 134).[7]

Beacon performance was measured in the following conditions: a stable, dry, stationary outdoor surface on land with no obstruction of the sky; carried on land; sky obstructed by trees on land; moving deck of a vessel at sea with no sky obstruction; life raft at sea; floating in the sea (EPIRBs only); submerged in water, set afloat and continually doused with water; afloat at sea with no dousing; attached to a life vest at sea after submersion (some models of PLBs); and simultaneous activations in close proximity on land.

Because results for these beacon models were deidentified and model-specific problems were apparent, Douglas S. Ritter, one of the 2003 test participants, conducted an independent follow-up test of 406-MHz GPS beacons in January 2004,[8] and he will publish results with beacon models identified. Ritter founded in 1994 the Equipped to Survive Foundation <www.equipped.org> and is its executive director. The Internet site is a comprehensive online resource for independent reviews of survival equipment and outdoor gear, as well as survival and search-and-rescue information. He said that the 2004 test included 15 examples of each of three PLB models (45 beacons) and four examples of each of nine EPIRB models (36 beacons). The 21 scenarios were designed to represent optimum conditions (to collect baseline data), rough sea conditions off the coast of California, U.S., and land conditions at forest/canyon sites in a California state park. The scenarios were similar to the 2003 test and included simulation of rainfall under open sky and under life raft canopies, PLBs tipped over with incorrectly oriented antennas, PLBs held by survivors floating in life vests and EPIRBs and PLBs used with open/closed life raft canopies. All beacons were programmed with test codes to broadcast simulated distress signals; the data received by Cospas–Sarsat satellites were provided to the test team by NOAA and the U.S. Federal Aviation Administration, and on-site GPS receivers and 406-MHz beacon-test kits were used. Some beacons had been tested in a laboratory to finalize protocols for the field-testing phases, Ritter said.[9]

"Manufacturers had a litany of complaints about the 2003 test methods, and it is risky to draw far-reaching conclusions about beacon performance other than to say that there are some problems," Ritter said. "We did not know if those results were anomalies, so we conducted additional testing to validate the surprising earlier results. We looked again at the question of whether 406-MHz GPS beacons offer a substantial reduction in SAR-response time — which they should when they work correctly. We also have tried to answer questions raised and the what-ifs when beacons are not activated in optimum conditions. Consumers need to know what they can expect when they pay a premium price for the advantage of accurate position reporting. I have no doubt, no question, that 406-MHz beacons and Cospas–Sarsat work, however." ■

— FSF Editorial Staff

Notes

1. U.S. Coast Guard. "Analysis of a 406-MHz Location Protocol Beacon Test." Report presented to the 17th meeting of the Cospas–Sarsat Joint Committee, June 15–18, 2003.

2. Frequencies in the range of 406.0 megahertz (MHz) to 406.1 MHz are reserved exclusively for emergency radio beacons designed to broadcast distress alerts in the Cospas–Sarsat International Satellite System for Search and Rescue. Most current 406-MHz beacons operate on 406.025 MHz or 406.028 MHz. In 2004, beacons that use an additional channel — 406.037 MHz — will be available.

3. A rescue coordination center (RCC) is an organization — established by a country or a group of countries in the same geographic area — that takes responsibility for promoting efficient organization of SAR services and for coordinating the conduct of SAR operations within a specific region.

4. The time limit was 31 minutes; some beacons were turned off before the time.

5. Cospas–Sarsat Secretariat. Cospas–Sarsat Information Bulletin No. 16 (August 2003). U.S. National Aeronautics and Space Administration Goddard Space Flight Center; U.S. National Oceanic and Atmospheric Administration; U.S. National Environmental Satellite, Data and Information Service. *Cospas–Sarsat Search and Rescue System*. Publication no. LG 2000-XX-XXX-GSFC, 2000. <www.sarsat.noaa.gov> and <poes.gsfc.nasa.gov/sar/sar.htm>. Cospas–Sarsat currently includes satellites provided by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) with the European Space Agency, India, Russia and the United States. Cospas is the acronym for the Russian words Cosmicheskaya Sistyema Poiska Avariynich Sudov, which means "space system to search for marine vessels in distress," and refers to a SAR-instrument package carried on Russia's polar-orbiting satellites. Sarsat, the acronym for Search and Rescue Satellite-aided Tracking, refers to Canadian/French-built SAR-instrument packages carried on U.S. polar-orbiting satellites.

6. Steward, Paul. Interview by Rosenkrans, Wayne. Suitland, Maryland, U.S. April 9, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Steward retired from the Coast Guard in June 2003.

7. Dell, Jay. Interview by Rosenkrans, Wayne. Washington, D.C., U.S. July 2, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. Distress signals from 406-MHz beacons are messages comprising digital-pulse radio broadcasts: a 0.5-second broadcast, called a "data burst," is sent every 50 seconds.

8. The January 2004 test was conducted with the U.S. Federal Aviation Administration Civil Aerospace Medical Institute as government sponsor. Costs were underwritten by West Marine (a U.S. retail distributor of beacons and other marine products), Boat USA Foundation and the Equipped To Survive Foundation.

9. Ritter, Douglas S. Interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Jan. 14, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.

Some U.S. aircraft operators believe that FAA's evolving automatic dependent surveillance-broadcast (ADS-B) system, which uses avionics on the aircraft flight deck and electronic equipment on the ground for non-radar airspace surveillance and airborne aircraft-separation assurance, will eliminate the need for ELTs.

"Voluntarily equipping an aircraft with a 406-MHz ELT is money very well spent," said Dan Lemon, chief of the Coordination Division, Coast Guard Office of Search and Rescue. "We disagree with those who argue that ADS-B equipment will make the ELT function unnecessary. A lot of aircraft will not be required to carry ADS-B. The ELT is still important."[9]

Lemon said that ADS-B equipment will not be functionally equivalent to an ELT because it does not have to meet ELT crashworthiness requirements, independent electrical power requirements or automatic-activation requirements.

Rule Changes Favor 406-MHz ELTs

The number of 406-MHz ELTs used in some sectors of civil aviation will increase, however, because of changing international requirements and national requirements.

Since Jan. 1, 2002, the International Civil Aviation Organization (ICAO) has required that any ELTs that are installed in aircraft used for international operations must operate on both 406 MHz and 121.5 MHz.[10,11] (Currently, most 406-MHz ELTs transmit auxiliary signals on 121.5 MHz and on 243.0 MHz, primarily for homing.)

Beginning Jan. 1, 2005, ICAO will require that all ELTs in aircraft used for international operations must operate on both 406 MHz and 121.5 MHz — which means that ELTs operating solely on 121.5 MHz must be replaced before 2005.

ICAO currently recommends that ELTs be installed in all airplanes, regardless of how they are operated, and requires that commercial airplanes carry ELTs on flights beyond gliding distance of shore and during takeoffs and landings over water when "in the event of a mishap, there would be a likelihood of ditching."

ICAO also requires that at least two ELTs (including one automatic type) be carried aboard airplanes during long-range overwater flights conducted in international commercial air transport.[12]

U.S. Rescinds ELT Exemption for Some Jets

Before 2004, turbojet aircraft operated privately under U.S. Federal Aviation Regulations (FARs) Part 91, in on-demand operations under Part 135 and in on-demand air carrier operations under Part 121 were not required to be equipped with ELTs.

FAA said that the exemption was included in Part 91.207, "Emergency locator transmitters," because turbojet aircraft "are normally flown under instrument flight rules and are normally in radio contact throughout their flight with [ATC]; as a result, their location is generally known by ATC throughout their flight."[13] Thus, turbojet aircraft "were considered to be more readily located after an accident," FAA said.

The exemption was rescinded by legislation passed in April 2000 by the U.S. Congress in response to the delay in locating a Learjet 35A that struck mountainous terrain in instrument meteorological conditions during a nonprecision instrument approach to Lebanon (New Hampshire, U.S.) Municipal Airport. The accident, in which both pilots were killed, occurred during a Part 135 positioning flight on Dec. 24, 1996. Extensive searches on the ground and in the air failed to locate the airplane, which was not equipped with an ELT. The wreckage was found by a forester on Nov. 11, 1999.[14]

In response to the congressional mandate, FAA revised Part 91.207, rescinding the exemption, on Jan. 1, 2002, but allowed affected operators two years to equip their aircraft with ELTs.

FAA said that to "limit the scope of the rule change," Congress also mandated that Part 91.207 be revised to exempt from the requirement to carry an ELT "aircraft with a maximum payload capacity of more than 18,000 pounds [8,165 kilograms] when used in air transportation."[15]

Currently, Part 91.207 also exempts the following aircraft from carrying ELTs:

- "Aircraft while engaged in scheduled flights by scheduled air carriers;
- "Aircraft while engaged in training operations conducted entirely within a 50-nautical-mile [93-kilometer] radius of the airport from which such local flight operations began;
- "Aircraft while engaged in flight operations incident to design and testing;
- "New aircraft while engaged in flight operations incident to their manufacture, preparation and delivery;
- "Aircraft while engaged in flight operations incident to the aerial application of chemicals and other substances for agricultural purposes;
- "Aircraft certificated by the [FAA] for research and development purposes;
- "Aircraft while used for showing compliance with regulations, crew

An 'automatic fixed' ELT is … the type typically installed in aircraft.

training, exhibition, air racing or market surveys;

- "Aircraft equipped to carry not more than one person; [and,]
- "An aircraft during any period for which the transmitter has been temporarily removed for inspection, repair, modification or replacement, subject to the following:
  - "No person may operate the aircraft unless the aircraft records contain an entry which includes the date of initial removal, the make, model, serial number and reason for removing the transmitter, and a placard located in view of the pilot to show 'ELT not installed'; [and,]
  - "No person may operate the aircraft more than 90 days after the ELT is initially removed from the aircraft."

RTCA and EUROCAE Set ELT Standards

RTCA (formerly the Radio Technical Commission for Aeronautics) and the European Organization for Civil Aviation Equipment set design standards and operating standards for ELTs.

The RTCA standards include specifications for crashworthiness, waterproofing, radio-frequency output power, resistance to cold and to heat, and signal duration. For example, the standards for a 406-MHz ELT include radio-frequency output powers of 5.0 watts for the 406-MHz distress signal and 0.1 watt for the 121.5-MHz homing signal, and sufficient battery capacity for the 406-MHz signal to be broadcast every 50 seconds for a minimum of 24 hours.[16] Battery capacities must be sufficient for the 406-MHz signal of an EPIRB to be broadcast every 50 seconds for a minimum of 48 hours and for the 406-MHz signal of a PLB to be broadcast for a minimum of 24 hours.

RTCA categorizes ELTs according to factors such as whether they transmit position information, how they are installed and how removable/deployable types are designed and activated.

ELTs are categorized as follows:

- An "automatic fixed" ELT is designed to remain attached to the aircraft before and after impact, and to be activated either automatically by a crash sensor or manually. This is the type typically installed in aircraft. Some regulations require automatic fixed ELTs to be installed as far aft as practicable.
- A "survival-type" ELT is designed to be attached to a packed life raft or stowed near an exit, so that a survivor can tether it to a life raft or to a survivor's life vest, and to be activated manually. Optional standards for buoyancy require that a survival-type ELT be self-righting and substantially maintain a normal operating position while floating. A survival-type ELT must not be affected adversely by immersion in salt water or by standing water on the equipment surfaces. It must have features such as one-hand operation, a tether, "foolproof" attachment of the antenna and visual indication that it is operating. This type of ELT is required to pass a more limited set of crashworthiness tests than an automatic fixed ELT. In the United States, survival-type ELTs are required by Part 135.167 for extended overwater operations by on-demand and commuter aircraft and by Part 121.339 for extended overwater operations conducted by air carriers. A 121.5-MHz survival-type ELT costs about $400 to $700. A 406-MHz survival-type ELT costs about $2,100 to $5,000.
- An "automatic portable" ELT is designed to be attached rigidly to the aircraft (to function as an automatic fixed ELT during impact) and to be readily removed from the aircraft after impact so that it can be tethered to a life raft or to a survivor's life vest. An automatic portable ELT has an integral antenna or an auxiliary antenna that can be attached after the aircraft antenna is disconnected from the ELT. Some regulations require that this type of ELT be installed in the aircraft as far aft as practicable. A 121.5-MHz automatic portable ELT costs about $500. The costs for 406-MHz automatic portable ELTs range from about $2,100 to $2,300.
- An "automatic deployable ELT" (ADELT) is designed to be attached rigidly to the aircraft and to be ejected and deployed automatically after the crash-force sensor has been activated. This type of ELT must be waterproof and buoyant. Some ADELTs are integrated with deployable digital flight data recorders and cockpit voice recorders. An ADELT costs about $10,000 to $15,000.

All current EPIRBs and PLBs transmit distress signals on 406 MHz. EPIRBs are classified as follows:

- A "Category I" EPIRB is designed to be activated automatically when released from a bracket by water pressure (i.e., when the marine vessel sinks) or manually. This type of EPIRB must meet maritime requirements for waterproofing and saltwater operation. A strobe light illuminates while the EPIRB is activated. A Category I EPIRB costs about $700 or about $1,000 with an internal GPS receiver.

- A "Category II" EPIRB is designed to be activated manually. Cost is about $600 or about $900 with an internal GPS receiver.

PLBs are compact beacons designed for personal portability and to be activated manually. PLBs must be waterproof; some are inherently buoyant. PLBs cost about $600 or $900 with an internal GPS receiver or a built-in interface to an external GPS receiver. (The Coast Guard has issued 406-MHz PLBs, encoded as personal EPIRBs [PEPIRBs], to its boat crews as standard safety equipment attached to life vests for all missions.)

There are several other types of portable beacons that transmit distress signals on 121.5 MHz. The specifications and costs vary widely.

How to Keep a 121.5-MHz Beacon From 'Crying Wolf'

The U.S. National Oceanic and Atmospheric Administration (NOAA), which operates the U.S. mission control center for Cospas–Sarsat, said that owners of 121.5-MHz beacons should do the following to prevent false alerts:[17]

- "Mount your beacon properly;

- "Maintain fresh batteries in accordance with the manufacturer's recommendations [and check whether ELT maintenance must be performed by a certified maintenance technician];

- "Disconnect your battery when the unit is shipped or disposed of;

- "Familiarize yourself with all beacon-operating instructions — before an emergency situation arises;

- "Monitor 121.5 MHz after each landing to verify [that] your ELT is not accidentally transmitting; [and,]

- "Test your 121.5-MHz beacon only during the first five minutes of any hour and limit the transmission to three audio sweeps."

NOAA said that "although 406-MHz beacons have a lower false-alarm rate, there is still room for improvement." NOAA said that owners should do the following to prevent false alerts:

- "Test your 406-MHz beacon in accordance with manufacturer's instructions. Most beacons have a 'test' switch which will fully test the unit [i.e., electronics, battery and antenna but not signal transmission] at any time; [and,]

- "Register your beacon. (This may not reduce the number of false alarms, but it will greatly reduce their impact on search-and-rescue personnel.)"

In summary, aircraft operators have many incentives to upgrade equipment so that survivors of a ditching or other water-contact accident have at least one 406-MHz beacon as a backup means of communicating distress to SAR authorities anywhere in the world. The aircraft operator's selection of this preferred technology is important, but knowledge of the beacon's strengths and limitations may be equally important in helping SAR forces find and rescue survivors as quickly as possible. ■

The bottom line, in our opinion …

- **Choose an emergency radio beacon wisely; your life will be at stake if you ever need to use it.**
- **Upgrade now to 406-MHz technology to be in tune with the global search-and-rescue system.**
- **A beacon with built-in GPS position-reporting will bring help sooner.**
- **The ELT attached to your aircraft will be useless when the aircraft sinks.**
- **Carry at least one portable 406-MHz beacon that can be transferred to the life raft.**

Notes

1. Frequencies in the range of 406.0 megahertz (MHz) to 406.1 MHz are reserved for emergency radio beacons designed to transmit distress signals for reception by the Cospas–Sarsat International Satellite System for Search and Rescue. Most current 406-MHz beacons operate on 406.025 MHz or 406.028 MHz. In 2004, beacons that use an additional channel — 406.037 MHz — will be available.

2. International Maritime Organization (IMO); International Civil Aviation Organization (ICAO). *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual*. Document 9731–AN/958. Volumes 1–3. 1998, 1999.

3. U.S. National Oceanic and Atmospheric Administration (NOAA). *Cospas–Sarsat Search and Rescue Satellite System*. 2003.

4. U.S. Federal Aviation Administration (FAA). *Aeronautical Information Manual*. Chapter 10, "Search and Rescue."

5. Steward, Paul; Cospas–Sarsat liaison officer and implementation officer for the Distress Alerting Satellite System, office of Search and Rescue, U.S. Coast Guard. Steward retired from the Coast Guard in June 2003. Interview by Rosenkrans, Wayne. Suitland, Maryland, U.S. April 9, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. NOAA, which operates the U.S. mission control center for Cospas–Sarsat and maintains the U.S. 406-MHz beacon-registration database, in August 2003 launched an Internet site for initial registration of all types of 406-MHz beacons. The secure database can be accessed by rescue coordination centers (RCCs) worldwide only for search-and-rescue (SAR) purposes. Although beacon owners can use mail or fax to submit registration forms, the online process enables owners to provide updated data, such as different emergency contacts, 24 hours or more before a flight. Since 2002, Cospas–Sarsat has been studying the costs and funding for one Internet site that would enable beacon owners worldwide to register and to update registrations.

6. An RCC is an organization — established by a country or a group of countries in the same geographic area — that takes responsibility for promoting efficient organization of SAR services and for coordinating the conduct of SAR operations within a specific region.

7. Cospas–Sarsat Secretariat. "Cospas–Sarsat Data Distribution Plan." Issue 4, Revision 5. October 2002.

8. Steward.

9. Lemon, Dan. Interview by Rosenkrans, Wayne. Washington, D.C., U.S. June 24, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

10. ICAO. International Standards and Recommended Practices. *Annex 6 to the Convention on International Civil Aviation: Operation of Aircraft. Part I, International Commercial Air Transport — Aeroplanes*. Part II, *International General Aviation — Aeroplanes*. Part III, *International Operations — Helicopters*. Chapter 6, *Aeroplane Instruments and Equipment*.

11. ICAO. International Standards and Recommended Practices. *Annex 10 to the Convention on International Civil Aviation: Aeronautical Telecommunications*. Volume III, Part II, *Voice Communication Systems*. Chapter 5, *Emergency Locator Transmitter (ELT) for Search and Rescue*.

12. ICAO. Annex 6, 6.5.3, "All aeroplanes on long-range over-water flights," defines long-range overwater flights as "routes on which the airplane may be over water and at more than a distance corresponding to 120 minutes at cruising speed or 740 kilometers (400 nautical miles), whichever is the lesser, away from land suitable for making an emergency landing in the case of aircraft operated in accordance with 5.2.9 ["En route — one power unit inoperative"] or 5.2.10 ["En route — two power units inoperative"], and 30 minutes or 185 kilometers (100 nautical miles), whichever is the lesser, for all other airplanes."

13. FAA. "Emergency Locator Transmitters (Final Rule)" *Federal Register* Volume 65, No. 247 (Dec. 22, 2000): 81316–81319.

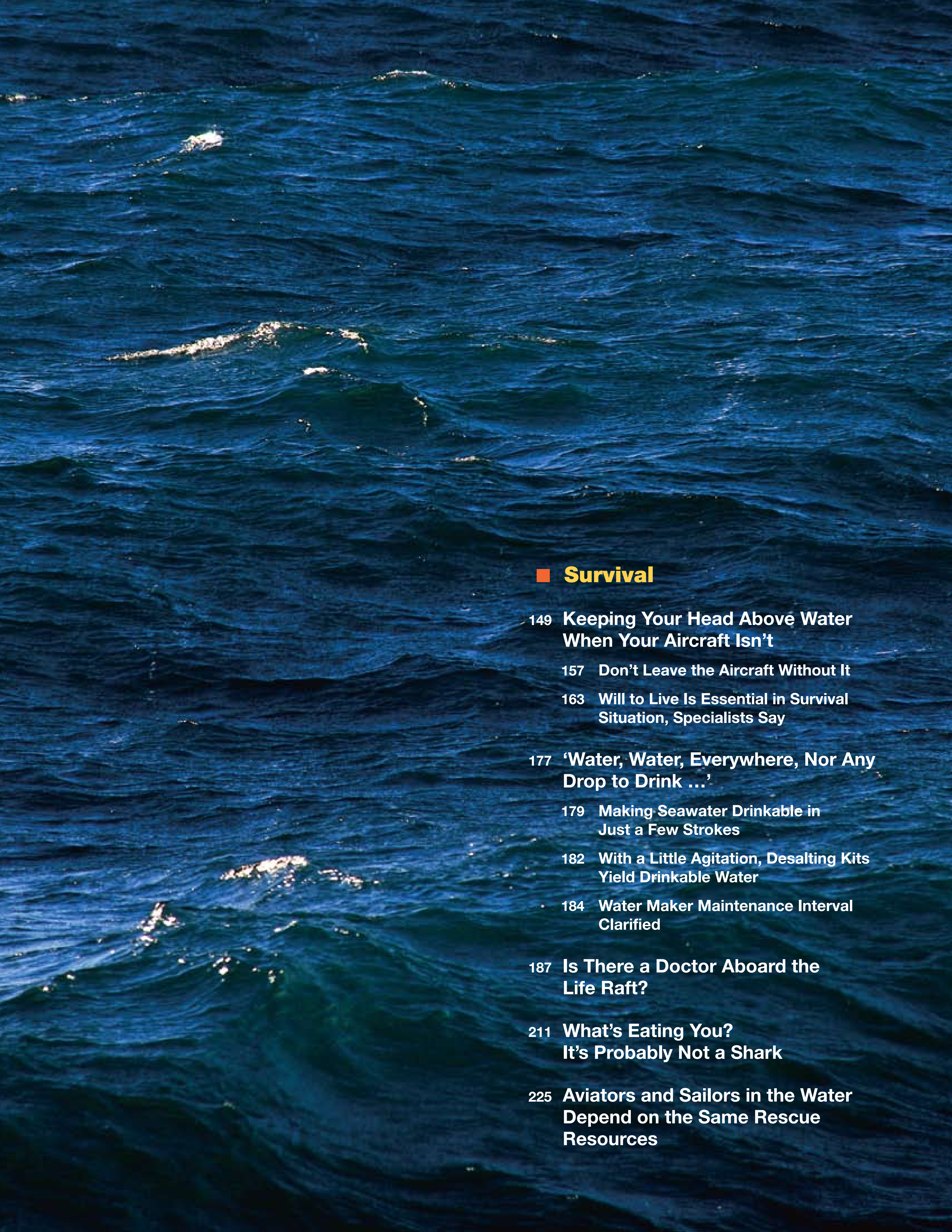
14. FSF Editorial Staff. "Failure to Maintain Situational Awareness Cited in Learjet Approach Accident." *Accident Prevention* Volume 60 (June 2003). The U.S. National Transportation Safety Board (NTSB), in its final report (NYC97FA194), said that the probable causes of the accident were "the captain's failure to maintain situational awareness, which resulted in the airplane being outside the confines of the instrument approach, and the crew's misinterpretation of a step-down fix passage, which resulted in an early descent into rising terrain."

15. "Air transportation" is defined by FAA as "the carriage of persons or property as a common carrier for compensation or hire — [that is,] operations conducted by air carriers."

16. RTCA (formerly Radio Technical Commission for Aeronautics). Document (DO)-204, *Minimum Operational Performance Standards 406 MHz Emergency Locator Transmitters (ELT)*, contains standards for the use of 406-MHz ELTs as optional adjuncts or replacements for 121.5-MHz ELTs. Standards also are included in DO-183, *Minimum Operational Performance Standards for Emergency Locator Transmitters – Automatic Fixed – ELT (AF), Automatic Portable – ELT (AP), Automatic Deployable – ELT (AD), Survival – ELT (S) — Operating on 121.5 and 243.0 Megahertz)*. Some countries use European Organization for Civil Aviation Equipment (EUROCAE) Document ED.62 for specifying the technical characteristics and operational performance of 121.5-MHz ELTs and 406-MHz ELTs.

17. NOAA.

Survival



Survival

Keeping Your Head Above Water When Your Aircraft Isn't

Thinking about the unthinkable for most of his working life, a survival specialist shares the raw facts of living aboard a life raft: A floating shelter that is surely the last place at sea anyone wants to be, unless it is the only option for survival.

— FSF EDITORIAL STAFF

Floating in the Gulf of Mexico classroom of survival specialist Ken Burton, a student is enclosed in a large clear plastic trash bag, which helps trap water warmed by the student's body and illustrates the importance of thinking differently in survival situations.

The experience of surviving at sea in life rafts for several days, weeks or months does not have to be repeated today by aviators — or mariners — who prepare themselves for the unexpected.

"For the prepared survivor, technology probably will curtail the time at sea," said Ken Burton, president of STARK (Sea, Tropical, Arctic, Regional Knowledge) Survival Co. <starksurvival.com>, which conducts an open-water life raft survival training program for aircraft operators, crews and passengers (see "If You Need It, They Have It," page 382). "If the survivor isn't prepared, he or she is likely to die before being rescued."

Burton has operated his company for nearly 25 years in Panama City, Florida, U.S. The company's clients are primarily in the aviation sector — ranging from recreational aviation and corporate flight departments to airline operations — although many mariners also have participated in his training programs, which include land survival, underwater egress, open-water training in the Gulf of Mexico, executive training for frequent passengers aboard corporate

Ken Burton believes that open-water training offers the most realistic experience for students.

aircraft, and in-house training at the client's location.

"We owe a lot of our knowledge about long-term survival aboard life rafts to cruising sailors who have done the real-time 're-search,' especially during the past 30 years," Burton said. "Aviators during this same period had the advantage of better communication and preplanned routes that helped with rapid rescues. Unlike aviators, rescued sailors often abandoned their vessels without being able to alert anyone [to] their condition, and rescue became a matter of chance.[1]

"Modern 406-megahertz [MHz] ELTs [emergency locator transmitters; see 'Truths About Beacon Signals and Satellites Hidden in the Details,' page 134] with built-in GPS [global positioning system] position reporting have reduced life raft durations to a few days or even hours," said Burton, who — unexpectedly — was on a life raft for two days when weather became too rough and forced a military training exercise he was leading to continue until the weather abated. "A week on a life raft would today be a long time."

During 21 years of service in the U.S. Air Force, Burton also attended Army and Navy survival schools. Most of his career was as a certified instructor in aviation physiology, hyperbaric therapy and water-survival training.

Burton has a series of questions for aviators who conduct overwater flights: "How long could you stay afloat without a life vest? How long could you live without fresh water? How long could you live knowing that no one knew that your aircraft had been ditched or knew where you were?

"Some people may laugh at the unlikelihood of these kinds of predicaments, but you won't be laughing if you find yourself treading water in the Atlantic Ocean. And pilots do ditch in the oceans and other places — often close to shore — every year [see 'The Unthinkable Happens,' page 3].

"Ditchings are survivable, but with every successful ditching, a series of challenging events is set in motion for survivors, from evacuating the aircraft to launching life rafts, boarding life rafts and surviving until a rescuer brings them home. Then they are truly *survivors*."

Never Risk the Life Raft

As long as the aircraft remains afloat, it provides a bigger and different target that is more easily seen than a life raft. Nevertheless, Burton favors an early disconnection from the aircraft to lower any risks that would place the life raft near any jagged metal or debris that could damage the life raft (see "Prepare to Ditch," page 20).

"In the ocean, you need that life raft to survive," said Burton. "The life raft must not be put at risk. A sinking aircraft could drag the life raft on the surface of the water, where floating debris could puncture or tear the life raft. The mooring/inflation line is designed to break, however, so the life raft won't be dragged under water.

"Hopefully, the aircraft remains afloat long enough for everyone to get in the life raft and for the raft commander to cut the mooring/inflation line with the raft knife. If the evacuation isn't complete and the aircraft begins to sink, then a flight attendant or other designated person in charge of the evacuation should command everyone in the aircraft to get in the water immediately and *hold on tightly to the mooring/inflation line before the flight attendant cuts the line.* The life raft will hold the mooring/inflation line very taut. When the mooring/inflation line is cut, the life raft is going to move downwind from the aircraft and take the mooring/inflation line with it. The sea anchor, if deployed automatically, will slow — but not stop — the life raft's downwind drift; if the sea anchor hasn't been deployed, then it should be deployed, if possible, before the mooring/inflation line has to be cut.

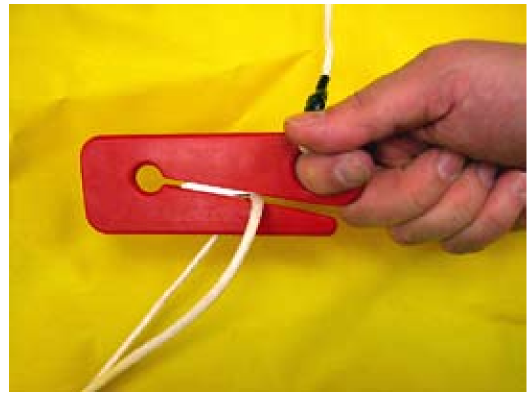
"Survivors in the water also will be moving downwind, toward the life raft — probably faster than the life raft is moving if the sea anchor has been deployed. The survivors should continue to use the mooring/inflation line to pull themselves to the life raft, where other survivors will help them aboard.

"Survivors should not release their grip on the mooring/inflation line and attempt to swim to the life raft, which would be very difficult to accomplish while wearing an inflated life vest. No one should deflate his life vest to make swimming easier. Exhaustion may easily overcome the survivor.

"If a survivor loses his hold on the mooring/inflation line, he may be able to reach one of the other survivors and be pulled close enough to regrip the line. If the survivor is too far to reach another survivor, then he should allow the current and wind to carry him toward the life raft, without struggling, which could exhaust him. Survivors on the life raft should get the heaving line and make sure that it is secured to the life raft. Because throwing a heaving line successfully usually requires practice, the raft commander should consider asking for an able-bodied volunteer to secure the heaving line around his waist. Then, if the floating survivor's path is not taking him directly to the life raft, the able-bodied volunteer can go overboard and try to intercept him before he passes the life raft. Then, survivors aboard the life raft can pull the survivors to the life raft and help them aboard.

"If there are no volunteers, or if the raft commander elects not to allow anyone else to be put in jeopardy, the heaving line can be thrown to the survivor when he comes close to the life raft. In my practical experience, a person throwing the heaving line, with its attached quoit [a doughnut-shaped buoyant grip at the end of the line], for the first time is not likely to throw it more than 20 feet [six meters] or so. And if the throw isn't accurate, a quick second throw will be unlikely because the wet line will likely tangle.

"If the survivor floats past, but there are several survivors holding the mooring/inflation line, the survivors on the mooring/inflation line must be retrieved first. Then the sea anchor can be retrieved; and if the water-ballast bags can be 'emptied' — some life rafts have lines attached to the bottoms of the bags to allow them to be pulled upward to reduce the amount of water they hold, to further reduce drag — these actions will allow the life raft to drift faster toward the floating survivor. Paddles can be used to try to steer the life raft in a general direction downwind, but they won't be very effective for much more than that. In benign conditions, the sea anchor might be retrieved and the water-ballast bags might be emptied before retrieving the survivors on the mooring/inflation line. But all these actions must be taken with great caution and are not warranted in rough sea conditions."



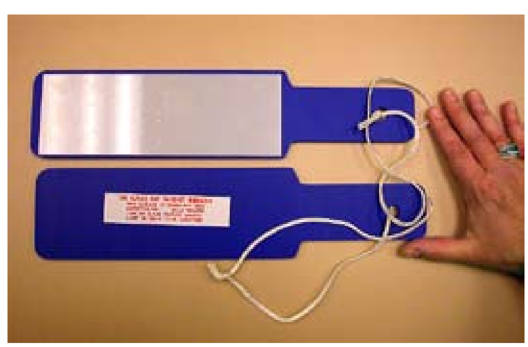
The raft knife is provided to cut the mooring/inflation line and allow the life raft to drift free of the sinking aircraft.

If two life rafts have been deployed on the same side of the aircraft and from the same or nearly the same deployment point, free-floating survivors might be aided more easily. Moreover, the life rafts should be joined together with about 15 feet (five meters) of line, so when the mooring/inflation lines are cut, the life rafts will drift together. Burton said that if the life rafts are deployed from opposite sides of the aircraft, they might be too far apart to allow a connection, but they likely will remain in the same area.

"If a sinking aircraft forces the raft commander to cut the line away at the life raft, the survivors on the aircraft — who no longer can use the mooring/inflation line to pull themselves to the life raft — must be in the water as quickly as possible. Again, with the sea anchor deployed from the life raft, the survivors will probably drift on the same track as the life raft and faster than the life raft. The raft commander will be faced with the same question of whether to ask a tethered volunteer for assistance or to throw the heaving-line quoit."

And if all this activity is at night in rough weather conditions?

"Darkness and rough weather make things more difficult, but not impossible," said Burton. "A light on the life raft should be visible to all survivors in



Retroreflective tape allows signaling, but no one is paddling a raft home with these paddles.

Retroreflective tape shines brightly from light directed onto its surface and makes life rafts more visible in darkness or low-level light conditions.

the water. If the life raft has retroreflective tape, a well-located survivor-locator light on the life raft canopy might reflect light from the tape, further enhancing visibility of the life raft. [Retroreflective materials are engineered to reflect light in the direction of its source and are most effective when the ambient light is low.]

"The survivors should be wearing life vests with lights, too; unfortunately, retroreflective tape isn't required on U.S. aviation life vests or on U.S. life rafts. Situational awareness — knowing where everyone and everything are located — will be very important.

"The raft commander can use a flashlight to attract attention and to see survivors. He can use a whistle to help survivors locate the life raft. Again, he must be familiar with the life raft and know where this equipment is located. Seconds count. In rough seas, high waves and darkness, a survivor in the water could pass by a life raft before anyone has time to react. Think about that, because it will be a whole lot scarier than it sounds."

Getting Aboard

Design improvements have made the boarding of modern life rafts much easier than in the past, but some people will require assistance, especially if they are injured.

"Inflatable boarding ramps that have appeared on life rafts in the past few years have greatly improved boarding access for many people," Burton said. "Even if they can't climb all the way in, they can get in a better position for being pulled aboard. But these devices can fail, so a ladder constructed of flexible-nylon webbing may be the only means of getting aboard, and that can require more physical effort; so, some people might require more help.

"The 'bob method' of boarding requires two people on the life raft, each pushing down on one side of the life vest of a survivor in the water. You count 'one,' and push the survivor down into the water — you won't be able to push him too far — then allow him to bounce back up. Then you count 'two,' and do it again. Then you count 'three,' but the two people on the life raft put their hands under his armpits and use that last bob to help launch-pull him into the life raft.

"If someone is injured, you do the best you can to get him in the life raft, but accept that doing it without causing further pain or injury may be impossible.

"Under the best of conditions, getting into a life raft isn't marked by gracefulness. Just get in."

Who Is in Charge?

Burton said that passengers are likely to assume that the aircraft captain and the other crewmembers are trained in life raft operations, but passengers will quickly learn how much confidence they should place in them.

"The captain of the aircraft, or one of the surviving crew in order of rank, will be the life raft commander based on the tradition of maritime law, not on aviation regulations," said Burton. "But 'cream rises to the top.' Another person who has had survival training as the result of military experience, for example, might be selected by the raft commander to oversee the operation of the life raft, a sure sign of good leadership by the raft commander."

Listening to others and sharing knowledge will help the raft commander to instill confidence in his leadership.

"A benevolent dictatorship might be one way to describe the leadership style," said Burton. "The raft commander can't allow everyone to be in charge. A final-decision maker is required, but being fair and honest in leadership will be important. A strong and self-confident personality will be necessary, because this will be a high-stress environment. Other personalities — maybe a company president with no appropriate experience — may compete for leadership. Obviously, having life raft training will go a long way in winning the raft commander the confidence of the other survivors [see 'Will to Live Is Essential in Survival Situation, Specialists Say,' page 163]."

Immediate Action

Seriously injured survivors will need immediate first aid (see "Is There a Doctor Aboard the Life Raft?" page 187). A person who has stopped breathing requires prompt attention, as does someone who is bleeding profusely or is showing symptoms of shock. Burton said that these three conditions can be treated with first aid, which might prevent much more serious conditions for which no treatment can be successful on a life raft. He calls it the BBS method: breathing, bleeding and shock.

"If someone isn't breathing and there are no obvious injuries, ideally, resuscitation should begin within four minutes but probably not later than six minutes of when the person stopped breathing," said Burton. "Beyond the first critical minutes, this type of casualty calls for advanced life support, not first aid."

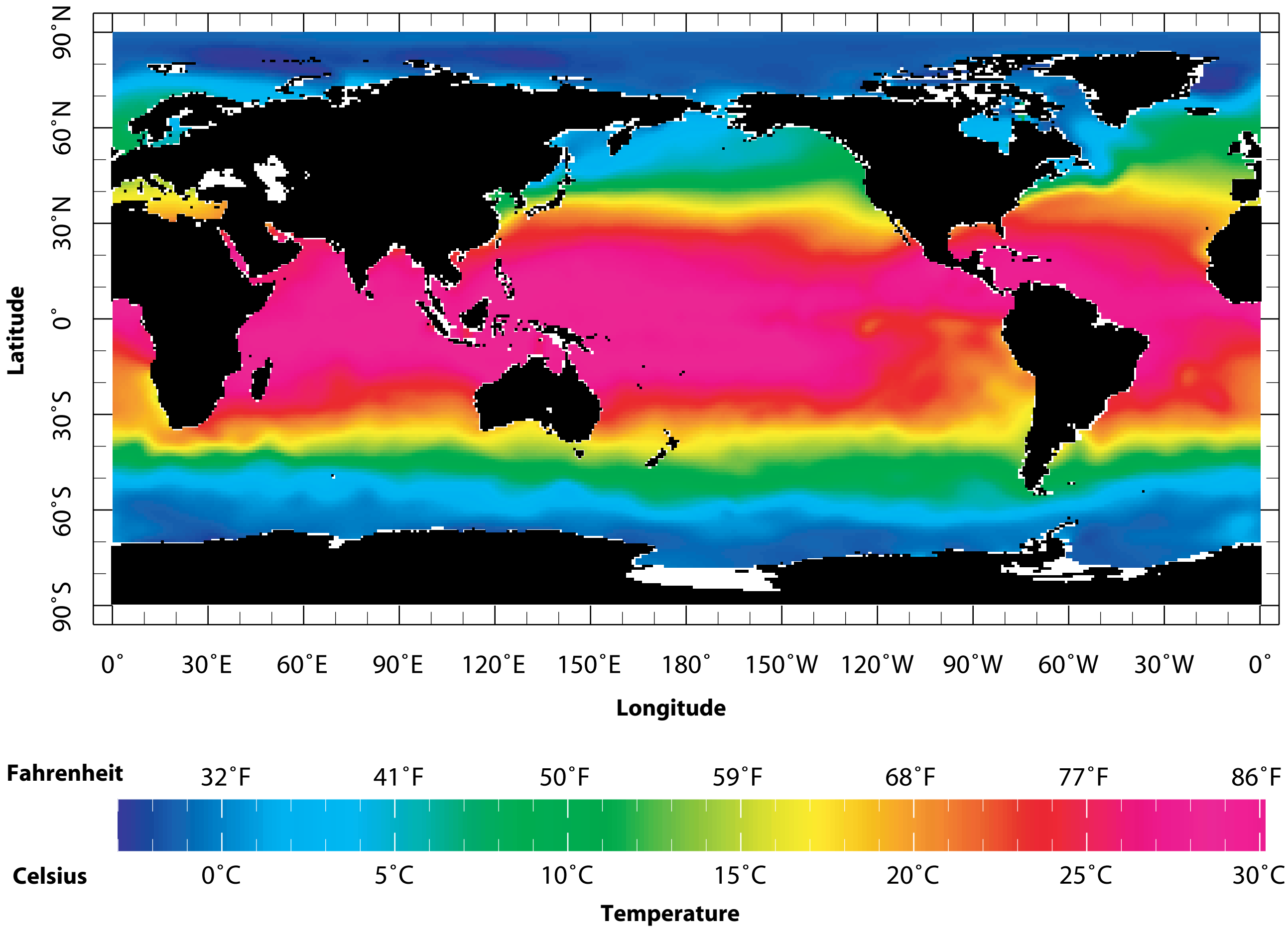
Burton said that the raft commander might be faced with a tough decision, depending on available resources. If survivors in the life raft are bleeding or suffering from other serious injuries while other survivors are in the water, unless assistance is available to render first aid, the raft commander might take the decision not to initiate cardiopulmonary resuscitation because of insufficient resources. He must think in terms of doing the greatest amount of good for the greatest number of people.

"A person showing signs of shock should have his feet elevated and should be kept warm, wrapped in an emergency space blanket [small, lightweight, packaged blanket made of laminated layers of polyester film, such as Mylar, with a reflective coating that can be used either to retain body heat or to protect from sunlight]. Ideally, a person should be in dry clothing, but wearing dry clothing after boarding a life raft isn't likely. Really wet clothing could be removed, wrung dry and put back on.

"Anyone who has had training on a life raft knows just how difficult this scenario would be while trying to board other survivors in a space barely big enough for each person to sit. You have to understand that this is a life raft, not a hospital. Restart breathing, stop bleeding, prevent shock and hypothermia, and do your best to prevent

"You have to understand that this is a life raft, not a hospital."

Figure 1
Approximate Seawater Temperatures



seasickness. That's reality; extraordinary measures may not be possible."

He said that some types of injuries — a crushed chest or spinal injuries — may preclude some people from evacuating the aircraft, but anyone able to make his way to the life raft is likely able to be treated effectively. Unless someone among the survivors has been trained appropriately in first aid, Burton said there should be no attempts at extraordinary treatment, such as attempting to set broken bones.

"Don't attempt to set broken bones unless you know what you are doing," said Burton. "Splint them in place and do the best you can to make the survivor as comfortable as possible."

While directing immediate first aid actions, the raft commander also will be ensuring that survivors get aboard the life raft. Usually after boarding, they will move to the opposite side from where the boarding is being conducted.

"Survivors in the water need to be retrieved from the water as soon as possible to delay the onset of hypothermia," said Burton. "Even in warm waters, they may be struggling against wind and waves, and they are likely to be exhausted from the experience of the ditching, evacuating the aircraft and making their way to the life raft [see Figure 1, Approximate Seawater Temperatures].

"As they board the life raft, each survivor should be told to partially deflate his life vest but to continue to wear it. With just a few breaths of air, the life vests can be re-inflated quickly if necessary. Bulky, fully inflated life vests would only add to everyone's discomfort."

When everyone is aboard, a roll call is necessary to determine the number of survivors and to gather any other information about missing persons.

"Roll call will confirm who is aboard the life raft and allow a quick determination of facts about those who did not survive," Burton said. "This confirmation also allows the raft commander to cut the mooring/inflation line and disconnect from the aircraft."

No one returns to the airplane to look for survivors or to gather equipment.

The basic assumption is that the airplane is going to sink.

"I just can't think of any circumstances under which anyone should return to the sinking aircraft," Burton said. "The risks are just too high. This emphasizes why the evacuation must be well planned and be conducted swiftly."

Burton said that a prompt burial at sea will be necessary for anyone who succumbs after boarding the life raft. The dead person's clothing — if it is serviceable — and personal items should be removed and the body lowered overboard; current and wind will move the body downwind. The clothing might help other survivors; the personal items should be held by a family member, friend or the raft commander and given to the next of kin after rescue. If the survival equipment pack (SEP) includes a waterproof notebook and a writing tool, the raft commander should record information about deaths and injuries.

"Under no circumstances can the body be tethered to the life raft in hopes of keeping the body for a burial on land," said Burton. "Predators will be immediately attracted to the body… you don't want that. Brief words, prayers, songs or a period of silence will have to suffice for the burial. This may seem cold, but there really are no other options. The duty of the survivors is to survive."

Operation of the emergency radio beacon and the sea anchor must be confirmed.

"Hopefully, the beacon is a 406-MHz type with built-in GPS position reporting," said Burton. "That is the only type of beacon that you should rely on. On some life rafts, the beacon is water-activated automatically after deployment of the life raft. Without the optional water-activated operation of the beacon, manual activation will be required. If the raft commander has received sufficient training and is familiar with the life raft and its equipment, he can take care of this task as soon as he boards the life raft. Otherwise, he might not have time to search for the beacon, read the instructions and carry them out while getting survivors aboard. Activation of the beacon will have to wait until everyone is aboard the life raft, or he can assign an able-bodied passenger to the task.

"The sea anchor is an essential piece of equipment in stabilizing the life raft, so the raft commander needs to ensure that it has been deployed correctly. He can pull the sea anchor line in close enough to confirm that the sea anchor hasn't become fouled, which would prevent it from functioning correctly. If the sea anchor is a manually deployed device, then the raft commander needs to deploy it quickly. Hopefully, the sea anchor is equipped with a swivel, which will help prevent fouling. If not, when a watch is established and the sea anchor line is checked for chafing and fraying, the person on watch needs to be certain that it hasn't fouled. The sea anchor is so important, that having a spare with at least 50 feet of line packed either in the life raft or the ditch bag would be a good idea [see 'Life Raft Primer: Guidelines for Evaluation,' page 233]."

Ready-to-drink Fresh Water

Fresh water must be readily available to survivors as soon as they board the life raft (see "Water, Water Everywhere, Nor Any Drop to Drink," page 177). Such readiness rules out water produced by a desalting kit or from a hand-operated water maker [manual reverse-osmosis desalinator]. Old concepts of waiting 24 hours before drinking any water and of rationing water are no longer espoused.

Packaged ready-to-drink fresh water will offer immediate relief to survivors on the life raft.

A life raft and its survival equipment pack are laced tightly during packaging under pressure.

"Holding back dehydration is going to be a number one priority, so that means seasickness has to be prevented," said Burton. "Ready-to-drink water must be immediately available to the survivors, who have exerted themselves and will have swallowed plenty of seawater while they were in it. And anyone who didn't take anti-seasickness medication before ditching should take it immediately after boarding the life raft. The first time somebody pukes, in short order most everyone on the life raft will be puking, and that dramatically speeds dehydration. However, a dab in each nostril of Vicks VapoRub — packed in the ditch bag [see 'Don't Leave the Aircraft Without It,' page 157] — will help mask the odor of the vomit and might prevent other people from vomiting.

"The survivors need to have drinking water — if they want it — without learning how to use the water maker or the desalter. The life raft should be equipped with at least eight ounces [250 milliliters] of fresh water per person — packed in small plastic containers or in soft-foil packages. The supply of fresh water should be adequate for the life raft's rated overload capacity. Of course, water carried from the aircraft in the ditch bag is another source of readily available water, but survivors might not be able to rely on that being available. Ideally, the water should be packed in the life raft/SEP."

The water might be packed at the top of the SEP or it might be packed in a storage pocket on the life raft. Only with knowledge about the equipment and with planning would the raft commander know where to find the water or be able to direct someone else to it. Moreover, except for the water used immediately after boarding, the remaining packaged water should be saved for an emergency, and the survivors should rely on the hand-operated water maker and rain for daily drinking water.

"When the life raft is purchased, the aircraft operator should designate a member of the flight crew or the cabin crew to work with the life raft manufacturer to get information about the placement of water and other supplies and equipment [see 'Life Raft Evaluation: Pooling the Resources,' page 258]," said Burton. "Most of the manufacturers will be

Continued on page 159

Don't Leave the Aircraft Without It

A ditch bag (also known as an abandon-ship bag, a grab bag and a jump-out bag) carries specific survival equipment and personal items that might not be packed in a life raft or a survival equipment pack (SEP). There are limits to what can be packed into a life raft (or a ditch bag), and some items might have practical uses that would be beneficial in situations that do not require deployment of the life raft. Most important, the ditch bag would be readily accessible for carry-out and require no effort by the crew to remember gear that should be in it. In a ditching, an aircraft crewmember should be assigned the responsibility to ensure that the ditch bag reaches the life raft (see "Prepare to Ditch," page 20).

A variety of purpose-built ditch bags are on the market, but few combine durability, waterproofness and buoyancy. Plastic cases, such as those available from Pelican Products,[1] provide these features, but fabric bags might provide some flexibility in an aviation environment.

One company (there may be others) that offers ditch bags that are durable, waterproof and buoyant is Watershed, which provided two models of its ditch bags for evaluation by Flight Safety Foundation (FSF).[2] The bags are constructed of seamless polyurethane applied in layers to nylon pack cloth, which is available in a variety of colors; yellow is preferred for a ditch bag because of its high visibility. The company said that the material is flexible in cold weather, ultraviolet stable and resists abrasion and puncture. Both bags were equipped for "backpacking" with plastic buckles that could be adapted to secure the bag to a life vest or a mooring/inflation line. The company has a simple lifetime repair/replacement guarantee.

The Foundation's in-water evaluation showed that attaching a four-foot (one-meter) lanyard between a life vest and a ditch bag provided an easy way to float the ditch bag to the life raft. Putting a snap clip or carabiner at each end of the lanyard will allow fast attachment.

Watershed's Ultimate Ditch Bag measures 15 inches by 32 inches (38 centimeters by 81 centimeters) and is fitted with a very large, full-length, waterproof zipper and an oral-inflation tube to add air for buoyancy. The Foundation loaded this US$250 bag with 130 pounds (59 kilograms) of weight, and it floated. This bag would be sufficient aboard corporate jets to store most supplemental survival equipment, with room left for storing personal items such as money, credit cards, driver licenses and passports; most survivors cite the loss of such personal items as major inconveniences between the rescue and arrival at home.

A buoyant ditch bag is buckled to the mooring/inflation line and is pushed by the survivor as he pulls himself to the life raft.

The Ocoee Duffel (above) measures eight inches by 17 inches (20 centimeters by 43 centimeters) and has a very large, full-width, self-locking closure. No oral-inflation tube was included (but the company will fit one for a small cost), but with 15 pounds (seven kilograms) of weight, the $69 Ocoee Duffel floated easily. This bag would be more suitable for carrying minimum equipment, such as a very-high-frequency (VHF) marine handheld waterproof transceiver, a 406-megahertz (MHz) personal locator beacon (PLB), a few flares, prescription medicine and other personal items.

Ken Burton, president of STARK (Sea, Tropic, Arctic, Regional Knowledge) Survival Co. <starksurvival.com>, suggested the items below for a ditch bag for a corporate jet, based on the possibility of having 15 people (overload capacity) in a 10-person life raft and a rescue within one week.[3] Nevertheless, operators should review their individual requirements to determine the contents of their ditch bags. Discuss with the life raft manufacturer how some supplemental items might be packed with a life raft/SEP. Burton also advocates that *anything* in the aircraft — blankets, paper towels, trashcan bags, cans of soda/water — that might be useful on the life raft should be placed in plastic bags (impromptu ditch bags) or clothing and carried to the life raft by the survivors, conditions permitting.

Safety Items

(Avoid glass containers.)

- Eight red SOLAS (International Convention for the Safety of Life at Sea) parachute flares;
- Two red handheld flares;
- One 406-MHz emergency locator transmitter (ELT) or PLB with built-in GPS position reporting; consider emergency position-indicating radio beacon (EPIRB) because of 48-hour nominal operating time;
- Two orange smoke flares;
- One waterproof VHF marine transceiver with two sets of spare batteries;

- One Rescue Laser Flare with two sets of spare batteries;
- Two waterproof, medium-size flashlights with accessory red lenses and with two sets of spare batteries;
- Two hundred feet (61 meters) of nylon twine (165-pound [75-kilogram] test);
- One hundred fifty feet (46 meters) of 550 military-specification parachute cord;
- One waterproof notebook;
- Two waterproof pens;
- Two pencils;
- One multi-purpose knife-tool;
- Six Cyalume light sticks;
- One spare life raft inflation pump;
- One spare sea anchor with line;
- One package of gallon-size zipper-lock bags;
- Two packages of small-size trash bags;
- Two medium sponges;
- Six large, heavy-duty 30-gallon (114-liter) trash bags;
- One roll of duct tape;
- One collapsible, one-gallon (four-liter) water bottle;
- Sufficient plugs for life raft pressure-relief valves and topping valves, as required; and,
- Four spare small mechanical clamps and two medium mechanical clamps for buoyancy tube leaks.

Food and Water

- Fifteen eight-ounce (237-milliliter) water packets;
- Fifteen emergency space blankets; and,
- Fifteen high-carbohydrate energy bars.

First Aid

- Two large tubes of over-the-counter multi-antibiotic ointment;
- Variety of transparent waterproof breatheable bandages;
- Two six-ounce containers of Betadine;
- One small container of Vicks VapoRub;
- Ninety anti-seasickness tablets;
- Ninety Ibuprofen;
- Sixty aspirin;
- Package of gauze;
- Two SAM Splints (constructed from malleable aluminum); and,
- Three rolls of adhesive tape.

Personal Items

- Two eight-ounce containers of SPF (sun-protection-factor) 30 sun block;
- Two pairs of sunglasses;
- Two sunshade hats;
- One 16-ounce container of liquid soap and a bar of soap;
- Sixty waterless cleansing wipes;
- One roll of tissue paper; and,
- One large container of toothpaste (for finger-brushing of teeth).

Special Items

If any passengers flown regularly on the corporate aircraft require ongoing prescription medicines (e.g., nitroglycerine), a 10-day supply of the drugs should be included in the ditch bag; typically, drugs have a shelf life of one year.

Burton believes that corporate aircraft should be equipped with a customized first aid kit. No matter the type of operation, the aircraft first aid kit should be carried to the life raft.

Discuss with the company physician recommendations for including in the ditch bag one or two prescription broad-spectrum antibiotics for treatment of infections and prescription drugs for pain. For more specialized assistance, seek the advice of specialists, such as the staff of MedAire <medaire.com>, a company that provides aviation and marine assistance in health and security issues, including customized first aid kits for aircraft operators (see “If You Need It, They Have It,” page 382).

By the way … Iridium Satellite System <iridium.com> is currently the only provider of global — oceans, polar regions and airways — satellite voice and data coverage, with a constellation of 66 low-earth-orbiting satellites. If you sign on for service and have your portable satellite telephone with you, call home from anywhere with a clear view of the sky … maybe even from a life raft. ■

— FSF Editorial Staff

Notes

1. <www.pelicanproducts.us>.
2. Watershed, 2000 Riverside Drive, Asheville, NC 28804 U.S. <www.drybags.com>.
3. See <www.equipped.org> for more information and discussions about ditch bags and the equipment that might be included in them.

willing to make special arrangements, such as placing water and anti-seasickness medication among the first available items in the SEP or placing water containers in the life raft's storage bags. The crewmember should carefully examine the items in the SEP for their quality and adequacy for the aircraft's geographic area of operations. Consider, too, that a life raft and the SEP can provide shelter and supplies on land."

Auto-erecting Canopy, Insulated Floor Provide Immediate Protection

If the life raft has been deployed with an auto-erecting canopy, the survivors have immediate shelter with minimal effort by the survivors. U.S. Federal Aviation Administration Technical Standard Order (TSO)-C70a, *Liferafts (Reversible and Nonreversible)* (paragraph 4.4) says, "The erected canopy must be capable of withstanding 35-knot winds and 52-knot gust[s] in open water. The canopy must provide adequate headroom and must have provision for openings 180 degrees apart. … If the canopy is not integral with the [life] raft, it must be capable of being erected by occupants following conspicuously posted, simple instructions. It must be capable of being erected by one occupant of an otherwise empty [life] raft and by occupants of a [life]raft filled to rated capacity."

Burton, however, is not an advocate of manually erected canopies.

"If the life raft is equipped with an auto-deploying canopy, shelter is available immediately, especially desirable if sea conditions and weather conditions are rough," he said. "Although an entry will be open to board survivors, any means of preventing more water from getting aboard means you have that much less water to bail. Protection from the water — and the wind — will be useful in preventing hypothermia for all the wet survivors who are aboard. When everyone is aboard, the entrance is closed and life becomes more tolerable. Body heat generated by the survivors in the confined space will help prevent hypothermia.

"Although I have had plenty of experience with manually erected canopies — stick-built is what I call them — I just can't recommend them, unless people are well-trained to use them. They require too many separate parts that are too easy to lose overboard. And the canopy — which is so important to protect the survivors — can be blown away during the construction phase or washed away or damaged during a capsizing. You can't wait for the weather to improve to install the canopy, because the survivors need shelter immediately or they may die of hypothermia.

"Ocean water, no matter how warm it is, is cooler than human body temperature."

"In my training programs and in the military, too, I've used these types of life rafts. They require considerable coordination, especially in a survival situation made more difficult by darkness, wind, high waves and heavy rain. These types of life rafts have been used by many airlines, whose crews have been trained to use them, but even with training, erecting the canopies on these types of life rafts can be very challenging.

"Yet, until life rafts were improved in recent years, these types of life rafts were very common. Flight crews and cabin crews who currently have this type of life raft should get in a swimming pool and train with it, so they know how to use it. They might be satisfied with this type of life raft or they might decide to buy a different type of life raft."

Burton said that he prefers an auto-inflating, insulated floor and he believes strongly that insulated floors are essential. Extra insulation on the life raft floor will help prevent hypothermia. Burton favors features that will make the life raft more comfortable for survivors.

"Ocean water, no matter how warm it is, is cooler than human body temperature," said Burton. "That means survivors must guard against hypothermia. An insulated floor will help extend survival time, especially when the water is cool — or cold.

"Auto-inflating floors aren't that common, but just like the auto-erecting canopy, anything the life raft can do for the survivor will be in the survivor's best interest, especially if the survivor is injured — or more likely — is untrained and knows nothing about the life raft. Most inflatable floors must be inflated with the raft pump. I'm not that familiar with life rafts that have a layer of foam that provides additional insulation, but the design does promise protection without action by the survivor.

"I am in favor of features that will help morale. A life raft built to the minimum TSO standards doesn't offer much. But a clear plastic window on a rainy day may help prevent seasickness and, in turn, prevent dehydration. That simple feature could mean the difference between life and death on a life raft. People need to give careful thought about such details before they buy a life raft."

Settling In

Everyone is aboard, immediate first aid has been initiated, the beacon has been activated, roll call has been taken, drinking water has been made

Life raft bellows pump and a backup oral inflation hose.

available, survivors' life vests have been deflated partially, the sea anchor has been deployed, the mooring/inflation line has been cut, the canopy has been deployed as necessary, the insulated floor has been inflated, and lights on the life raft have been activated — or have been deactivated (water-activated batteries can be removed from the water to extend their longevity) — as necessary. Now the raft commander can begin to establish the next phase of life raft operations.

Survivors are more than likely to be in life rafts at or near their rated capacity, and little extra room will be available for anyone to lie down to sleep. More than likely, survivors will be sitting in a round-type life raft because more of these are made than any other type. Survivors will be sitting with their backs to the inside walls of the buoyancy tubes and with their legs intertwined in the center and/or knees drawn upward against the survivors' chests. Survivors, whether awake or asleep, likely will be seated side-by-side. Moreover, some allowances might be necessary to help survivors who have been injured.

"People need sleep," said Burton. "Without sufficient sleep, people will be less alert, which could lead to unsatisfactory decisions or to unpleasant morale. People on watch must have sufficient sleep to remain awake, especially those whose watches will be at times when they normally would be sleeping. Naps may be one way to cope, but an effort should be made to ensure that each survivor has at least a few hours of uninterrupted daily sleep. The watch schedule also fashions a rudimentary sleep schedule."

If weather conditions are hot, the survivors need to stay in the shade and wear clothing to protect their arms, legs, neck, face and head from the sun. Sunscreen can be applied to exposed skin, especially for survivors on watch during 10 am to 2 pm, when sunlight is most intense. Moreover, water will reflect sunlight too. An adult exhales a quart of moisture in breathing during a 24-hour day. And in a warm climate, sweating probably causes the greatest loss of moisture.

"Dampening clothing may offer some relief from heat," said Burton. "Tasks, such as daily organizing and cleaning of the life raft, should be scheduled in the cooler hours of early morning or late afternoon. Even in cool conditions, the sun can cause sunburn, so survivors need to protect themselves from the sun, but they should be sure to keep their heads covered because most body heat is lost from the head and neck. Huddling together for warmth will be important. Emergency space blankets can be used to trap body heat, and if a person puts his body into a large plastic bag, even more warmth can be trapped."

All the survivors are likely to be exhausted, and a variety of emotions will be expressed as they settle into the next phase of preparing to be rescued. Nevertheless, a routine must be established quickly to tend to tasks necessary for survival, as well as preparations for rescue.

"The raft pump must be tethered so it won't be lost overboard," Burton said. "The inflated parts of the life raft are probably going to need to be 'topped off' with air, especially as the life raft cools at night. If the life raft is equipped with an inflatable floor, it may have to be topped off, too. Getting that done quickly will be another important means of preventing hypothermia.

"The bailer is important, because you need to get the water out of the life raft. 'Dry' will be a relative term, but water shouldn't be sloshing on the life raft floor. A sponge will help get the water that the bailer won't get, especially in the sections where the floor meets the buoyancy tube."

Survivors must perform these tasks because everyone needs to participate in surviving. The SEP must be retrieved. In some life rafts, it is ejected into the water and connected by a tether to the life raft. In other life rafts, it is contained in the life raft.

"Obviously, the SEP that is contained in the life raft probably has less opportunity to be lost or damaged by water," said Burton. "Sometimes, the raft instructions may not be adequate and the survivors may not realize that a survival kit is under water [where the manufacturer intended it to be] and attached to the end of a line from the life raft."

In the United States, for example, the Federal Aviation Regulations for Part 91 extended overwater operations more than 100 nautical miles or more than 30 minutes flying time from the nearest shore [see "Regulations, Judgment Affect Overwater Equipment Decisions," page 387] for large and turbine-powered multi-engine airplanes require that "a survival kit [SEP] appropriately equipped for the route to be flown, must be attached to each required life raft." Under Part 135 extended overwater operations (more than 50 nautical miles from the nearest shore), the operator can choose between an SEP "appropriately equipped for the route to be flown" for each life raft *or* an SEP with 18 specific items; three of those items — a canopy, retaining line (mooring/inflation line) and a CO_2 inflation cylinder — are normally attached to the life raft. The remaining 15 items are barely sufficient to ensure survival aboard a life raft for a short period: radar reflector (emergency space blanket or reflective tape); one life raft repair kit; one bailing bucket; one signaling mirror; one police whistle; one raft knife; one inflation pump; two oars; one magnetic compass; one dye marker; one flashlight having two D batteries or equivalent; two-day supply of emergency food rations supplying at least 1,000 calories per day per person; for each two persons the life raft is rated to carry, two pints of water or one seawater desalting kit; and one book on survival appropriate for the area in which the aircraft is operated.

"The quality of the contents of any SEP can vary from manufacturer to manufacturer, and some may include additional equipment in the SEP," said Burton.

"Get details about the gear in the SEP from the life raft manufacturer. And operators should pack supplemental gear in a ditch bag [see 'Don't Leave the Aircraft Without It,' page 157]."

The raft commander should record, in the waterproof notebook, a basic inventory of the supplies and equipment aboard the life raft.

"An inventory soon after settling in will be helpful in determining what equipment and supplies are aboard the life raft, especially those brought aboard as personal items by the survivors," said Burton.

The emergency signaling equipment, including a signal mirror, whistle and flares, should be grouped together so that it is readily accessible and everyone in the life raft knows where it is located. The same should be done with first aid supplies, food and water, and survival tools, such as the utility knife and fishing kit.

"The quality of the contents of any SEP can vary from manufacturer to manufacturer."

A good fishing kit includes a variety of small and large hooks; that kit must be securely stored so the hooks do not puncture the life raft or the survivors. Even if they are packed in a tough bag, a short time in a wet life raft probably will weaken the package so the hooks can break through the package.

Some manufacturers provide storage bags that are attached to the life raft; others provide individual plastic bags with zipper-type closures; and some don't provide any extra bags. Anything that has a tether must be tied securely to the life raft, and anything that should not be lost overboard should be packed in a storage compartment or fitted with a tether.

"The equipment may be much less than what your children took on a weekend scout-camping trip, but it will be all the gear that is supplied," said Burton. "You want to be sure it does not go overboard, especially if the life raft is capsized."

More Drinking Water

Burton said that every life raft should be packed with a manual reverse-osmosis desalinator (see "Making Seawater Drinkable in Just a Few Strokes," page 179, and "With a Little Agitation, Desalting Kits Yield Drinkable Water," page 182).

"The [Katadyn] Survivor-06 hand-operated water maker is a must-have item, although the bigger model [Survivor-35] may be better for situations where 10 or more people may be on the life raft," said Burton. "First, the weight tradeoff. Try to carry a week's worth of packed water for 15 people or enough desalting kits to keep them going for a week. The water would be heaviest, followed by the desalting kit, followed by the Survivor. But when the packaged water is consumed, and the desalting kits are expended, the water maker can still be pumped, and it will provide the survivors with a lot more water than the minimum required to survive."

He said that using the water maker comes at the cost of using human energy in a situation in which there is likely to be an insufficient replacement of that energy. Children and ill or injured adults probably will be unable to pump sufficient water.

"So, the raft commander has to assign people to pump the water, which should be stored in a separate water bag," said Burton. "Refill the containers that provided the ready-to-drink water, especially if the water was in containers with screw-on caps. If plastic storage containers, plastic trash bags, vacuum bottles or other closeable containers were transferred from the airplane to the life raft, fill them, although the trash bags

Four of these sealed packets of food would be only 500 calories short of meeting the requirements of 1,000 calories per day per person for 15 persons.

shouldn't be filled so much that they would burst or prevent a knot from being tied with the bag's end. And if people want to drink water, let them. They shouldn't guzzle it, but thirsty people should drink. As long as drinking water is available, no rationing of water should be necessary."

If containers of juice, soft drinks, etc., have been retrieved from the airplane (see "Prepare to Ditch," page 20), these should be retained after the liquids have been drunk, because they will be useful for storing fresh water from the hand-operated water maker or to hold rainwater. Small openings for drinking — the smaller the better — in these containers will help prevent spillage as the life raft moves in the water. A larger container — such as a bailer — can be used to capture water and fill small-hole containers. Alcoholic beverages, which cause dehydration, shouldn't have been retrieved from the aircraft.

The canopy should be rinsed with seawater to remove any packing powder or other materials that might be present from when the life raft was packed. Washing the canopy should be a daily task, which will help to keep salt buildup on the fabric to a minimum. When rain arrives, remaining salt can be washed away quickly and the canopy can be used to funnel rain into a bailer and into any other containers the survivors have opened. Some life rafts are equipped with a special scoop on the canopy that will funnel water via a fabric tube into the interior of the life raft, where it can be directed into containers. These internal scoops are usually equipped with some type of closure, so the flow of water can be stopped.

Food and Energy Conservation

If the food in the SEP is packed to Part 135 requirements, for example, then it will be no more than 1,000 calories per person per day for two days (see "If You Need It, They Have It," page 382).

"If plenty of water is available for digestion, then the food can be eaten," said Burton. "And it might be a tasty treat in a survival situation. But people can go a long time without food, and the raft commander must emphasize that fact to people who may not understand the realities of survival, especially when the meager food supplies have been eaten.

"That will go hand-in-hand with survivors refraining from any unnecessary physical activity, but that doesn't include in-place exercises to stretch muscles in the neck, shoulders, back, legs and feet, which will go a long way to making cramped positions more bearable. Energy conservation is very important, so unless survivors are performing assigned chores or scanning the horizon for ships, land and airplanes, they should be doing as little as possible. Talk games or playing cards (waterproof playing cards are sometimes included in an SEP) can be used to pass time. People can share funny stories, laugh and sing songs to keep positive outlooks."

The survival manual on the life raft will include information about fishing for food, which types to avoid and which body parts aren't edible. The raft commander should assign a team to try their hand at fishing, especially if experienced fishermen are among the survivors. In addition to nourishment, fish provide some moisture. Care is required when fishing to prevent injuries to the survivors in the life raft and to prevent punctures of the buoyancy tubes.

"Of course, everyone had better like raw fish," said Burton, who noted that sufficient water will be necessary to digest food.

Continued on page 164

Will to Live Is Essential in Survival Situation, Specialists Say

Maintaining a positive mental outlook may be the single most important factor in any water-survival situation.

In advisory information about aircraft ditchings, the U.K. Civil Aviation Authority (CAA) called the will to live "the most powerful force to prolong life."[1]

"Without a will to survive, there can be no survival," said Roger Storey, aviation physiologist and survival-training instructor for the U.S. Federal Aviation Administration (FAA) Civil Aerospace Medical Institute (CAMI). "If you do not have a desire to survive, there is no equipment made that will help you survive."[2]

Furthermore, Ken Burton, president of STARK (Sea, Tropic, Arctic, Regional Knowledge) Survival Co., said, "If you're not focused on your survival, all the other things are going to bother you."[3]

In a survival situation, mental depression and boredom can be devastating, he said.

One of the best ways to avert such conditions and to develop a positive attitude is to undergo survival training, Storey and Burton agreed.

"Everybody has survival instincts," Burton said. "Training helps you develop skills that give you confidence that you will survive in an alien environment, on the life raft."

Storey said, "There are two simple, but important, ways you can increase your chances of survival. These involve preparation — before you ever find yourself in an actual survival situation. The first is to admit to yourself that 'it can happen to me.' The next step is to prepare yourself, both mentally and physically. It is not enough to prepare mentally if you cannot withstand the physical requirements of a survival situation.

"The mental preparation can come in the form of educational courses, books or conversations [with people who have been in survival situations]. … Preparing yourself physically for a survival situation depends greatly on the shape [physical condition] you are in now."

Every situation will include several priorities, but the order of their importance will vary, depending on the specific situation, Storey said. Those priorities are the following:

- First aid — caring for yourself or others who may require medical treatment;
- Shelter — ensuring that the life raft has been deployed properly; that the canopy, if there is one, has been erected; that the inside of the life raft is as dry as possible; and that occupants of the life raft are evenly spaced on the life raft;
- Signaling — having signaling devices available and ensuring that someone knows how to operate them;
- Water — knowing how to procure water. (Food is of secondary importance, especially if rescue is likely within several days.); and,
- Rest — providing opportunities for the body and the mind to recuperate from the physical stress and mental stress inherent in a survival situation.

Life on a life raft is likely to be better with as many people and as many supplies as possible, said Paul D. Russell, a maritime safety specialist and accident investigator, and a retired U.S. Coast Guard captain with more than 5,000 flight hours in fixed-wing and rotary-wing aircraft. As a result, in situations in which two or more life rafts are deployed, the life rafts should be tied together as closely as possible. The designated leader — often the captain of the aircraft — should ensure that everyone on the life raft is assigned a specific task.[4]

Those individual assignments are required to ensure that everyone on the life raft is involved in a worthwhile task until rescuers arrive and that, in addition to being busy, they feel that they have some control over what will become of them.

"If someone has nothing to do, the mind is going to start to wander," Storey said. Depression may follow, along with a loss of the will to live.

In addition, although people can survive without food, hunger pains can contribute to mental stress and can weaken the will to live. CAMI said that, in these cases, the best response is to ensure that the individual has assigned survival-related tasks to perform.[5]

An assigned task is the best method of relieving anxiety, which is "most contagious and can destroy chances of survival on the open sea," said the United Nations World Health Organization in its *International Medical Guide for Ships*.[6]

Extreme anxiety and other mental disturbances may appear among survivors, either before or after rescue, the guide said.

"Acute agitation should be treated promptly, as the situation demands; in some situations, forcible restraint may be required," the guide said.

The will to live is enhanced by thoughts of loved ones, survival-training specialists said.

Doug Stanton, author of a book about the survivors of the *USS Indianapolis*, a U.S. Navy heavy cruiser that sank after being struck by Japanese torpedoes in the Pacific Ocean during the final days of World War II, said that during interviews, the men told him that "their survival had to do with will, with a sharpened consciousness of one's own self, with a stunning awareness of what one would and would not do to keep living.[7]

"Every man I talked to said that, early on in the disaster, he somehow decided he was going to survive. Most actually said to themselves, 'I am going to live.' They heard within themselves some voice — a mother's whisper, a father's urging to try harder; at other times, it was a basketball coach's chewing out over not playing a great game. Sometimes, it was the memory of a girlfriend back home, her hair lit by a halo of sun on a summer day. These men clung to these apparitions with all their might, and they lived."

Cold-water survival specialists Frank Golden, M.D., Ph.D., and Michael Tipton, Ph.D., writing in *Essentials of Sea Survival*, said that the will to survive and other psychological considerations cannot be considered apart from physiological considerations for individuals on a life raft.[8]

"In a survival scenario, the boundary between psychological and physiological responses becomes blurred because many of the signs and symptoms associated with both are similar and therefore difficult to distinguish," they said. "We know that the physiological state can alter perception. For example … hypothermia will usually produce introversion; dehydration and hunger cause lassitude [fatigue and/or indifference]; and hyperventilation is associated with panic."

Survival specialists say that the will to survive can help people overcome many physiological challenges.

"People who keep centered on living, centered on something they yet want to do, are the ones who survive," Russell said. "People who intend to perish and get wrapped up in their current situation are the ones who die."■

— FSF Editorial Staff

Notes

1. U.K. Civil Aviation Authority (CAA). *General Aviation Safety Sense: Ditching* (Leaflet 21A). 2000.

2. Storey, Roger A. *Airman Education Programs Topics of Interest: Striving to Survive*. <www.cami.jccbi.gov/aam-400/striving.htm>. Aug. 12, 2003.

3. Burton, Ken. Interview by Werfelman, Linda. Hollywood, Florida, U.S., April 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

4. Russell, Paul D. Interviews by Werfelman, Linda. Hollywood, Florida, U.S., April 22, 2003, and Alexandria, Virginia, U.S., May 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

   In the U.S. Coast Guard, Russell conducted more than 200 water landings and served in various positions, including commander of two air stations, chief of the Aviation Training Center Training Division and chief of search-and-rescue operations in the Northwest Region, before retiring in 1984 with the rank of captain. He is chief engineer, aviation system safety, Boeing Commercial Airplanes, and a maritime safety and accident investigator for Safety Services International.

5. U.S. Federal Aviation Administration Civil Aerospace Medical Institute. *Basic Survival Skills for General Aviation: The Will to Survive*. Global Survival Video Series.

6. United Nations World Health Organization (WHO). "Medical Care of Castaways and Rescued Persons." *International Medical Guide for Ships*. Chapter 12. Geneva, Switzerland: WHO, 1988.

7. Stanton, Doug. *In Conversation With Doug Stanton and Survivors of the USS Indianapolis*. <ussindianapolisinharmsway.com/qa.htm>. June 10, 2003.

   Stanton is the author of *In Harm's Way: The Sinking of the USS Indianapolis and the Extraordinary Story of Its Survivors*. The "conversation" is on an Internet site maintained by the book's publisher, Henry Holt and Company, New York, New York, U.S.

8. Golden, Frank; Tipton, Michael. *Essentials of Sea Survival*. Champaign, Illinois, U.S.: Human Kinetics. 2002.

Some fishing kits are much better than others. For example, a preferred kit approved by the U.S. Coast Guard provides extra fishing line, a variety of hooks, a variety of lures and several leads. Unfortunately, unless this information is learned beforehand, an inferior fishing kit — line with a hook on it and wrapped around a piece of cardboard — can be packed in the SEP.

"Don't allow anyone to wrap the fishing line around a hand, which could result in a serious cut if a big fish took the bait," Burton said. "Use a paddle to wrap the line. If a fish breaks it, you didn't need that fish aboard the life raft anyway. The line needs to be retrieved very carefully to ensure that a hook doesn't snag and puncture the life raft, which would be likely to occur below the water when pulling the line in. The SEP should have a utility knife that can be used to cut the fish, which must be done very carefully on a paddle or other hard surface to avoid puncturing the life raft."

Traveling Companions

Reports by survivors are generally consistent in saying that sharks — and other fish — will be congregating under the life raft and "bumping" it while competing for the survivors' next meal, said Burton (see "What's Eating You? It's Probably Not a Shark," page 211).

"Some of those bumps have been described as painful," said Burton. "Unfortunately, shark skin is just like

U.S. Coast Guard-approved fishing kit provides a wide variety of aids necessary to catch fish to supplement life raft rations.

sandpaper, so it can abrade the life raft material, but a lot of rubbing would be required to do damage. To most sharks, a life raft is just a lifeless shape that doesn't invite a taste-test. That is one reason to dispose of human waste in a plastic bag. While plastic packaging won't prevent a shark's very sensitive senses from associating the waste with a potential meal, lessening its association with the life raft may prevent the life raft from being confused with something good to eat."

The likelihood that sharks and other large fish will be in the area is another reason that no one should go overboard, except in an emergency.

"Except under emergency circumstances, no one should leave the life raft to 'exercise' or to 'bathe,'" Burton said. "Such activity will require energy that can't be replaced, and getting back into the life raft will probably require the assistance of other energy-depleted survivors. Moreover, anyone who goes overboard can be bitten by fish, and those wounds might become infected.

"If an important piece of equipment falls overboard and floats, then a heaving line can be tied to an able-bodied volunteer's life vest and he can go overboard and try to retrieve the gear, but only as far as the line allows. The raft commander might follow a similar procedure for a survivor who falls overboard but cannot be recovered with the heaving-line quoit.

"The sea anchor can be retrieved, the water-ballast bags can be emptied, if possible, to allow the life raft to drift faster toward the survivor, and paddles can be used to attempt to steer the life raft, although they aren't very effective for propulsion. But all these actions must be taken with great caution and are not warranted in rough sea conditions."

Keeping Watch

Ideally, pairing people to perform tasks, including watches, provides a backup and a teammate with whom to share tasks. A watch system must be introduced to ensure that at least one survivor is on watch all hours of the day. The simplest system is to divide 24 hours by the number of people physically able to be on watch (e.g., with six people, each watch period is four hours, or if divided into three teams, each watch period is eight hours). When on watch, a survivor should be assigned a seat position at the primary entry (and the alternate entry with a team). If people on watch don't have their own sunglasses and hats, people off watch should loan them their accessories.

"The watch will be on lookout for ships, low-flying aircraft, land, changing weather conditions and anything else that might affect the condition of the life raft and the survivors," said Burton. "For example, being aware of weather conditions will allow the watch to be prepared to collect rain for drinking water and to ensure that the canopy will be secured to maintain a dry interior.

"The watch will also be responsible for checking the life raft equipment, including topping off the life raft with air if necessary and checking the sea anchor line to ensure that it isn't chafing, which could damage the life raft or dramatically reduce its stability if the line parted and the sea anchor was lost. Moreover, chafing could result in an air leak from the buoyancy tube and require a repair.

"Caring for sleeping, ill and injured survivors will be a duty of the watch, and range from ensuring that people do not fall asleep where they could suffer sunburn to preventing someone's arm from hanging in the water, which could attract a predator."

Flashlights supplied with SEPs generally are not the most effective signaling devices. They have been provided so that survivors can use them at night to locate equipment and to check the condition of

Flashlights will be essential to locate equipment and to check the condition of the life raft during darkness.

the life raft. Survivors should use flashlights judiciously, even if extra batteries have been supplied in the ditch bag. Nevertheless, survivors should use any available device to attract attention when possible rescuers are seen or heard.

"Before the flight crew and cabin crew abandon the aircraft, they should be grabbing every flashlight and spare battery carried on board," said Burton. "Flashlights will be very useful to the evening watch and the early morning watch. They will need them to check the condition of the life raft, to get the flares to signal a passing ship or a low-flying search plane and to check the condition of the other survivors. Even on a rainy day, some enclosed life raft interiors can be relatively dark."

Chemically powered lights, such as those manufactured under the Cyalume brand by American Cyanamid Co., can provide a bright light for several hours. A six-inch (15-centimeter) "light stick" is a robust plastic tube that houses a glass vial of chemicals separated from other chemicals in the plastic tube. To generate light, the plastic tube is bent, which breaks the vial and mixes the chemicals together. The light is claimed to be nontoxic, but eye contact with the chemicals should be avoided. Burton said that white light is best, but other colors are available.

"One of these lights will provide sufficient illumination for the interior of the life raft for an entire night," said Burton. "That will save a lot of flashlight batteries. If you tie one of these lights onto a short string and twirl it around, it will be a good signal light that can be seen for a mile or more. Remember, on the ocean, there will be no background lights, just light from stars and the moon. 'Dark' is really dark on the ocean, so light is readily visible. Moreover, despite the importance of light, the survivors on watch must protect their eyes from unnecessary light so their night vision won't be impaired."

A variety of flashlights are available that use long-life LEDs (light-emitting diodes), which require less power and which dramatically extend battery life. These lights vary from simple minimal lights seen on key chains to powerful and waterproof high-intensity spotlights with 60 LEDs. For example, a one-LED self-powered — no battery — flashlight evaluated by the FSF editorial staff required only gentle shaking for 30 seconds to charge the capacitor that powered the light for five minutes and was claimed to be good for more than 100,000 charges. The waterproof light floated. Although not a bright light, it could be used to locate equipment in the life raft.[2]

"Light will be important, so a couple of rugged flashlights — with accessory red lenses to protect night vision — with waterproof switches will be good additions to the ditch bag," said Burton.

"In addition to using his eyes, the survivor on watch will be using his ears to listen for airplanes and ships," he said. "The sounds of a ship's engine can travel in the water, so survivors should be informed that if they are awakened from sleep by engine sounds, they probably are engine sounds, and everyone should be looking for a ship. Sometimes engine sounds can be heard through the water before they can be heard through the air.

"The person on watch needs to know how and when to use the flares, which should be stored close to where the watch is seated. If a ship is visible, a flare should be launched. If the watch has to first wake the raft commander and discuss the situation before action is taken, the opportunity could pass very quickly.

"So, once again, the raft commander must know the capability of the equipment that he has at hand and how best to use it, so he can transfer that information to the other survivors."

Sightings of ships and aircraft should be reported to the raft commander, so that he can record the sightings in the notebook.

Personal Hygiene

The survivors are going to stink very quickly. They are going to smell like fish or worse.

They and their clothing will have been wet with salt water teeming with a variety of tiny organisms, and they probably won't be dry until they are rescued. Moreover, salt is accumulating on their skin, and that can cause problems.

"Remember, no survivor goes overboard to bathe, but liquid soap taken from the airplane or packed in the ditch bag can be used to wipe salt accumulations from exposed skin, and that will be useful in preventing boils," said Burton. "Napkins, toilet tissue or paper towels can be used to apply the soap. In seawater, soap does not create suds and tends to leave a film on the skin. The survivors also must ensure that they maintain clean hands, including under the nails. Dirty hands are a primary means of spreading sickness."

With a hand-operated water maker aboard the life raft, sufficient fresh water might be available occasionally to damp clean the skin. Nevertheless, survivors most often will use only seawater to rinse accumulations away, but without harsh rubbing that could further irritate skin.

While life raft survivors' accounts tell how the legs of men who were urinating overboard were held by other survivors to prevent them from falling overboard, Burton has a more modest means of coping with the logistics of bodily waste.

"The raft commander has to make sure soon after everyone is aboard the life raft that a 'swimming pool' mentality doesn't threaten the health of everyone in the life raft," said Burton. "Unless the ditch bag has been supplied with prescription antibiotics, an infection caused by urine/fecal contamination is going to be impossible to treat with a Band-Aid."

For most survivors, bowel movements will stop within a day or two of being on the life raft, but the excretion of urine will continue, probably at the rate of a pint (a half liter) or less per day. Women's menstrual periods are likely to stop, too.

"Those paper products taken from the airplane may also be useful for completing bodily functions," Burton said. "Small-size plastic trash bags can be placed on pulled-down pants and undergarments to capture bodily waste — liquids and solids — as one stoops over the bag. Then the plastic bag is knotted and thrown overboard. This goes for men and women. While this position provides for some modesty, it can be made to work in a crowded life raft and its primary purpose is to prevent people from being in a position where they could fall overboard."

By putting waste into a plastic bag, there are less organic scents to attract predators. No one should be allowed to attempt to perform bodily functions from the side of the life raft because of the risk of falling overboard and the risk of contaminating the interior of the life raft.

If no trash bags or plastic resealable bags are available, then a bailer might have to be dedicated to the task.

Taking Care of Home

In daylight, especially in bright and unobstructed sun, the air in the life raft's buoyancy tube(s) will be warmed, and expansion will occur. Most life rafts are equipped with pressure-relief valves that automatically vent air when the air pressure is excessive, and survivors may be surprised to hear the sudden WOOOOOOOOOSH of air being released. As the sun sets lower in the sky and the life raft becomes cooler in the evening, air contracts and additional air must be pumped into the buoyancy tubes until they are very firm and without wrinkles caused by insufficient air.

The manufacturers pack only one pump to a life raft, so if that pump is lost or damaged beyond repair, despite human ingenuity, no more air can be added to the life raft.

"I know of only one manufacturer who also supplies a length of hose with a valve fitting on one end that is intended to inflate a life raft orally," said Burton. "The process may tax the physical condition of some people, but the device works. Nevertheless, adding a spare pump to the ditch bag is a good idea."

A modern life raft is remarkably strong; nevertheless, caution is necessary to ensure that the buoyancy tubes are not punctured by

Duct tape can be used to patch air leaks in the buoyancy tubes … and for a variety of other uses on a life raft.

jewelry, fish hooks, aluminum cans, ballpoint pens, signal mirrors, utility knives, or anything else that could damage the life raft. Survivors will have to be alert to hard objects that could chafe the life raft's fabric. Any section of the life raft that shows signs of wear should be protected with extra clothing or anything else that would prevent further damage.

Fixing Air Leaks

Leaks can have a variety of causes: The pressure-relief valve can malfunction in the open position; glue or stitching can fail; or a puncture can occur. The survivors might hear the escaping air first, but pinpointing the leak may require moving fingertips over the area of a suspected leak. If the leak is under water, a steady stream of bubbles may signal its location.

"Leaks have to be repaired," said Burton. "Most life rafts today are equipped with two or three mechanical clamps for air-holding repairs: Two oval-shaped pieces of metal face each other and are connected by a screw-down winglet on a threaded rod. The oval metal with a rubber gasket is inserted in the leak hole, which is usually made into a wider slit with a utility knife to accept the metal oval. The metal oval, now inside the buoyancy tube, is placed with the rubber gasket against the buoyancy tube fabric. The oval face on the outside is screwed tightly against the oval piece on the inside of the buoyancy tube. The clamps come in three-inch, five-inch and eight-inch [eight-centimeter, 13-centimeter and 20-centimeter] sizes, and they provide a good long-term seal. Even so, repaired leaks should be checked by each scheduled watch.

"Sometimes cone-shaped and threaded rubber plugs are available, but they are generally used only as temporary plugs. And if a leak is serious, then anything at hand should be used to stem the loss of air, from clothing to a 'finger in the dike.' Losing air in a buoyancy tube will mean that the life raft's freeboard [the distance from the top of the buoyancy tube to the water] will be lowered, and that will make the life raft more susceptible to water entering the life raft. Actually, duct tape applied to a clean and dried buoyancy tube can stop leaks above the waterline."

Patch-and-glue repair kits require that the surface be dried — a challenge on a life raft — before the repair can be made. For serious leaks on the buoyancy tube below water, the life raft must be capsized to make the repair.

A mechanical clamp provides a leakproof repair of buoyancy tubes.

Capsizing

Several ocean-going sailboat races in the past few decades have provided the life raft industry with tragic examples of life raft failures when weather conditions worsened so much that many of the yachts — some undamaged — were abandoned by their crews. Insufficient ballast, loss of sea anchors and physical destruction of life rafts provided lessons learned. Sailors who were separated from their life rafts after capsizing usually died; survivors who were able to right their life rafts and get back on board — sometimes several times — were rescued.

While a storm often generates high winds, the high winds alone are not directly responsible for capsizing life rafts. For example, a six-person round-type life raft might have a cross section of about 18 square feet (1.7 square meters).[3] Thus, at wind speeds of 10 knots, the total dynamic wind pressure on the life raft would be about six pounds (three kilograms); 20 knots = about 23 pounds (10 kilograms); 30 knots = about 54 pounds (25 kilograms); 40 knots = 90 pounds (41 kilograms); 50 knots = 144 pounds (216 kilograms); and 60 knots = 216 pounds (98 kilograms).[4]

Thus, a life raft downwind from its sea anchor is not subjected normally to tremendous forces by the wind. (Rectangular-shaped life rafts benefit from this configuration, because the smallest profile of the life raft should face the wind with a correctly mounted and deployed sea anchor.)

TSO-C70a (paragraph 5.3) requires that "a sea anchor, or anchors, or other equivalent means must be provided to maintain the raft, with rated capacity and canopy installed … to reduce the drift to two knots in 17[-knot] to 27-knot winds." These winds are sufficient to build waves of four feet to six feet (one meter to two meters) and create very rough sea conditions.

Wind blowing across open water can generate very large and powerful waves. A life raft is subjected to the same destructive force of water that sinks ships and racing sailboats, said Daniel Shewmon, an engineer who is best known for his comprehensive studies of sea anchors.[5]

> *The average North Atlantic storm wave is 30 feet [nine meters] high and 250 feet [76 meters] from crest to crest. Such a wave travels at a speed of over 20 knots and can easily overtake most boats running before it. If a storm were to last 18 hours before abating, roughly 9,000 such waves would pass a single point. Many would be topped with tumbling or falling breakers.*
>
> *When they break, such large waves have unimaginable power. For example, on top of a 30-foot breaking wave and just behind the top of its foam, is a short, shallow surface layer of solid green water being blown about 22 knots, so fast it continually tumbles ahead of the crest. This moving layer of water has the potential to strike a stationary or slowly moving vessel with a force of about 1,400 pounds [635 kilograms] on each square foot. Here then, is the potential to damage or even sink most standard boats. … It is no surprise that boats so struck have been rapidly broken up, heeled over, rolled, slewed around, or occasionally flung through the air. Under such movement, everything inside may be torn or ripped loose and turned into missiles. … Some [crewmembers] successfully get into their life rafts, but even those who do will probably discover that they have jumped from the frying pan into the fire, [because] their [life] raft will still be upset by passing breakers, causing the people [in the life raft] to be ejected or tumbled and smashed into each other.*
>
> *In fact, a BFGoodrich Co. [now Goodrich Co.] engineer told me that during a Caribbean hurricane in the 1970s one of their enclosed ballast-type life rafts containing a "group of people" was tumbled over 100 times by breaking waves. Luckily, no one was ejected. Upsetting a ballasted life raft requires a fairly large … breaker.*

"Capsizing is something people have to prepare for."

"Capsizing is something people have to prepare for," said Burton. "The wind will be howling, the waves will be huge, and people will be having a heck of a time hanging onto the grasp line.

"Everything in the life raft has to be stored in pockets or must be tethered to the life raft. If the life raft is capsized, the survivors can't afford to lose any of the equipment. And they need to hang on to the grasp line inside the life raft."

The survivors should all be tethered to the life raft with several feet of line: enough from their tether point near the entry to allow the life raft to be righted without having to disconnect their tethers. When the life raft overturns, air will be trapped under the life raft floor, so the survivors will be able to breathe. Nevertheless, the life raft and the water will be moving and if the capsizing occurred in darkness, the survivors will use the grasp line to lead them to the exit and to the surface. They will hold on to the life raft's line.

"An able-bodied volunteer should be preassigned to right the life raft in these conditions, but in rough sea conditions anyone who can right it, should right it," said Burton. "Ideally, the entry will face the wind, which will help turn the life raft upright. In these conditions, and without the benefit of the weight of the water ballast, the life raft may turn upright with little effort. The usual righting method, of someone boarding the life raft near the inflation cylinder and then grasping the righting line while leaning outward from the life raft until it falls upright, may be modified by events.

"Then, everyone will board the life raft and repeat many of the actions taken during the first boarding. This is a rather simple maneuver on a calm day, but it is going to be scary and difficult in storm conditions. But you do it.

"Under no circumstance should survivors allow themselves to become separated from the life raft. Anyone who drifts away in these conditions can't be retrieved and will die."

Electronic Signaling

The 406-MHz ELT with built-in GPS position reporting is the last resort to alert search-and-rescue (SAR) resources that survivors are in distress (see "Truths About Beacon Signals and Satellites Hidden in the Details," page 134). Current technology makes these devices very reliable. Nevertheless, electronics can fail, can be damaged or can be lost, so this piece of equipment should have a backup. Moreover, the automatic fixed ELT will sink with the aircraft, so one or more backup beacons could make a life-saving difference. *Most ELTs currently installed on aircraft do not use 406-MHz technology*; activating immediately any type of secondary 406-MHz beacon would be preferable to relying on a 121.5-MHz ELT after a ditching (see "If You Need It, They Have It," page 382).

"Anyone betting lives on an electronic device like an ELT better have a 406-MHz version, preferably with built-in GPS position reporting," said Burton. "And they better have two of them. If the primary 406-MHz ELT was lost or damaged during the life raft deployment, for example, a backup ELT will be very welcome.

"Let the ELT packed with the life raft operate for 24 hours, then activate the backup beacon. Now you have beacon signals operating in series for a total of 48 hours. Do not deactivate any radio beacon until told by rescuers to deactivate it."

"Do not deactivate any radio beacon until told by rescuers to deactivate it."

Burton said that he recommends that operators consider an EPIRB [emergency position-indicating radio beacon] rather than an ELT or PLB for the ditch bag. He said that the EPIRB is worth the extra bulk created by its buoyancy requirement; aviation life rafts are designed to carry ELTs.

"An EPIRB is waterproof and has a nominal operating time of 48 hours rather than the 24 hours operating time of an ELT or a PLB," said Burton. "Out in the middle of the ocean, or in a part of the world where SAR resources may not be optimal, rescuers may not get to your location in 24 hours or more. Thus, with an ELT [or an EPIRB or a PLB] when the battery power is drained, rescuers won't have the benefit of a homing signal. For example, even with the ELT's last reported position before the battery failed, in steady winds, a lightly ballasted life raft that later lost its sea anchor could probably move at two [knots] or three knots. Over a period of 24 hours, that total unanticipated drift could amount to 48 [nautical miles] to 72 miles.

"ELTs attached to life rafts are designed to operate out of the water, but most EPIRBS are designed to operate in the water. They should be tethered to the life raft and allowed to float for optimum transmission."

A handheld waterproof marine VHF [very-high-frequency] transceiver will be a useful communication aid to have and should be part of the ditch bag. Some pilots have a carry-on handheld VHF aviation transceiver that can be useful, too.

"These types of handheld transceivers cost only a few hundred dollars for a waterproof model that operates with alkaline batteries, not just rechargeable batteries," said Burton. "Alkaline batteries have a long storage life, but spares should be packed in the ditch bag. Rechargeable batteries lose their charge fairly quickly in storage, so they are not satisfactory for a survival situation, especially if they can't be replaced with alkaline batteries. Be sure to tether the radio to the life raft, and hold it [and ELTs] with their antennas vertical. Although life raft manufacturers report their canopies as RF [radio frequency] transparent, the transceiver antennas should have a clear 'view' of the sky.

"A handheld waterproof marine transceiver makes it possible to transmit a mayday [i.e., a declaration of a distress condition] on the maritime universal hailing-and-distress channel, which is monitored by many vessels at sea, although GMDSS [Global Maritime Distress and Safety System] has changed monitoring procedures. If a vessel is spotted by the watch, for example, then the watch can transmit on the distress channel or a ship-to-ship channel. The channels can be marked in indelible ink on the back of the radio. A successful contact with a ship will make it possible for the survivors to communicate with the ship's crew to coordinate a rescue. Most SAR aircraft will be able to communicate on the marine distress frequency, too.

"With a handheld aviation radio, a mayday can be transmitted on the aviation distress frequency when aircraft or aircraft contrails are visible — or when engines are audible. If a 406-MHz ELT [or a 121.5-MHz ELT] has been activated, its homing signal will be broadcast on 121.5 MHz. Just ignore it and broadcast appropriate mayday information; do not turn the ELT off. The transceiver will be broadcasting a much stronger signal than the ELT [homing signal]. The watch can also broadcast that he will listen on a different frequency for a response from the aircraft.

"Of course, you could be in one-way communication with an aircraft flight crew. But the flight crew can confirm your survival and provide up-to-date information to SAR personnel. If the ditching was within a few hundred miles of land and the flight crew remembers any en route VHF frequencies that were in use, a transceiver listening watch might be established on those frequencies too.

"VHF signals are typically line of sight [for aircraft frequencies and marine frequencies]. At life raft height, the horizon is less than five nautical miles. But the antenna on a ship may be 30 feet to 50 feet [nine meters to 15 meters] or more above the water, so the range of your handheld transceiver to a particular ship could be 15 nautical miles to 20 nautical miles [28 kilometers to 37 kilometers] or farther. Finally, if you hear a strong signal, there is a good chance that your signal can be heard, too. Nevertheless, if the watch doesn't receive a response to the mayday after several attempts, avoid depleting the transceiver's batteries. Turn the transceiver off and save the batteries for future attempts."

If communication is established with a ship or aircraft, the watch must be accurate in transmitting position information in relation to the ship or aircraft. For example, Burton suggests that survivors use a simple procedure that places the ship or airplane as the reference point.

"Tell the ship's crew where the life raft is located in relation to the ship," he said. "Tell them 'you are heading toward us' or 'you are heading away from us' or 'we are on your left side' or 'we are on your right side.' You just need to give them some idea of where they have to begin looking for you. A life raft is a small target, so any relative-position information you can provide rescuers will help. Even with powerful radars installed on ships, the life raft is not likely to be visible on radar, although the reflective side of an emergency space blanket may reflect sunlight while secured on one side of the canopy, and it might reflect radar at close range [five nautical miles (nine kilometers) or less]."

Used correctly, a signal mirror can be one of the most effective signaling devices during daylight.

The watch must be able to provide information about the aircraft type and registration number, the number of survivors, the types of injuries, the number of life rafts and the type of signaling equipment available. This information will confirm the aircraft's condition and will enable SAR resources to know how many people remain to be rescued.

Day Signaling

A signal mirror, which reflects the sun, can be seen for several miles and is not energy-dependent no matter how many times it is used, and the wet environment of a life raft will not diminish its effectiveness. It is most effective in line-of-sight applications, and airplanes may see the signal at altitudes even above 20,000 feet.

"The mirror is usually packed in the SEP, and it is one of the most effective signaling devices a survivor can have," said Burton. "Instructions are usually printed on the back of the mirror, which might be highly polished stainless steel or plastic with a metallic reflective finish. A hole usually is provided in the middle to help aim the mirror.

"Basically, the sun is reflected off the mirror, which is aimed at the target: a ship or aircraft. The survivor forms a V with two fingers with the target in the bottom of the V. Using his other hand to hold the mirror, he aims the reflected light from the mirror at the V formed by the fingers on the hand of his outstretched arm. Simple, really, and with a little practice the survivor can become very accurate with this type of device."

Other daytime devices include kites and even helium-filled balloons, but their use aboard a life raft is not practical. Burton believes that one simple device — the See/Rescue Streamer — is an especially effective visual aid.[6] The company provided FSF editorial staff an Aviator model in both a non-retroreflective version and a retroreflective version, both made of polyethylene. The compact Aviator weighed 6.7 ounces (189.9 grams), but the polyethylene package unrolled into a long single sheet six inches wide by 40 feet long (15 centimeters by 12 meters). The device is available in three primary sizes, varying in width and length, and has an indefinite storage life.

"The See/Rescue Streamer is an excellent lightweight device that is designed to trail behind the life raft or a person in a life vest," said Burton. "The device varies in length and width, but the bright orange color is very visible and contrasts with the water. It is lightweight and easily deployed. This device will help make the life raft more visible to SAR personnel — especially aboard aircraft — when they are conducting a search. Of course, I like it because it doesn't require any energy. It is always working [see "If You Need It, They Have It," page 352]."

Smoke and sea-dye markers also are effective as signals for help and for position fixing, but they have some limitations.

"Smoke — usually orange — is an excellent signaling device when the wind isn't blowing, but even then, it will remain effective for only a few minutes," Burton said. "When the smoke isn't blown away, it can be seen from aircraft and ships that are fairly close, usually less than three nautical miles [six kilometers].

"Packets of luminescent dye — usually green — can cover an area of a few thousand square feet. But over a period of time — 30 [minutes] to 60 minutes, the life raft will have drifted away from the dye, which will have dissipated. The dye is really best seen from aircraft."

Night Signaling

Flares packed in SEPs often are inadequate both in quantity and quality. SOLAS [International

Green luminescent dye is readily visible from an aircraft.

After deployment, the See/Rescue Streamer requires no attention from life raft survivors.

Convention for the Safety of Life at Sea] flares, for example, exceed the requirements of the U.S. Coast Guard in brightness, altitude and burn time (one exception is the burn time for red handheld flares). A SOLAS red parachute flare may burn for nearly a minute, reach a height of about 1,000 feet and burn with the brightness of 40,000 candle power. A non-SOLAS flare may reach the same height, but burn half as long with only 10,000 candle power. Because SOLAS flares are self-contained, they do not require separate launchers.

"Only one approved pyrotechnic signaling device is required in a U.S. aviation life raft," said Burton. "That means you might get one opportunity to signal a ship or an aircraft. Most SEPs include at least three flares, but chances are, they won't be SOLAS flares. Given a choice, get SOLAS flares.

"In my experience, out-of-date flares have about a 50 percent failure rate. Flares typically have a three-year life rating, but even flares that are not expired often fail."

Rocket-launched red parachute flares are packed in a waterproof container that is the launcher; instructions are printed on the container. Burton said that these and other flares must be handled with caution.

"Higher is better, but all these flares should be used when a ship is visible on the horizon, ideally when the ship is headed toward the life raft. While a parachute flare may have a claimed visibility of 40 nautical miles [74 kilometers], at that distance the illumination would be minimal for a chance sighting by the ship's crew. Nevertheless, if you can see the lights of a ship, that ship's crew is close enough to see a flare. Flares will be in short supply, so they should be used only if they have a high likelihood of being seen by a vessel that is coming toward the life raft or passing close by."

Unfortunately, ships have become highly automated; far at sea, only one crewmember may be on the bridge, and he may not be looking outside while performing a variety of tasks related to the

A military helicopter with a well-trained crew can rescue survivors.

ship's operation. Rescued survivors frequently have reported that they launched flares to signal one or more ships, but there was no indication that the ships' crews saw the flares. Some survivors reported that flares were launched even as ships nearly overran the life rafts. Despite his use of flares, nine ships passed by Steve Callahan during his 76 days aboard a life raft.

"Parachute flares are launched downwind, so that survivors' faces and bodies are protected from the flames and smoke that are part of the launch," said Burton. The person launching the flare should lay across the upper buoyancy tube with outstretched arms. Ideally, any flare will be launched within 10 degrees or so of vertical, so that it is directly ahead of the vessel for the greatest likelihood of being seen. Pistol-launched flares are launched similarly. If a flare fails to fire after 15 seconds, drop it in the water. Never point a flare at anyone, and don't look into a launching tube that fails to ignite, he said.

"Red handheld flares burn longer than parachute flares, but at life raft height, the light easily can be obscured by swells," said Burton. "The burn time on these flares can be about one minute to three minutes. Using them should be timed very carefully so that they will be burning at the top of the swell, not in the trough between swells. Handheld flares are used to help guide rescuers to the life raft." Burton cautions that molten slag can drip from flares and cause serious burns to exposed skin or damage the life raft. Flares should be held away from the body at an angle to allow any drips to fall away from the hand. Moreover, most flares will be good daytime distress signals, too.

Burton said that he has tested a battery-powered device, Rescue Laser Flare, and he believes that this offers powerful signaling capability. Burton has used the Rescue Laser Flare to successfully signal aircraft several miles away. Manufactured by Greatland Laser, its Magnum model is about the size of a small flashlight and is powered by two AA batteries. The company said that the laser light emits a vertically expanding line of red light that is 6,000 feet (1,820 meters) wide at 16 statute miles (26 kilometers). The waterproof light can operate continuously for 72 hours.[7]

"The light is aimed at a target much the same way a signal mirror is used," said Burton. "Then the survivor slowly moves the vertical light beam to the right and to the left — back and forth. On the receiving side, the light is a sudden bright red flash that definitely attracts attention. In some ways, this might be a better signal tool to use first in attempting to attract the attention of a ship's crew, because its duration is much longer and can be kept operating as long as charged batteries are available."

A portable strobe light can be used to attract attention at night, but such a light is not officially recognized as a distress device because strobe lights are used to mark navigation buoys, fishing nets and weather buoys. Thus, a ship's crew may assume that it is not a distress signal. Nevertheless, a strobe light can attract attention, and most strobe lights are powered by replaceable alkaline batteries.

"Portable strobe lights are relatively inexpensive and lightweight," said Burton. "Attracting attention of passing vessels is important, but most important, the strobe light — or any light — will be visible to SAR personnel who will be looking for anything that might be a signal from a life raft."

Rescue

A rescue likely will be completed by a helicopter or a ship. If by a helicopter, trained rescuers probably will be conducting the rescue.

"Off the coasts of the United States, if the life raft is within the range of a helicopter, the survivors likely will be rescued by U.S. Coast Guard personnel who are trained and experienced professionals," said Burton. "That's good for the survivors.

"When the helicopter arrives on the scene, be sure not to fire flares or shine lights in the direction of the helicopter, especially at night. An orange smoke flare may help the crew see the life raft more readily and provide them with some basic information about the wind at sea level.

"Equipped with a marine transceiver, the survivors will be able to communicate with the helicopter crew. If not, a transceiver might be dropped to the life raft, or a rescue swimmer will be dropped into the water. The rescue swimmer will swim to the life raft and issue instructions. Listen to him. Do what he says. The raft commander should advise the swimmer of any of the survivors' physical, emotional or medical problems, especially any that might influence the rescue."

If the survivors are several hundred miles from land, there is a high likelihood that the rescue will be conducted by a commercial ship's crew who probably have not been trained or been equipped to rescue survivors from a life raft.

"Rescue under these circumstances could be one of the most dangerous phases of the entire period since the ditching," said Burton. "Maneuvering a large ship alongside a small life raft can be done, but tremendous skill is required. In those circumstances, the crew may expect you to jump into the water and to swim to a rope ladder, which you climb to the deck.

"Get a safety line secured to the life raft, with lots of slack to allow for the motion of the waves and the ship, to prevent the life raft from drifting too far from the ship. Ask for a second safety line from the deck that could be used to help you get to the ladder. Tie it securely around your waist. Struggling in the water to reach the ladder could be exhausting, so that safety line could be very helpful. Add rough weather conditions to a steel mass that could easily flatten the life raft and its occupants, and this type of rescue becomes very dangerous.

"If the ship has a small motor vessel that can be launched, the rescue could be far safer. They launch the vessel, which will be easier to board from the life raft. Then you ask to remain aboard while the vessel is hoisted aboard the ship. Most likely, you will remain aboard the ship until it reaches its destination. *Now you're a survivor.*" ■

The bottom line, in our opinion ...

- **A passenger might say "we have a life raft" (which also may express his total knowledge of life rafts), as if the life raft is ready to appear magically to rescue survivors from disaster. It can't.**
- **We cannot overemphasize the importance of in-the-water training (pools and open water) as the most effective means of preparing flight crews and cabin crews to learn how to use a life raft and its associated equipment.**
- **Learn from the manufacturer exactly what is included with the life raft and its survival equipment pack.**
- **Pack a separate durable, buoyant and waterproof ditch bag with other essential equipment and ensure that it will arrive at the life raft after a ditching.**
- **The life raft commander will inspire confidence by his understanding of the life raft and its equipment, while providing firm but caring leadership to the survivors, all of whom (unless seriously ill/injured) must participate in completing tasks to survive until rescue.**

Notes

1. On Nov. 23, 1942, German U-boats torpedoed the British ship *Benlomond*, which sank in the Atlantic Ocean in two minutes. The sole survivor was a second steward, Poon Lim, who, with no knowledge of the sea and no survival rations or water, survived for 133 days on a small wooden raft by eating fish and birds and drinking rain water. He was rescued by a Brazilian fishing family off the coast of Brazil near the mouth of the Amazon River. (McCunn, Ruthanne Lum. *Sole Survivor*. Boston, Massachusetts, U.S.: Beacon Press, 1985.)

   On June 15, 1972, the 43-foot (13-meter) schooner *Lucette* was struck by killer whales and sank 60 seconds later about 180 nautical miles west of the Galapagos Islands in the Pacific Ocean. Dougal Robertson, his wife, his 18-year-old son and two 12-year-old boys and a family friend, a teenaged boy, were equipped with rations and water for only three days. The six of them survived for 37 days before the crew of a Japanese fishing boat saw their 10-foot [three-meter] dinghy and rescued them about 290 nm from Costa Rica. (Robertson, Dougal. *Survive the Savage Sea*. New York, New York, U.S.: Praeger Publishers, 1973.)

   On March 4, 1973, the 31-foot (nine-meter) sailboat *Auralyn* was 300 nm east of the Galapagos Islands, when the vessel was struck by a sperm whale and sank an hour later. Maurice Bailey and his wife, Maralyn, survived 117 days before they were rescued in the Pacific Ocean by the crew of a Korean fishing boat about 1,500 nm northwest of where the *Auralyn* sank. (Bailey, Maurice. *Staying Alive*. Ballantine Books, 1975.)

   On Feb. 4, 1982, the 21-foot (six-meter) sailboat *Napoleon Solo*, built by Steven Callahan, struck an object in the Atlantic Ocean, 1,800 nm northwest of the Cape Verde Islands. The boat sank in less than a minute. Callahan, alone on the sailboat, survived 76 days aboard his life raft before being rescued by fishermen near the Caribbean island of Guadeloupe. (Callahan, Steven. *Adrift*. Boston, Massachusetts, U.S.: Houghton Mifflin Co., 1986.)

   On June 15, 1989, the 38-foot (12-meter) sailboat *Siboney* was struck by pilot whales in the Pacific Ocean 1,200 nm west of Panama and sank about 30 minutes later. Bill Butler and Simonne Butler survived 66 days aboard their life raft before being rescued by the crew of a Costa Rican coast guard boat less than 10 nm off the coast. (Butler, Bill; Butler, Simonne. *Our Last Chance*. Coral Gables, Florida, U.S.: 1991.)

2. Eternity Flashlights, P.O. Box 4066, Annapolis, Maryland 21403 U.S.

3. Williams, David. E-mail communication with Rozelle, Roger. Alexandria, Virginia, U.S. June 19, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.

4. Hinz, Earl. *Heavy Weather Tactics Using Sea Anchors & Drogues*. Arcata, California, U.S.: Paradise Cay Publications, 2000.

5. Shewmon, Daniel. *The Sea Anchor & Drogue Handbook*. 1998. Shewmon Inc., 1000 Harbor Lake Drive, Safety Harbor, Florida 34695-2310, U.S.

6. Rescue Technologies Corp., 99-1350 Koaha Place, Aiea, Hawaii 96701 U.S.

7. Greatland Laser, 4001 W. International Airport Road #2, Anchorage, Alaska 99502 U.S. <greatlandlaser.com>. The company provided a Magnum model that was tested by FSF editorial staff.

Additional Notes

Burton, Ken; president, STARK Survival Co., 6227 E. Highway 98, Panama City, Florida 32303 <starksurvival.com>. Interviews by Rozelle, Roger, during training program. Panama City, Florida, U.S. Oct. 22–26, 2002.

Resch, Dean; former U.S. Army helicopter pilot/instructor and retired U.S. Federal Aviation Administration safety specialist who participated in the STARK Survival Co. training program and provided a fast boat for photography in the Gulf of Mexico. Interviews by Rozelle, Roger. Panama City, Florida, U.S. Oct. 22–26, 2002.

McLendon, Capt. Jerry, and the crew of *Double Time*, a 52-foot (16-meter) dive boat provided for in-water STARK Survival Co. training program in the Gulf of Mexico. Interviews by Rozelle, Roger. Panama City, Florida, U.S. Oct. 25, 2002.

Burton. Telephone interviews by Rozelle, Roger. Alexandria, Virginia, U.S. Jan. 26–29, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.

'Water, Water, Everywhere, Nor Any Drop to Drink ... '

But when Samuel Taylor Coleridge's *Rime of the Ancient Mariner* was published in 1798, there was no such thing as a manual reverse-osmosis desalinator, which converts seawater into safe drinking water.

— FSF EDITORIAL STAFF

Humans can live for several weeks without food but only several days without water. In a life raft, obtaining an adequate supply of safe drinking water is a primary concern for survival; food is secondary (see "Is There a Doctor Aboard the Life Raft?" page 187).

Civil aviation authorities typically recommend that life rafts carry a small amount of packaged water (about 1.0 pint [0.5 liter] per person)[1] or equipment designed to make seawater drinkable, or both (see "For Ditching Survival, Start With Regulations, But Don't Stop There," page 395).

For example, U.S. Federal Aviation Regulations (FARs) Part 135 ("Commuter and On-demand Operations") says that operators have the option of including either of the following:

- A survival kit that contains — for each two people that the aircraft's life raft is rated to carry — 2.0 pints (1.1 liters) of water or one seawater desalting kit; or,

- A survival kit that is "appropriately equipped for the route to be flown" — a phrase that includes no specific mention of water.

Part 91 ("General Operating and Flight Rules") does not specify how much water or desalting equipment should be carried; instead, it says that aircraft must contain a survival kit "appropriately equipped for the route to be flown."

Some operators might construe the absence of specific information in the regulations as carte blanche to carry a minimal amount of water (see "Regulations, Judgment Affect Overwater Equipment Decisions," page 387).

Canadian Aviation Regulations (CARs) Part 725.95 *requires* life rafts to be equipped with "a two-day supply of water, calculated using the overload capacity of the raft, consisting of one pint of water per day for each person or a means of desalting or distilling salt water sufficient to provide an equivalent amount."

Water packaged for use on life rafts usually is available in aseptic (free of disease-causing microorganisms) containers or flexible pouches containing sterile (without microbial growth) emergency drinking water with a five-year usable life. Each container holds about four ounces (118 milliliters) or eight ounces (237 milliliters).[2,3,4]

Both types of containers are designed with several layers of packaging to hold sterile water within an airtight, light-resistant sterile container.

Aseptic containers probably are easier to store inside an aircraft, if space is adequate. If the water containers must fit into a life raft survival equipment pack (SEP) or a ditch bag, flexible pouches probably are a better choice, said Roger Storey, aviation physiologist

Manual reverse-osmosis desalinators, such as Katadyn's Survivor-06 hand-operated water maker, left, and chemical desalting kits are used to remove salt from seawater, making it safe for drinking.

and survival-training instructor for the U.S. Federal Aviation Administration Civil Aerospace Medical Institute.[5] If an empty water container is being stored "with the intent of using it to collect water in a survival situation," that container also should be flexible so that it will require less space in a life raft SEP or ditch bag, Storey said.

Ray E. Smith, a U.S. Navy survival-training specialist, said that survivors should think of their packaged water as a reserve supply, to be saved for use when other sources of water are not available.[6]

One of those other sources is seawater that has been made drinkable by a manual reverse-osmosis desalinator, which can be used to desalinate about 1.0 quart (0.9 liter) to more than 1.0 gallon (3.8 liters) of water per hour, depending on pump size (see "Making Seawater Drinkable in Just a Few Strokes," page 179). Reverse-osmosis desalinators function by pumping seawater under pressure through a semipermeable membrane that removes salt and other contaminants, including bacteria and many viruses, leaving drinkable water.[7]

Storey said that the device is "a must" for survivors on a life raft; Smith agreed.

"Pumping is the most reliable means of ensuring that you'll have all the water you need," Smith said. "Supply is unlimited, as long as you're pumping."

Bill Butler, who with his wife, Simonne, survived 66 days adrift on a life raft in the Pacific Ocean after a collision with whales sank their sailboat on June 15, 1989, credited a manual reverse-osmosis desalinator with helping save their lives.[8] The desalinator they used was Katadyn's Survivor-35 hand-operated water maker, which weighs seven pounds (3.2 kilograms), desalinates about 1.2 gallons (4.5 liters) of water per hour and sells for about US$1,500. A smaller model, the Survivor-06 hand-operated water maker, weighs 2.5 pounds (1.1 kilograms), desalinates about one quart of water per hour and sells for about $600.

In their book, *Our Last Chance: Sixty-six Deadly Days Adrift*, Bill Butler wrote that they had consumed most of their stored water before he decided, on their eighth day in the life raft, to "check

Continued on page 180

Making Seawater Drinkable in Just a Few Strokes

For a thirsty survivor in a life raft, getting water from a manual reverse-osmosis desalinator like Katadyn's Survivor-06 hand-operated water maker isn't quite as easy as turning on a faucet, but it's close (Photo 1).

1

Katadyn describes the Survivor-06 water maker as the smallest hand-operated water maker in the world. The stainless steel and plastic device weighs 2.5 pounds (1.1 kilograms), measures 5.0 inches by 8.0 inches by 2.5 inches (12.7 centimeters by 20.3 centimeters by 6.4 centimeters) and can produce more than six gallons (23 liters) of fresh drinking water a day, the manufacturer says. A tether sold with the water maker — when secured correctly — prevents the water maker from becoming separated from the life raft.

Katadyn says that the Survivor-06 hand-operated water maker works this way: "A semipermeable membrane inside the unit acts as a molecular filter. When seawater is pressurized to 800 psi [pounds per square inch] (about 55 bar) by pumping the handle and [is] forced against the membrane, only the water molecules can pass through. Salt molecules are unable to pass and flow out of the system."

A laminated sheet of instructions attached to the Survivor-06 hand-operated water maker's tether line tells users how to operate the device and also provides storage instructions and important precautions. Several first-time users read the instructions and found them confusing in one respect: Neither the instructions nor the accompanying unlabeled diagram clearly identified which of the water maker's three hoses was the "product hose" from which they would obtain fresh water.

The confusion was resolved by looking at a more complete diagram in the operating manual, which shows that the product hose is separate from the attached intake/reject hoses. The approximately four-foot-long (one-meter-long) product hose emerges from the water maker's end cap; the intake/reject hoses (both about 6.6 feet [2.0 meters] long) are attached hoses that emerge from the body of the water maker. The tips of both the product hose and the reject hose are protected by small red caps when the water maker is not in use; at the end of the intake hose is a black water strainer.

The manual comprises about five pages of instructions in each of 11 languages, plus eight blank pages for notes. The manual was included in the box in which the water maker was delivered, but — even if the manual was available on the life raft when the water maker was in use — it likely would not remain readable very long in the wet environment because it is printed on non-laminated paper.

As instructed, the water maker's users positioned the black strainer, the accompanying weight and the attached intake/reject hoses (Photo 2) in a vase containing seawater taken from the Atlantic Ocean during a colleague's vacation in Florida; the product hose was positioned to allow fresh water to drip into a glass. (The intake/reject hoses are long enough to hang over the side of a life raft to draw water directly from the ocean. Nevertheless, if survivors prefer — because of rough seas or because large fish might mistake the plastic filter for a meal — the intake/reject

2

hoses can be placed in an onboard container of seawater.)

After about one minute of pumping, the first drops fell into the glass. Those drops, along with the other water pumped during the first two minutes, were discarded, according to instructions, because Katadyn said that the first water to be pumped contains the biocide solution used by the factory to prevent the growth of bacteria within the water maker. Then the product hose was repositioned to allow pumping to resume and water to be collected in the glass.

Each person took a turn operating the water maker, positioning the left hand under the water maker's end cap and the right hand over the end of the handle and pumping the handle up and down, as far as it would go in each direction, trying to achieve the manufacturer's recommended 40 strokes per minute.

Pumping was not difficult — but not effortless, either — and after just a few minutes, some of those who pumped were ready for a break.

"There is resistance in the machine, so it requires an effort to pump it," one person said.

Nevertheless, during his first two minutes, he pumped nearly two ounces (59 milliliters) of drinking water — more than the typical amount, presumably because his pumping speed was faster than recommended.

The users surmised that pumping presumably would be more difficult for survivors in a life raft, especially if they were on rough water or if they were weakened by seasickness.

Another user expressed concern that, despite an attached weight, the lightweight hose and strainer might float in the water; if that occurs, attaching an additional weight to the hose near the strainer should solve the problem.

After others took their turns pumping, it was time for a drink. One person described the water as "just fine"; others thought they detected a slight aftertaste — perhaps because the purified water tasted different than chemically treated tap water. Nevertheless, everyone agreed, "Absolutely, that wouldn't stop you from drinking it."

The laminated instruction sheet says that a slight salt taste is normal but cautions against drinking water with a "strong salt flavor."

The instructions also say that, during periods of prolonged use, the Survivor-06 hand-operated water maker should be pumped for at least 10 minutes a day to prevent seawater from becoming stagnant inside the device. Customer service representative Nate Mueller said that the goal is to prevent any buildup of microbes or mineral deposits that might clog the membrane or hoses.[1] Such a buildup is unlikely after just one day without pumping, he said, but daily pumping is part of a "very conservative" plan for keeping the water maker in good operating condition on the life raft.

Whenever the water maker will not be used for a couple of days — for example, if a heavy rainfall has provided the survivors with enough water to eliminate the need for daily pumping — seawater should be removed from it by removing the intake strainer and intake hose, turning the device upside down and pumping the handle until water no longer exits.

After rescue, if survivors are able to take the water maker with them as they leave the life raft and the water maker will not be used again for at least seven days, it should be cleaned by pumping one quart (one liter) of water containing about one spoonful of biocide solution (purchased separately) through the system. The water maker should be allowed to dry thoroughly and then should be stored. The biocide treatment, if performed according to directions, should be adequate for three years — just as it is if the treatment is performed by the factory or by authorized service providers.

Otherwise, although the instructions say that the device should be inspected annually, Katadyn North America said that in 2004, it began recommending three-year service intervals for Survivor-06 hand-operated water makers that are stored inside life rafts in a controlled environment (see "Water Maker Maintenance Interval Clarified," page 184). ■

— FSF Editorial Staff

Note

1. Mueller, Nate. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S., Feb. 3, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.

The Katadyn Survivor-35 hand-operated water maker (also known as a manual reverse-osmosis desalinator, can desalinate 1.2 gallons (4.5 liters) of water per hour.

out the water maker and see how it works. …

"The body of the pump is almost 2.0 feet [0.6 meter] long and has a two-foot handle attached to one end," he said. "As I stroke the handle and salt water is sucked in from the sea, the pressure needed to move the handle increases. After a dozen strokes, bubbles and finally water drips from the small tube which [Simonne] holds over the side until the water is clear.

"I put the tube in my mouth while I continue to pump. The water is salty at first, but 10 strokes later, the water becomes sweet and pure."[9]

Each liter of water required 20 minutes of pumping, at a rate of one stroke of the pump per second; 40 minutes of pumping produced a day's supply of water, he wrote.

His wife described the taste of the water as "first class" and compared it with bottled water from her native France.

"The knowledge that we could drink any quantity of fresh water we wished gave us peace of mind with which to cope with the many other facets of survival," Butler said.

In addition to supplying drinkable water, manual reverse-osmosis desalinators have another benefit, said Cmdr. J. Russell Bowman, D.O., a U.S. Coast Guard flight surgeon in Sitka, Alaska.[10]

"Pumping is a labor-intensive process, but it keeps your mind on something while you're waiting for help," he said.

Another water-collection method is the solar still, an inflatable floating device with an outer layer of clear plastic and an inner layer of dark, absorbent material. Solar stills sell for about $150 to $200. As sunlight passes through the clear plastic, the inner material is warmed. After this inner material is wetted with seawater, the water evaporates; then the water vapor pressure increases in the air between the plastic and the dark material; the water vapor condenses on the inner surface of the clear plastic and drips into a collection area that can be drained periodically.[11]

Cold-water survival specialists Frank Golden and Michael Tipton said that, in theory, the concept of the solar still is excellent, but "their practical performance at sea is extremely poor. The movement of the stills in a seaway makes it extremely difficult to prevent saltwater contamination of the collected moisture in some [types of solar stills]."[12]

Smith said that the solar stills he has used were effective, although they functioned poorly in rough seas.

Steven Callahan, who survived 76 days adrift in an inflatable life raft after his sloop sank in the Atlantic Ocean, west of the Canary Islands, said in *Adrift,* his book about the experience, that two solar stills failed before he performed modifications that allowed him to place a solar still on his life raft, rather than in the ocean. With those modifications, Callahan collected about 20 ounces (0.6 liter) of drinkable water a day.[13]

Chemical desalting kits are another method of making seawater drinkable (see "With a Little Agitation, Desalting Kits Yield Drinkable Water," page 182). The kits contain a plastic bag for collecting seawater and six or eight clay "briquettes" embedded with particles of silver zeolite. When a briquette is added to the seawater in the bag, the chemical reaction involving silver zeolite and sea salt removes the salt from the water. The silver zeolite is dissolved during the mixing process. The kits, manufactured by Van Ben Industries, a division of Truetech of Riverhead, New York, U.S., sell for about $200.[14,15]

"It tastes a little salty, and it [may look] very slightly brownish, but it's drinkable," said Fred Prozzillo, president of Aviation-Marine Specialty Products of Pipersville, Pennsylvania, U.S., a distributor of the desalting kits.

"Most of the time, the water is clear as it comes through the filter bag," he said. "Some salt is intentionally left in the water to compensate for perspiration losses. If a less salty taste is desired, a smaller amount of water can be used in the bag." The kits must be inspected every five years. Nevertheless, they can be expected to last indefinitely, as long as the briquettes remain properly sealed, said Prozzillo, who has a number of World War II-era desalting kits that appear to be in good condition.

Richard Brower, president of Life Support International of Bristol, Pennsylvania, U.S., another distributor, said that, if he were assembling supplies for an aviation life raft that he might use himself, "I personally think I would use a mix of [packaged] water and desalters, and I would spend my money on good electronics," including communication radios, personal locator beacons and a satellite cellular telephone to be used to attract rescuers.

His supplies would include enough prepackaged water for the first 24 hours and desalting kits to provide water for an additional 48 hours, he said.

Desalting kits similar to those in use today were routinely issued to soldiers and sailors during the last two years of World War II. Each kit produced 10 times its weight in water.[16]

A report originally published in the 1950s about a study of 2,500 accounts by military airmen of survival at sea after bailing out of an aircraft or ditching said that most narratives mentioned desalting kits without comment, "which would leave one to believe they worked satisfactorily."

The study said, however, that "some dissatisfaction was expressed" — often when the men tried to use the same briquette to desalinate more water than directed.

"The survivors' usual practice was to drink a little, then add more seawater," the report said. "A few tried to drink the water from the top of the bag instead of through the filter, as prescribed in the instructions. One survivor who lost his spare briquettes when his raft [was] upset used the remaining briquette several times. When rescued, he was delirious and suffering from the effects of drinking salt water.

"Several survivors remarked that the time it took to produce

Continued on page 183

"[Solar stills'] practical performance at sea is extremely poor."

With a Little Agitation, Desalting Kits Yield Drinkable Water

Carefully following instructions, survivors in a life raft can use chemical desalting kits to make seawater fit to drink.

The kits, manufactured by Van Ben Industries, a division of Truetech of Riverhead, New York, U.S., are packaged in orange plastic boxes that weigh slightly more than 1.0 pound (0.5 kilogram) and measure 4.5 inches by 4.5 inches by 2.0 inches (11.4 centimeters by 11.4 centimeters by 5.1 centimeters). The kits contain either six packages or eight packages of desalting chemicals (clay "briquettes" containing particles of silver zeolite), one plastic bag for collecting seawater, and tape to mend the bag in the event of a tear (Photo 1). Each package of two briquettes (Photo 2) can be used to make about one pint (16 ounces, or one-half liter) of drinking water. The bag can be tied to the life raft with a length of attached material to prevent it from being washed overboard; an attached cord can be used to secure the box.

1

2

Instructions printed on the outside of the orange box explain how the process works: "Each pack of chemical, when mixed with seawater in the plastic bag, makes about one pint of drinking water. The mixture of seawater and chemical appears muddy. Filter at bottom of the bag holds back all sediment. Only pure water can come out through this filter."

For these articles, several people used a desalting kit, which was supplied by a life-raft manufacturer. The date stamped on the outside of the box was 1989; inside, the labels on each package of briquettes said that they were packed in 1987 — still good because of the briquettes' indefinite shelf life. The kit's users followed the detailed instructions printed on the bag, which had a greasy film on the inside and outside and a strip of what appeared to be brittle, yellowed cellophane tape at the top.

A package of two briquettes and slightly less than one pint of seawater (obtained from the Atlantic Ocean during a colleague's vacation in Florida) were placed in the bag, which clearly shows — in two ounce increments — how much water it contains (Photo 3). The instructions say that the water should be in the bag before the briquettes are added, but for photographic purposes, the kit's users reversed the order. The instructions allowed for a full pint but included an explanation that using the full amount of water would "leave a little salt in the desalted water to compensate for perspiration losses. If you desire it less salty, fill the bag to about an inch [2.5 centimeters] below the filling line [which marks about one pint.]"

As instructed, the top of the bag was folded and snapped in place for a watertight seal. The briquettes dissolved quickly in the water, eliminating the need for the next step in the instructions — to "if necessary, pulverize [the] chemical by kneading gently until dissolved."

3

There was no avoiding the step that followed: "Agitate bag gently for 60 minutes." The kit's users took turns shaking the bag at intervals of about five minutes each — a somewhat tedious process, they agreed, but as one person said, "If you were in a

4

life raft with nothing else to do, this would fill the time."

After an hour, the water inside the bag was dark gray but ready to drink, according to the instructions (Photo 4). The small valve at the bottom of the bag was unscrewed over a glass and the bag was squeezed to push out the first few drops, which also were gray. Quickly, however, the water emerging from the bag was clear and the valve was positioned over clean glasses to give each of the kit's users an ounce (30 milliliters) or so to taste.

"There's nothing wrong with it; there's really no flavor at all," one person said.

Others detected a peculiar taste, and even the first person said later that he had noticed a slight aftertaste for several hours after the water-tasting session.

The taste was not so unpleasant that anyone would have been deterred from drinking if they had been in a life raft.

"Out there on the ocean, it wouldn't matter," one person said.

After all drinking water has been consumed, the instructions say that the bag should be rinsed in seawater to remove the desalting chemicals. Then the bag can be reused to make the next batch of drinking water.

In the event the bag is punctured or torn, the instructions say that the affected area should be dried and patched using the mending tape included in the box. If the bag is damaged beyond repair or lost, the box itself can be used instead. Instructions on the box say that it should be filled with seawater to a level designated inside; after a package of briquettes is added to the water, the mixture should be stirred or shaken gently (if shaken, the box should be held upright, because the cover is not watertight) for one hour. Then, before drinking, the water should be poured through a piece of cloth to remove the desalting chemicals.

The instructions also caution that the plastic bag becomes brittle in very cold temperatures and should be soaked in seawater before it is unfolded.

The chemical desalting kit and Katadyn's Survivor-06 hand-operated water maker (also known as a manual reverse-osmosis desalinator; see "Making Seawater Drinkable in Just a Few Strokes, page 179) can be compared this way:

- The desalting kit weighs slightly more than one pound (0.5 kilogram) and measures 4.5 inches by 4.5 inches by 2.0 inches (11.4 centimeters by 11.4 centimeters by 5.1 centimeters); the Survivor-06 hand-operated water maker weighs 2.5 pounds (1.1 kilograms) and measures 5.0 inches by 8.0 inches by 2.5 inches (12.7 centimeters by 20.3 centimeters by 6.4 centimeters),
- One package of desalting chemicals, agitated in seawater for 60 minutes, according to instructions, produce about one pint (16 ounces; 0.5 liter) of water; pumping a Survivor-06 hand-operated water maker for 60 minutes at 40 strokes per minutes, according to instructions, produces about 30 ounces (0.9 quart; 0.9 liter).
- A desalting kit with eight packages of briquettes produces about 8.0 pints (128 ounces; 3.8 liters) of water; the water maker produces about 30 ounces an hour for an unlimited period. ■

— FSF Editorial Staff

drinkable water with the desalting kit made little difference because it gave them something to do. Some complained the kits produced too little water, others deplored its odor. Because survivors commonly tied the filled desalting kit overside to keep it cool, it was often the only water saved after capsizing."

Preparations Allow Survivors to Take Full Advantage of Rainwater

Rain often has been a primary source of fresh water for life raft survivors.

"The first rain [after boarding a life raft] has almost always proved a saving grace," Bernard Robin, a physician, sailor and author, wrote in *Survival at Sea*. "Most tales recount how anxiously it was awaited. Almost as numerous, by contrast, are the stories where the survivors have forgotten or disregarded the chores that have to be done to take full advantage of rain. One has to realize that it is not just a question of opening one's jaws wide — that only provides a square inch or two of collecting surface."[17]

Long before a rainfall, survivors should begin their preparations for collecting rainwater, Robin said. They should plan to spread canvas or plastic, including plastic bags, to make a large surface on which water can be collected; the water then can be poured into all available cans, bottles and plastic bags. Before they are used for collecting water, the canvas, plastic and other collection surfaces should be rinsed with seawater to rid them of accumulated salt crystals. Saltwater residue will contaminate the first of the rainwater, but the concentration of salt will be less than the concentration of salt in seawater; if a container is filled more than once, subsequent collections of water will be uncontaminated by salt.[18,19]

Some aviation life rafts have a built-in water collector that funnels water into a plastic bag for storage. SAE International recommends, in its Aerospace Recommended Practice (ARP) 1356, *Life Rafts*, that every life raft be equipped with "a means for the collection and storage of rainwater."[20]

Survivors should drink as much rainwater as they want and then should save as much as possible, Smith said.

Water Maker Maintenance Interval Clarified

For survivors who must spend more than a few hours in a life raft at sea, a source of drinkable water becomes essential. Drinkable water can be obtained from pouches in the survival equipment pack (SEP), a solar still or chemical desalting kits. But the preferred source is a manual reverse-osmosis desalinator (see "Water, Water, Everywhere, Nor Any Drop to Drink …" page 177).

The standard manual reverse-osmosis desalinator offered by life raft manufacturers is the Katadyn (pronounced "CAT-a-dine") Survivor-06 hand-operated water maker. (The Survivor-06 water maker was formerly marketed by PUR/Recovery Engineering, which Katadyn acquired in 2001). In the unit, a hand-operated pump forces salt water through a semipermeable membrane that water molecules can flow through but salt molecules cannot penetrate.

The instruction booklet that came with a sample model of the Survivor-06 hand-operated water maker says, "For your safety, we require that an inspection be completed once a year."

Beginning in 2004, Katadyn "will officially recommend three-year service intervals," said Alan Lizee, president, Katadyn North America. "Historically, non-military Survivors had one-year service intervals. We were being conservative. But as more Survivor water makers were stored inside life rafts in a controlled environment, our service experience indicated that a longer interval was acceptable and provided adequate safety guidelines.

"So we 'unofficially' became more flexible, because life raft companies understandably wanted our servicing to match their recommended frequency of inspection. In 2003, we completed an analysis of about 7,000 military units that have been serviced, which supported that extending the service guidelines to three years provides adequate frequency." (Katadyn continues to recommend annual service for units stored outside life rafts.)

This latest information from Katadyn resolves a controversy among life raft manufacturers, some of whom believed that they had been placed in an unfair competitive position against other life raft manufacturers that had recommended a three-year service interval for the water maker — despite Katadyn's previous recommendation of a one-year service interval.

Standard maintenance for the Katadyn Survivor-06 hand-operated water maker includes pumping water through the device to remove any biocide preservative that was used to prevent biological growth. The water flow is tested to ensure that it meets output specifications. The desalinization is then measured. The manufacturer said that although the official specification is 1,500 parts per million (ppm) salt, the company's internal guideline is 1,000 ppm. From time to time, a membrane, pump body, or rubber components such as o-rings and seals may need replacement. "Even a Survivor unit that has gone without servicing past the recommended time won't stop working," said Lizee. "Typically, the freshwater output might be a little reduced."[1]

Katadyn authorizes life raft companies to perform Survivor-06 hand-operated water maker maintenance, so that the water maker can be serviced at the same time as the life raft. ■

— FSF Editorial Staff

Note

1. Lizee, Alan. E-mail communications with Darby, Rick. Alexandria, Virginia, U.S., Nov. 10, 2003, and Nov. 25, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

Any rainwater contaminated by salt — and any fresh rainwater that has acquired a foul smell or foul taste — should be saved for other purposes, such as cleaning wounds and rinsing skin. (Because of the presence of bacteria, seawater should not be used in the thorough cleansing of wounds; nevertheless, it can be used to rinse foreign particles from wounds and to rinse the skin.)

Small amounts of water can be collected by using a sponge from the survival equipment to mop up condensation that collects inside the life raft. (The sponge should be stored in a plastic bag to prevent it from becoming contaminated with seawater.) Although the water may have acquired the flavor of the sponge and the taste probably will not be pleasant, the water will be drinkable.[21]

Survival Rations Are Preferred Food

Some civil aviation authorities recommend that a small quantity of survival rations be packed into life rafts — usually packaged food bars designed to meet survivors' basic nutritional needs. For example, FARs Part 135 says that aircraft flown in air taxi and commercial operations must carry either a survival kit "appropriately equipped for the route to be flown" or a kit containing a number of specific items, including "a two-day supply of emergency food rations supplying at least 1,000 calories per day for each person."

Part 91, however, says that general aviation aircraft must contain a survival kit "appropriately equipped for the route to be flown."

As is the case with the water, some operators might construe the absence of specific information in the regulations about food as carte blanche to carry a minimal amount of food.

Regardless of the type or amount of food available, survivors should eat only if they have an adequate supply of drinking water because the digestive process increases the body's requirements for water. The body converts stored fat and protein into glucose, allowing most people to survive for several weeks without food. Nevertheless, if survivors eat, they should choose carbohydrates rather than protein because carbohydrates require less water for digestion.

Specially formulated survival rations — typically wheat-based carbohydrate bars with added vitamins and a usable life of five years — are the preferred food, survival specialists said. Survival rations are formulated so that they will not stimulate thirst, a problem with the candy that in the past was included in SEPs; to be stored in all climatic conditions; and to fulfill basic nutritional requirements.

For example, S.O.S. Food Lab describes its emergency food as a "compact, lightweight baked survival food ration specifically formulated to provide a balanced minimum-daily diet (with critical drinking-water restriction) for aviation survival situations." For infants or injured people, the product can be "mixed with liquids for drinking or mashed into a porridge," the company says.[22]

Smith said, "If survivors have a choice between survival rations or fish, they should choose survival rations, which would have more balanced nutrition. They'd also be a lot more palatable to eat than a raw fish."

Some survival manuals include instructions for catching fish and birds, and typical survival kits include minimal fishing equipment. Fishing and catching birds are unlikely to be necessary if rescue occurs within several days.

Storey said that, even with the equipment included in the survival kit, "the task of catching fish or birds will be difficult at best" and should be attempted only after all packaged survival rations have been consumed.

Nevertheless, the process of catching food might have another benefit.

Storey said, "It can provide a useful diversion, which, in itself, may add to a positive mental attitude."■

The bottom line, in our opinion ...

- **Drink water when you're thirsty, but don't guzzle.**
- **A life raft survivor can live by drinking about one cup of water — sometimes less — per day.**
- **Without drinking water, survivors likely will die within three to five days, but they can survive weeks without food.**
- **Packaged water and desalting kits provide a limited amount of drinking water, but the most reliable source of an ongoing supply of water at sea is a hand-operated water maker (also known as a manual reverse-osmosis desalinator). As far as we know, Katadyn is the only manufacturer of these devices.**
- **Preparations for collecting rainwater should begin long before the first rain.**

Notes

1. Although people usually are told to drink about 2.0 quarts (1.9 liters) of water a day under normal conditions, cold water survival specialists Frank Golden and Michael Tipton said in *Essentials of Sea Survival* (Champaign, Illinois, U.S.: Human Kinetics, 2002) that people can survive by drinking as little as 3.7 ounces to 7.4 ounces (110 milliliters to 220 milliliters) a day.

2. AquaBlox. *Product Overview.* <www.aquablox.com/Product_Overview/product_overview.html>. Oct. 1, 2002.

3. S.O.S. Food Lab. *Aviation: For Use in Aircraft Life Rafts.* <www.sos-rations.com/AVIATION.HTM>. Aug. 19, 2003.

4. Survivor Industries. *Emergency Water Packets.* <www.survivorind.com/water.html>. Aug. 19, 2003.

5. Storey, Roger. Telephone interview and e-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., July 10, 2003; Aug. 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

6. Smith, Ray E. Telephone interview with Werfelman, Linda. Alexandria, Virginia, U.S., April 18, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

7. Katadyn. *The World's Smallest Desalinators.* www.army-technology.com/contractors/field/katadyn/press2.html. Feb. 14, 2003.

8. Butler, Bill; Butler, Simonne. *Our Last Chance: Sixty-six Deadly Days Adrift*. Miami, Florida, U.S.: Exmart Press, 1991.

9. Ibid.

10. Bowman, J. Russell. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S., July 3, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

11. Golden, Frank; Tipton, Michael. "Necessities for Sustained Survival: Water and Food." *Essentials of Sea Survival.* Chapter 8. Champaign, Illinois, U.S.: Human Kinetics, 2002.

12. Ibid.

13. Callahan, Steven. *Adrift.* Boston, Massachusetts, U.S.: Houghton Mifflin, 1986.

14. Prozzillo, Fred. Telephone interview and e-mail correspondence with Werfelman, Linda. Alexandria, Virginia, U.S., Sept. 5, 2003; Oct. 17, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

15. Brower, Richard. Telephone interview with Werfelman, Linda. Alexandria, Virginia, U.S., Feb. 2, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.

16. Llano, George Albert. *Airmen Against the Sea*. Arctic, Desert, Tropic Information Center (ADTIC), Research Studies Institute, U.S. Air Force. ADTIC Publication G-104. 1955. The preface said that the report was "the fourth in a series of ADTIC studies to determine how military personnel survived under emergency conditions in various parts of the world." The series included *999 Survived* (Southwest Pacific tropics), *Sun, Sand and Survival* (African deserts) and *Down in the North* (Arctic). Most of the information in *Airmen Against the Sea* was obtained from records of the U.S. Air Force and the U.S. Navy; the publication also includes information from records of the air forces of Australia, Britain, Canada, Germany and New Zealand, and from other sources. The report is based on information gathered from airmen who survived ditching or bailing out of airplanes mostly during World War II and to a lesser extent during the Korean War and the early 1950s. "The most valuable and informative material was found in the firsthand accounts written by the survivors themselves," the report said.

17. Robin, Bernard. "The Battle Against Thirst." *Survival at Sea*. Chapter 32. Camden, Maine, U.S.: International Marine Publishing Co., 1981.

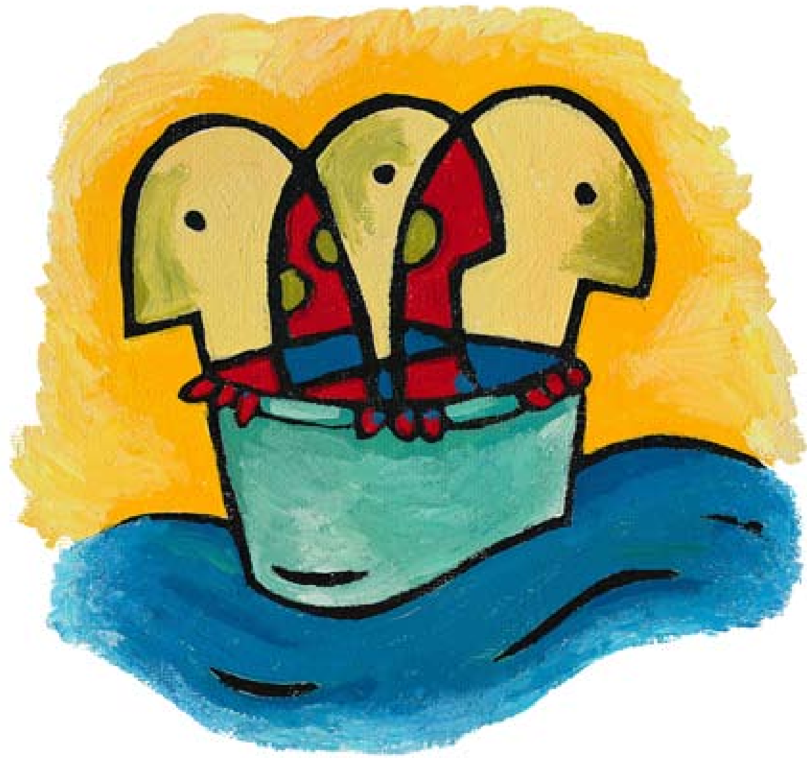
18. Ibid.

19. Craighead, Frank C.; Craighead, John J.; Smith, Ray E.; Jarvis, D. Shiras. *How to Survive on Land and Sea.* Annapolis, Maryland, U.S.: Naval Institute Press, 1984.

20. SAE International. Aerospace Recommended Practice (ARP) 1356. Warrendale, Pennsylvania, U.S.: 1990.

21. Golden, Tipton.

22. S.O.S. Food Lab.



Is There a Doctor Aboard the Life Raft?

Whether in a life raft or floating in the water, survivors must cope with a variety of physical risks, including drowning, temperature-related ailments and thirst. Survival will be influenced greatly by their preparedness and resourcefulness.

— FSF EDITORIAL STAFF

Ditchings[1] and other water-contact accidents present numerous risks to survivors. Even those who safely exit the aircraft and board a life raft sometimes do not survive.

Survivors may die of drowning, cold shock (the body's response to a sudden plunge into cold water), hypothermia (an abnormally low body temperature), dehydration, injuries received in the accident, or one of a number of other ailments. Usually, sharks and other sea creatures are unobtrusive neighbors; nevertheless, they have the potential to harm survivors (see "What's Eating You? It's Probably Not a Shark," page 211).

In many circumstances, crewmembers and passengers must cope with multiple risks simultaneously — usually without much medical expertise and with only the rudimentary supplies that are packed in typical life raft first aid kits or the first aid kits that sometimes can be salvaged from the aircraft.

"It's very dangerous out there," said Roger Storey, aviation physiologist and survival-training instructor for the U.S. Federal Aviation Administration (FAA) Civil Aerospace Medical Institute (CAMI). "You're in a raft out in the middle of nowhere; you just do what you can do."[2]

Cold-water Immersion Can Stop Survivors From Taking Lifesaving Action

Sometimes, the initial plunge into cold water results in rapid physiological changes that can cause death. This phenomenon is known as cold shock, in which there is a sudden increase in the rate of breathing, heartbeat and blood pressure. Cold shock occurs when the water temperature is below about 59 degrees Fahrenheit (F; 15 degrees Celsius [C]), although people who are unaccustomed to cold water may experience problems with their circulation and breathing in water as warm as 77 degrees F (25 degrees C).[3] Large areas of the world's ocean waters are cooler than 77 degrees F.

Immediately after an individual's immersion into cold water, he or she may gasp involuntarily — a response sometimes called the "gasp reflex" — and then may hyperventilate for as long as one minute. (Hyperventilation is usually marked by inappropriately rapid breathing often associated with anxiety.)

Writing in *The Onboard Medical Handbook,* Paul G. Gill Jr., M.D., said, "If you are under water when you gasp, you may aspirate a large amount [as much as three quarts (three liters)] of water into your lungs and asphyxiate [die or become unconscious because of inadequate oxygen]."[4]

Immersion in cold water also causes blood vessels below the skin's surface to constrict (narrow), increasing not only the body's resistance to the flow of blood toward and through those blood vessels but also the flow of blood returning to the heart. The heart beats faster, blood pressure increases, and the sudden stress causes hormones to be secreted into the blood. As a result, people with coronary artery disease may experience abnormal heart rhythms, which may occur because of the rapid cooling of the skin and because of breath-holding while the face is immersed in water; those with hypertension (high blood pressure) may experience a stroke (the death of brain tissue caused by insufficient blood flow and insufficient oxygen to the brain).[5,6]

"Intense cold may destroy [the] will to live."

Sudden death directly caused by cold shock is rare among people who are healthy; they are unlikely to suffer problems with increased heart rate and increased blood pressure. Nevertheless, they probably will be affected by the involuntary changes in breathing that follow immersion in cold water. The hyperventilation that follows cold-water immersion causes a decrease in carbon dioxide in the blood, resulting in constriction of blood vessels in the brain, inadequate blood flow and confusion, loss of coordination, fainting and drowning.

During the first few minutes in cold water, blood flow increases to the brain and to vital organs in the chest and abdomen; at the same time, blood flow decreases to the skin and muscles. After about five minutes, the survivor's muscles are too stiff to swim to safety, don a life vest, grip a rescue line or hold onto an object to stay afloat. After 15 minutes to 20 minutes, the survivor may "attempt to swim to a distant shore or take off his [life vest]," Gill said. "Intense cold may destroy his will to live."[7]

The most dangerous reaction to cold shock probably is the reduction in an individual's ability to hold his or her breath. Hyperventilation reduces breath-holding ability from a normal average time of 60 seconds to about 15 seconds to 25 seconds in cold water — a complicating factor for someone trying to escape from a sinking aircraft.[8]

Cold-water survival specialists Frank Golden, M.D., Ph.D., and Michael Tipton, Ph.D., writing in *Essentials of Sea Survival,* cite U.S. Coast Guard records of a 1973 boating accident in which eight crewmembers were trapped in an air pocket beneath the boat.

"Although it only involved a short underwater swim to escape, two of the crew were unable to hold their breath long enough to do so and drowned in the attempt," they said.[9]

An example of the effects of several minutes in very cold water followed the Jan. 13, 1982, accident in which an Air Florida Boeing 737 struck a bridge and plunged into the Potomac River after departure from Washington (D.C., U.S.) National Airport.[10] Five of the 74 people in the airplane — four passengers and one cabin crewmember

— survived the accident and escaped from the airplane into the river, where they awaited rescue.

The U.S. National Transportation Safety Board (NTSB), in the final report on the accident, said that the temperature of the river water at the time of the accident was about 34 degrees F (one degree C). Cold-water survival data show that half the people exposed to water at that temperature for 22 minutes to 35 minutes (the time period that the survivors were in the river before being rescued) typically lose consciousness.[11]

All five survivors remained conscious; nevertheless, the report said that the water was so cold that they lost the effective use of their hands; two of the five were unable to "get themselves into the life ring and/or the loop in the rescue rope that was dropped by the [rescue] helicopter crew." They also were unable to use their fingers to open the plastic package containing the only life vest that they were able to retrieve; they opened the package by "chewing and tearing at it with their teeth," the report said. The surviving cabin crewmember inflated the life vest and gave it to the most seriously injured passenger.

Later, the cabin crewmember, Kelly Duncan, described the situation:[12,13]

> *I was disoriented. I didn't know where I was. When I found myself in the water … when I surfaced, I saw the tail of our airplane in the water, and I was shocked. … I couldn't swim [because the water was numbingly cold], and I panicked. …*
>
> *I clung to pieces of metal wreckage floating nearby and tried to look for other survivors. The icy water made my entire body numb.*
>
> *Other people floated near me, clutching at the cold metal and trying to stay afloat. …*
>
> *As I clutched the wreckage and tried to stay above water, my hands began to stick to the cold metal; I lifted them one at a time to keep them from freezing. My elation at having survived the crash was replaced by the fear [that] I wouldn't be rescued in time. …*
>
> *The water was just so intensely cold. It hurt because it was so cold. …*
>
> *After 20 minutes in the freezing water, I heard the beautiful sound of an approaching helicopter. It was nearly impossible for any of us to catch the rescue rope and hold on while we were pulled to safety. Every survivor was seriously injured, besides being weak and stiff from the cold. After several tries, I was the second one of the survivors to be able to get the rescue rope around me. …*
>
> *As weak as I [had] felt in the water and as panicked as I felt in the water, I at no time felt like I was going to let go of that rope. … They had to pry the rope out of my hands when they got me over to shore.*

"As I clutched the wreckage and tried to stay above water, my hands began to stick to the cold metal."

Fourteen years earlier, also in the Potomac River, nine men who had just completed two months to three months of U.S. Marine Corps training — including 20 hours of water-survival training — to become military physical fitness instructors apparently drowned when their canoe capsized. A published news report on the drownings said that the men had been dressed in full-length exercise clothes and gym shoes and that they had seat-cushion flotation devices and no other gear.[14]

The water temperature was 36 degrees F (2 degrees C). Marine Corps officers said at the time that they believed that the paralyzing effects of the cold water prevented the men from either righting their canoe or swimming to shore. One officer was quoted as saying, "Any one of these guys could easily swim the river back and forth in good weather."

The American Canoe Association, after citing the Marines' experience in a subsequent newsletter, said, "This is the bluntest of messages for all of us. … Being able to swim in the warm waters of summer has nothing to do with survival in cold water."[15]

Drowning Kills Most Ditching Survivors

Most people who are "lost at sea," as well as most people in aircraft that have been involved in water-contact accidents, die of drowning — suffocating in water as a result of an inability to keep water out of the airway long enough to breathe normally.[16,17] Total submersion in water is not necessary for drowning; intermittent submersion resulting from "wave splash" (waves breaking over the face of someone wearing a life vest without facial protection) may cause an individual to inhale so much water that he or she drowns.

Peter Fenner, M.D., a specialist in drowning and an Australian designated aviation medical examiner, said, "Waves slapping against the face can cause the same involuntary hyperventilation, and subsequent waves slapping against the face during uncontrolled hyperventilation can mean that [a survivor] inhales water and can drown while floating with [his or her] head above the water."[18]

The sequence of events involved in drowning includes panic, a period of submersion in water while breath-holding, swallowing water, loss of consciousness (after about three minutes under water), brain damage (after about five minutes under water), irregular heart rhythm, and cessation of heartbeat.[19]

Because someone who is drowning concentrates on keeping his or her head above the water and breathing, there may not be a call for help. Instead, the victim's behavior in the water is the most reliable indication of whether assistance is required. Flailing arms, uneven swimming motions and/or an unusual position (lying face-down in the water or keeping only the head out of the water, with the mouth open) may be indications that someone is drowning.[20]

There are two types of drowning:[21]

- "Wet drowning" is caused by inhaling a relatively large amount of water — typically at least 1.5 liters (1.6 quarts), or about 22 milliliters per kilogram (0.34 ounces per pound) of the victim's weight.[22] Eighty-five percent to 90 percent of all drownings are wet drownings; and,

- "Dry drowning" occurs when the presence of water at the opening of the trachea (windpipe) causes muscle spasms that close the airway. Death occurs because oxygen cannot reach the lungs; during autopsy, water is not found in the lungs. Between 10 percent and 15 percent of all drownings are dry drownings.

Inhalation of as little as 0.25 liter to 0.50 liter (0.5 pint to 1.0 pint) of water can cause death as a result of "near-drowning" (sometimes also called "secondary drowning") a condition in which the victim survives after aspirating water but then incurs lung damage, impaired breathing, a severe deficiency of oxygen in the blood and a correspondingly severe reduction in the amount of oxygen delivered to the body's vital organs. In some cases, victims of near-drowning survive but suffer permanent brain damage. In other cases, they develop irregularities in heart rhythm, an imbalance in salt and water in the body, kidney failure, neurological damage and/or lung infections from bacteria in the water.[23]

Near-drowning can begin with inhalation of as little as a tablespoon of water.

Cmdr. J. Russell Bowman, D.O., a U.S. Coast Guard flight surgeon in Sitka, Alaska, said that near-drowning can begin with inhalation of as little as a tablespoon of water.[24] "It's like a bite of food going down the wrong way," he said. "You start coughing, and then you take in more water."

Symptoms of near-drowning include coughing, vomiting, rapid pulse, difficulty breathing and cyanosis (blueness of the lips and fingertips). Even people who have none of these symptoms should be monitored for about 12 hours for a delayed reaction.[25] Hospital treatment for near-drowning is designed to ensure that adequate oxygen is delivered to the blood. If sections of the lungs have collapsed, a respirator often is used to re-inflate them. Other treatment may include medication to prevent airway spasms, intravenous solutions to restore the blood's chemical balance, antibiotics to treat infections and blood transfusions to replace red blood cells.

On a life raft, however, even if those monitoring the victim observe a worsening of his or her condition, they probably will not be able to help.

"There's not a whole lot you could do for them," Bowman said. "Their breathing could get worse, and they could die. It may not progress to that point, but there could be difficulty breathing, or more respiratory problems, up to and including death."

Golden and Tipton said that victims of near-drowning have described a variety of memories of the experience:[26]

> *Some describe a period of terror while they struggled to hold their breath until they were no longer capable of doing so, and then feeling a tearing, burning sensation in their chests as water entered their airways. In contrast, others describe a feeling of absolute calmness and tranquility, with panoramic views of their past lives passing before their eyes.*

In addition, they said that other near-drowning victims experience high blood pressure; vomiting; involuntary urination, defecation and/or seminal emission; convulsions; coma; blood-pressure collapse; slowed respiration; and death.

On occasion, people have survived being submerged in cold water for one hour or longer because of the mammalian diving response (diving reflex) — the same reflex that enables seals and other marine mammals to go without breathing for 30 minutes or longer while under water. The reflex is stronger in marine mammals than in humans, and stronger in children than in adults.

The response occurs when the face is immersed in cold water, which stimulates the nerves around the eyes. Cold water enters the lungs, slows the heartbeat and redirects the flow of blood away from the hands, feet and intestines and toward the heart and brain. The cold water cools body tissues, which then require less oxygen.[27,28]

Ideally, cardiopulmonary resuscitation (CPR) should begin immediately on victims of near-drowning (including those who have been submerged for relatively long periods) — if necessary and if possible, while they are still in the water, even before they reach a life raft. If the victim's airway is obstructed, the Heimlich maneuver (an emergency technique for dislodging something from the victim's windpipe by applying upward force on the upper abdomen) can be performed in the water.

Nevertheless, administering "makeshift CPR" in the water is "not the easiest thing in the world," said Storey, who taught survival classes to U.S. Air Force pilots before he began teaching the FAA survival course 12 years ago. "I'm not sure I could do it."

The process is only somewhat easier in a life raft, especially if the life raft is crowded. The victim's body must be horizontal — or at least positioned so that the head is slightly lower than the chest — and firm support for the back is required for the rescuer to deliver effective compressions of the heart. In the water, with both the victim and the rescuer wearing life vests, the rescuer should be behind and under the victim. The rescuer should administer compressions by reaching under the victim's life vest and placing a fist, with the thumb down, on the lower one-third of the sternum (breastbone) and the other hand, palm-down on top of the fist. In a life raft, the floor may provide adequate support; otherwise, another person may lie beneath the victim to provide a more solid surface.[29]

Bowman said that after breathing has resumed during CPR, a victim should be placed in the recovery position, lying on his or her side. (This position is recommended to prevent the victim's airway from being obstructed by vomit or by the tongue rolling back into the throat.)

"You may have to dump the body at sea and say a prayer."

"They're going to have to get along until help arrives," Bowman said. "There's no medicine or piece of equipment that's going to help them."

Bowman also warned of the difficulties of administering effective CPR in a life raft to someone who had stopped breathing for more than a few minutes or who would probably require intensive medical treatment in addition to CPR.

"I would recommend not to even attempt it," he said. "You could try rescue breathing for someone, but the likelihood is low that that is all they would require to survive."

Deborah Kasman, M.D., M.A., assistant professor at the Georgetown University Medical Center Department of Internal Medicine and Center for Clinical Bioethics in Washington, D.C., U.S., said that if someone has not responded to CPR that is administered for near-drowning or for any other cause, "you're not going to save them at sea, in a boat in the middle of nowhere, without advanced medical help."[30]

"There are cases that are clearly futile, and no one is ever required to administer futile care," Kasman said. "Laypeople are going to feel uncomfortable with this concept, but sometimes you have to make very hard decisions. You may have to dump the body at sea and say a prayer."

For protection against drowning, aircraft crewmembers and passengers should wear suitable, properly maintained aviation life vests (see "Your Life Vest Can Save Your Life … If It Doesn't Kill You First," page 346). For additional protection, a spray hood or face mask should be worn to reduce the amount of water splashing into the nose and mouth.[31]

If a life vest is not available, other items from the airplane — such as flotation seat cushions, headrests, armrests or pillows; plastic boxes; or pieces of polystyrene (from a cooler, for example) — can be used to help someone stay afloat. Another possibility is to use a large plastic bag or a relatively large piece of material, lifting it into the air and lowering it to the surface of the water to trap air inside it. Another technique involves trapping air inside a pair of trousers by tying the bottoms of both trouser legs, lifting the trousers — open end first — into the air and lowering them to the surface; the legs fill with air and remain above the water.

Many survival specialists no longer recommend that someone in the water without a life vest use a technique called drown-proofing to prolong their survival time — or they recommend that the technique be used only in limited circumstances. Drown-proofing calls for floating face-down in the water with the chin on the chest, the waist bent and the arms extended to the side and regularly using a frog-kick (a kicking motion in which the knees are apart and turned out) to lift the head out of the water long enough to breathe. The drown-proofing technique was devised to help conserve energy and prevent aspiration of water.[32]

Today most survival specialists say that, especially in cold water, the drown-proofing position results in a rapid loss of body heat through the head and neck (as much as one-third to one-half of the body's heat loss) and can be exhausting for someone who is uneasy being in the water.

"If drown-proofing's going to work, the person's probably practiced it before," Bowman said. "There are better ways."

In recommendations to crews of commercial ships and recreational boats, the U.S. Coast Guard (USCG) says, "The more your body is out of water, the warmer you'll be. Don't use drown-proofing methods that call for putting your face in the water. Keep your head out of the water to lessen heat loss and increase survival time."[33]

Drowning sometimes results from "swim failure," a loss of ability to swim caused by a weakening of muscles in the arms and legs after swimming in cold water. A 1999 study evaluated 10 volunteers as they attempted to swim for 90 minutes in water at three temperatures — 25 degrees C (77 degrees F), 18 degrees C (64 degrees F) and 10 degrees C (50 degrees F). All 10 swimmers were able to swim for 90 minutes in 25-degree-C water, eight swimmers swam for 90 minutes in 18-degree-C water, and five swimmers swam for 90 minutes in 10-degree-C water.[34]

"The more your body is out of water, the warmer you'll be."

"At the end of swims in 10-degree-C water, swimmers reported that it became increasingly difficult to straighten their limbs and coordinate their swimming movements," said the report on the study, conducted by Tipton, Golden and two other researchers. "The loss in coordination was attributed to increased shivering which interfered with — and in some cases, almost inhibited — swimming."

The report said that the decrease in swimming efficiency was apparent in the characteristics of the swimmers' strokes, which became shorter and more rapid, and their position, which became nearly upright.

"Since stroke length and [stroke] rate and swim angle are more easily observed than swimming efficiency, they may also help to identify individuals who are about to reach swim failure," the report said.

Hypothermia Survival Times Vary

Hypothermia occurs when more heat escapes from the body than the body can produce. Hypothermia is present when an individual's body temperature — normally 98.6 degrees F (37.0 degrees C) — decreases to 95 degrees F (35 degrees C) or below.

Hypothermia can occur because of exposure to cold air or cold water. In water, however, hypothermia develops more quickly because body heat dissipates more quickly in water — even relatively warm water with a temperature below about 82 degrees F (28 degrees C; Table 1, page 193).

Hypothermia can be exacerbated by wind chill, which is based on the rate of heat loss from exposed skin caused by the combined cooling effect of the wind and the outdoor temperature (Figure 1, page 194). The U.S. National Weather Service Office of Climate, Water and Weather Services defines the wind chill temperature as the measurement of how cold people and animals feel when they are outdoors. As wind speed increases, heat is moved away from the body more quickly, resulting first in a decrease in skin temperature (which can cause frostbite, if the air temperature is below freezing) and/or a decrease in body temperature (which can become hypothermia).[35]

For example, if the temperature is 45 degrees F (seven degrees C) and the wind is blowing at 15 miles (24 kilometers) per hour, the wind chill temperature is 38 degrees F (three degrees C).

Table 1
Expected Survival Time in Cold Water

Water Temperature	Exhaustion or Unconsciousness in	Expected Survival Time
More than 80 degrees Fahrenheit (F) More than 26.5 degrees Celsius (C)	Indefinite	Indefinite
70–80 degrees F 21–26.5 degrees C	2–12 hours	3 hours–indefinite
60–70 degrees F 15.5–21 degrees C	2–7 hours	2–40 hours
50–60 degrees F 10–15.5 degrees C	1–2 hours	1–6 hours
40–50 degrees F 4.5–10 degrees C	30–60 minutes	1–3 hours
32.5–40 degrees F 0.3–4.5 degrees C	15–30 minutes	30–90 minutes
32.5 degrees F 0.3 degrees C	Less than 15 minutes	Less than 15–45 minutes

Source: U.S. Coast Guard

With wet clothing — a likely condition for someone aboard a life raft — an individual feels even colder.[36]

Visible symptoms of hypothermia include shivering; slurred speech; abnormally slow breathing; cold, pale skin; fatigue; lethargy; apathy; and loss of consciousness (Figure 2, page 195).

Golden and Tipton said that people with hypothermia may "exhibit uncharacteristic behavior or personality. They will usually be uncoordinated, with a general slowing in physical and mental activity. This condition will increase the incidence of errors of omission or commission and, in turn, may lead to poor judgment, bad decisions, reduced perception, or dropping or damaging vital equipment. In general, hypothermic individuals will be performing far below par and be a risk both to themselves and others."[37]

Sometimes, victims of hypothermia do not recognize — at least initially — that they are experiencing problems.

For example, one survivor of a deadly 1979 storm that disrupted the annual Fastnet sailboat race off the southern coast of Great Britain, killing 15 people and sinking five yachts, said later, "I remember sitting in the [boat] cockpit and noticing one of the buttons of my oilskin jacket was undone. For some reason, I was unable — and unwilling — to do anything about it, although I knew I should. But one of the effects of hypothermia is that your brain just seems to come to a grinding halt, which of course makes things worse."[38]

Those who typically are most at risk of hypothermia are the elderly, because they may have medical conditions that hinder the body's ability to regulate temperature, and children, because their relatively larger surface-area-to-mass ratio means that they lose large amounts of body heat to surface cooling more quickly than healthy adults.

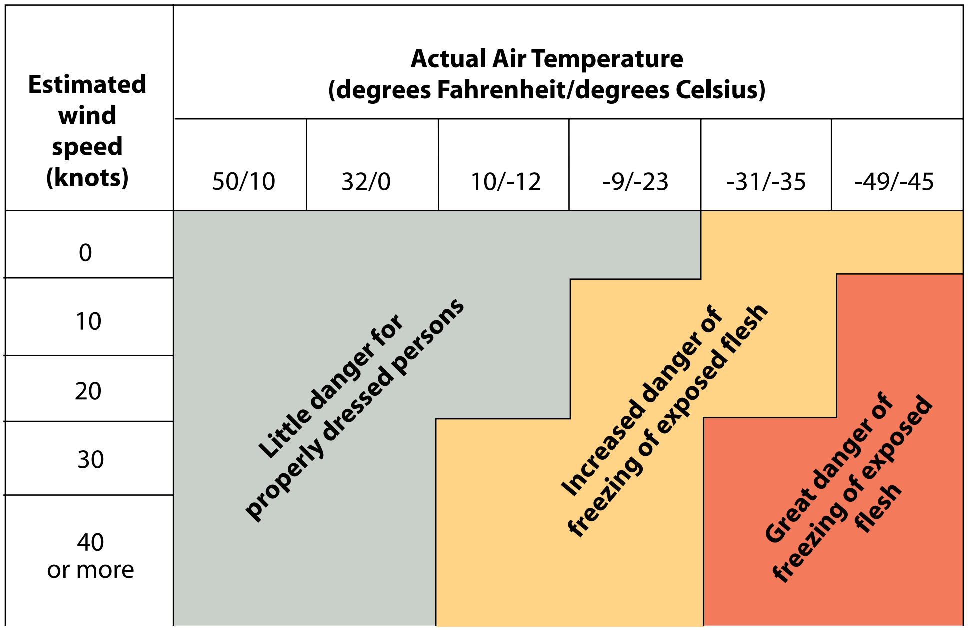
Others at increased risk of developing hypothermia include individuals with some medical conditions — such as hypothyroidism (an underactive thyroid); diseases such as stroke that cause paralysis and reduce mental awareness; diseases such as Parkinson's disease that restrict physical activity; conditions that restrict normal blood flow; and conditions that involve memory disorders — and individuals who take over-the-counter cold medications or medications for depression or nausea.

Typically, large people, with relatively greater amounts of body fat, develop hypothermia more slowly than thinner people. Cooling rates for men and women are about the same. Physical fitness is no defense against hypothermia; although those who are fit have more stamina than others, they also have less body fat.

Other factors also determine how quickly an individual will lose body heat, including the temperature of the water (the colder the water, the more rapid the heat loss), the condition of the water (wind and spray result in more rapid heat loss) and the insulating quality of the individual's clothing (several layers of heavy clothing can increase survival time in cold water as much as 30 percent to 40 percent).[39] Aircraft crewmembers and passengers who wear immersion suits have additional protection against the cold (See "Cold Outside, Warm Inside," page 357).

In laboratory tests, the body temperature of a man wearing non-protective clothing and keeping his head above water decreased 3.6 degrees

Figure 1
Effects on Exposed Skin of Wind and Outdoor Temperature



Source: *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual*

F (2.0 degrees C) to 95 degrees F (35 degrees C) after one hour in water with a temperature of 41 degrees F (5.0 degrees C). The same decrease in body temperature was recorded after three hours to six hours in water with a temperature of 59 degrees F (15 degrees C).[40]

Hypothermia affects people even in warmer waters. A June 19, 2003, report published in the Honolulu (Hawaii, U.S.) *Star-Bulletin* said that a 48-year-old fisherman was treated for hypothermia after being pulled from the water near a Pacific Ocean beach the previous day.[41] Water temperatures in that area in June average 79 degrees F (26 degrees C).[42]

An individual's behavior also influences the rate at which body heat is lost. Movement in the water (for example, swimming or treading water) results in an increase in circulation and increased blood flow near the skin, as well as an increase in the flow of water around the skin. This can cause the body to cool as much as 50 percent faster than maintaining a relatively still position.

Shivering is the body's attempt to generate heat with the involuntary contraction and expansion of many small parts of skeletal muscle tissues — an action that creates friction and, as a result, heat.[43]

The effectiveness of shivering is limited, however. Eventually — in very cold water, after a period of minutes, and in warmer waters or on land, after several hours — an individual becomes fatigued, the body's fuel reserves are depleted, and shivering stops. An individual's shivering is diminished when oxygen levels decrease or levels of carbon dioxide increase in inspired air; this situation is likely to occur in circumstances in which fresh air ventilation is inadequate, such as in enclosed life rafts.[44]

Shivering sometimes is considered a determining factor in whether someone has mild hypothermia (and may be able to rewarm himself or herself after reaching a warmer environment) or severe hypothermia, which may require medical treatment.

Hypothermia also may be classified according to how rapidly the condition develops:[45]

- Acute hypothermia develops after several minutes in cold water with a temperature of less than 59 degrees F (15 degrees C). Treatment is designed to carefully increase the body temperature to avoid forcing cold blood from the arms and legs back toward the heart and other organs. After the body is warmed, normal physiological processes resume; and,

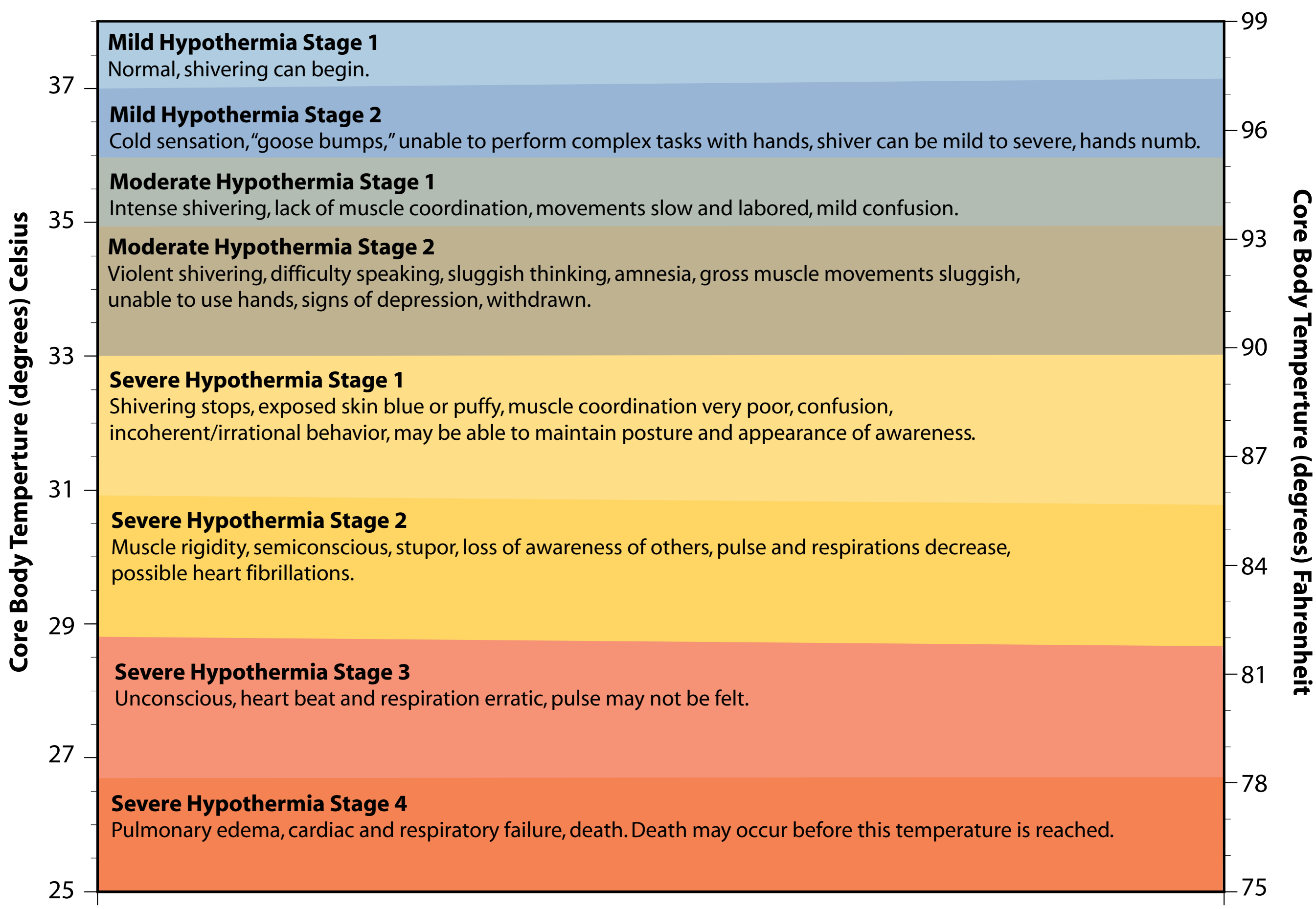
- Chronic hypothermia develops after longer periods of time, sometimes many hours, in water between 68 degrees and 82 degrees F (20 degrees and 28 degrees C). A person with chronic hypothermia probably is exhausted, and the body's fluid reserves may be insufficient for normal blood circulation after the body is warmed.

The lower an individual's body temperature is, the more likely he or she is to suffer serious complications, such as frostbite, loss of consciousness or heart arrhythmia. If the body temperature is at or above 90 degrees F (32 degrees C), there probably will be no lasting damage. If the temperature is between 80 degrees F (27 degrees C) and 90 degrees F, most people will recover, although some will experience permanent damage. If the body temperature is below 80 degrees F, death is likely. (Some people will lose consciousness and — if floating in the water — will drown before body temperature is low enough to cause death by hypothermia, however.)[46]

Treatment of hypothermia — after the victim has been removed from the cold — involves the following:[47]

- Exchanging wet clothing for dry clothing, or sharing body heat by removing the victim's clothing and the clothing of another individual without hypothermia and having them lie next to each other beneath other clothing or an emergency ("space") blanket (made of laminated layers of polyester film, such as Mylar, with a reflective coating that can be used either to retain body heat or to protect from sunlight) to transfer body heat to the person with hypothermia. This method requires care to ensure that the warmer person does not lose so much body heat that he or she, too, becomes hypothermic. (The space blanket material also is used in mummylike thermal protective aids, which have sleeves, a hood and a zipper in the front — and sometimes legs — and which are designed to provide warmth and shut out moisture and wind. Another use of the material is in drawstring bags designed to enclose the entire body, with an adjustable opening for breathing, and to be worn over life vests by survivors floating in the water. The bags slow the loss of body heat and prevent bodily wastes and blood from entering the water and attracting sharks, the manufacturer says.)[48];

Figure 2
Symptoms of Hypothermia



Source: U.S. National Aeronautics and Space Administration

- Covering the head to limit the loss of body heat;

- Laying the victim face-up on the warmest surface available and monitoring breathing. If breathing has stopped or if the breathing rate is determined to be dangerously slow (less than six or seven breaths per minute), the rescue breaths of CPR should be administered. Nevertheless, Paul S. Auerbach, M.D., clinical professor of surgery at the Stanford University Medical Center Division of Emergency Medicine, said that because hypothermia is "protective" — that is, the extreme cold causes the body temperature to drop and the metabolism to slow — the body is more tolerant of a lower-than-normal heart rate, respiratory rate and blood pressure. As long as the person shows any signs of life, including breathing, a pulse or movement, the chest compressions of CPR should not be administered. Auerbach said that "pumping on the chest unnecessarily is 'rough handling' and may induce ventricular fibrillation [a type of irregular heartbeat that can lead to sudden death]"[49];

- If the victim is able to swallow, he or she should drink a warm nonalcoholic beverage, although this may not be possible in a life raft. Alcoholic drinks reduce the body's ability to retain heat;

- Treat the person gently because of the risk of cardiac arrest. Don't rub the body or administer massage; and,

- Avoid applying heat to the person's arms and legs. This could cause cold blood from the extremities to flow toward the heart, lungs and brain, resulting in a potentially fatal decrease in body temperature.

Occupants of the life raft should attempt to create an environment that limits the effects of hypothermia, by erecting the life raft's canopy as soon as possible to limit the effects of wind chill, by keeping the floor of the life raft as dry as possible and by wringing out wet clothing.

In cold water without a life raft, survival specialists say that, because an individual's ability to use his or her hands will deteriorate quickly, any tasks requiring manual dexterity should be performed immediately.

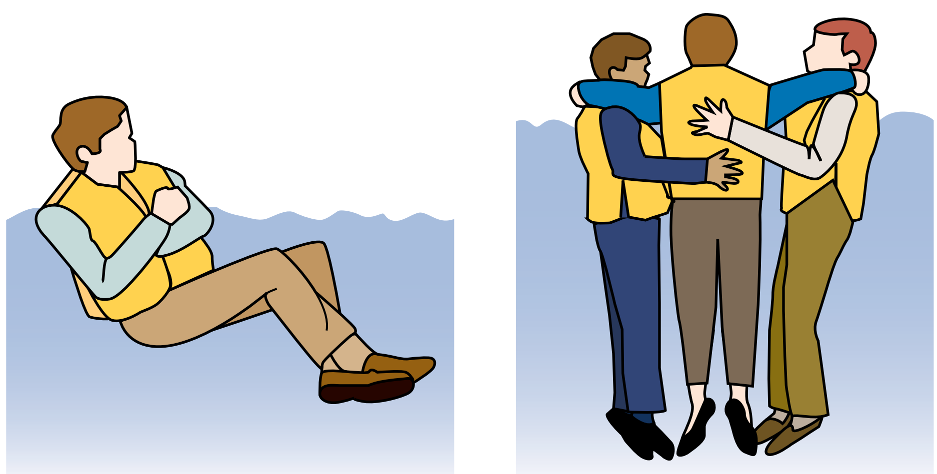
After that, the primary goal is to conserve heat. Survival specialists make the following recommendations:[50]

- A group of survivors should tie themselves into the huddle position (Figure 3), with their lower bodies and the sides of their chests pressed together. Children should be placed in the middle of the group;

- A lone survivor should use the heat-escape-lessening posture (HELP), with the sides of the arms against the chest and the thighs together and elevated slightly to protect the groin; and,

- Swimming should be avoided unless the distance is short. (The U.K. Civil Aviation Authority [CAA] said that the distance should be less than 1.0 kilometer [0.6 statute mile] and that the person should be a strong swimmer.) Swimming does not help anyone stay warm. Instead, the body heat

Figure 3
HELP and Huddle Positions



HELP (Heat-escape-lessening Posture) — **Huddle Position**

Source: U.S. National Aeronautics and Space Administration generated by increased blood circulation in the arms, legs and skin is transferred to the water.

Nevertheless, some specialists question the usefulness of the HELP and huddle positions.

Golden and Tipton said that "stability problems make [the HELP] posture difficult and impractical to maintain in an open seaway" and that less body heat is generated in the groin and the armpits than was once believed. They said that, although the huddle position might be useful in calm waters, survivors on the downwind side of a group in the huddle position in the open sea would constantly be splashed in the face by oncoming waves.[51]

In the past, some specialists said that removing clothing while in the water would aid survival. Today, specialists disagree with that recommendation. Instead, they recommend wearing all available clothing, including shoes and a hat, if one is available, and tightening collars, cuffs and hoods. (Clothing, including coats, should be worn under a life vest.) Water trapped inside clothing will be warmed by the body and then will provide insulation against colder water.[52]

Those floating in the water — especially in cold water — are presented with another risk: circumrescue collapse, a sudden loss of consciousness or death, which occurs immediately before, during or immediately after rescue. (This phenomenon also sometimes affects survivors in life rafts who have not been immersed in water.) Data show that, in incidents involving the rescue of large numbers of people who are immersed in water, about 20 percent may be subject to circumrescue collapse.[53] Golden and Tipton said that specialists believe that several factors could be responsible for circumrescue collapse, including the body's physical response to stress, lengthy exposure to cold and resulting hypothermia, the amount and type of physical activity required of the victim during rescue, hypovolemia (a decrease in the volume of circulating blood), hypoxia (a shortage of oxygen supplied to the brain) resulting from near-drowning, hemorrhaging from an internal injury, or too-rapid rewarming of a hypothermia victim. Survivors who collapse after rescue, however, usually do so because of hypoxia caused by near-drowning, they said.

In Frostbite Cases, Extremities Freeze First

Exposure to the cold can cause a variety of ailments.

Frostbite, in which parts of the body are damaged permanently by the cold, can occur when the temperature of exposed body tissues is 31 degrees F (minus 0.55 degrees C) and the fluid in the skin — or the skin itself — freezes.[54]

This is among the most serious types of injuries from the cold and usually affects the fingers, toes, cheeks, ears and nose, although prolonged exposure to the cold can cause the freezing to extend into the arms or legs.[55]

Exposure to the cold can cause a variety of ailments.

Symptoms cause the affected skin to appear white or grayish-yellow. After a period of pain, the affected area feels numb, although numbness may be accompanied by tingling or aching. If frostbite damage is superficial, the skin may feel hard and, when pressure is applied, the underlying tissue may feel soft; if damage is severe, the entire affected area may feel hard. Blistering will occur in 12 hours to 36 hours, and when the area thaws, it will be red and swollen; gangrene (death of tissue) may occur later.

On a life raft, treatment might be limited to providing the victim with a space blanket for warmth. Additional care, not possible on a life raft, usually includes slow warming of the frostbitten area by placing it in warm water and administering antibiotics.[56]

The best-known victim of frostbite at sea may be Howard Blackburn, whose two-man fishing dory was caught in a surprise storm in the Atlantic Ocean off Newfoundland, Canada, in January 1883. As Blackburn and his companion bailed water and rigged an anchor, Blackburn's mittens washed overboard. Knowing that his hands would freeze, he grasped the oars, so that his hands would freeze around them and he would be able to row the dory. The other man died, but Blackburn rowed for five days until he reached shore. He lost eight fingers and parts of both thumbs to frostbite and the subsequent gangrene.[57]

Immersion foot (trench foot), which occurs after the feet have been in water at temperatures between freezing and 50 degrees F (10 degrees C) for more than 12 hours, is most often found among people on life rafts where activity is limited, diet is inadequate and clothes (such as socks and shoes) are wet and cold. Symptoms include swelling of the feet and lower legs, numbness, itching, tingling, pain, muscle cramping and discoloration of the skin.[58] If untreated, infection may develop.[59]

Immersion foot usually is treated after rescue by warming, cleaning and drying the feet while avoiding too-rapid rewarming. Antibiotics and an injection to prevent tetanus may be administered.

To prevent immersion foot, people on life rafts should try to keep their feet as warm and dry as possible and should elevate their feet and exercise their toes and ankles several times a day.

Chilblains, in which part of the body becomes red and slightly swollen in response to cold, is a mild injury that occurs in temperatures between freezing and about 61 degrees F (16 degrees C) with high humidity. The affected areas, which may itch as they are warmed, usually are the ears, fingers and the back of the hand.[60]

If exposure has been brief, chilblains symptoms may disappear. Recurring exposure, however, may cause increased swelling and discoloration of the skin, blisters and bleeding areas. If petroleum jelly is available in the life raft, it may relieve discomfort.

In Survival Situations, Heat Illness Is Difficult to Treat

Heat presents other weather-related risks. Heat illness — heat exhaustion or heatstroke — occurs when the body's natural cooling mechanisms cannot compensate for excess heat generated by warm weather. The risk of heat illness is exacerbated by strenuous activity, which increases the amount of heat produced by the muscles; dehydration, which interferes with the production of perspiration; and high humidity, which reduces the cooling effect of perspiration.[61,62]

Those most at risk of heat illness are the elderly, young children, individuals who are very obese, alcoholics, and those using antihistamines, antipsychotic drugs or cocaine.

The early stage of heat illness is heat exhaustion, in which exposure to high temperatures causes the body to lose too much fluid through perspiration. As fluids are lost, so are blood electrolytes (dissolved mineral salts in the blood); the result is disruption of circulation and brain function.

Symptoms of heat exhaustion include fatigue, weakness, anxiety, heavy perspiration, a feeling of faintness (especially when standing), a slowing of the heartbeat and confusion.

If heat exhaustion is not treated, the condition sometimes — usually in cases involving strenuous activity in extremely warm weather — develops into heatstroke, a life-threatening illness in which the body temperature rises as high as 106 degrees F (41 degrees C). Heatstroke is unlikely to occur among occupants of a life raft, however.[63]

In a life raft, treatment of heat illness is difficult, and preventive measures should be emphasized. Nevertheless, if someone in a life raft experiences the early symptoms of heat exhaustion, he or she should — if possible — remove outer clothing, lie in shade and expose the skin to a breeze to aid evaporation of perspiration. He should drink water until he is rehydrated and then try to limit further exposure to the heat.

Severe sunburn is a risk for people in life rafts, especially those in life rafts without a protective canopy and at latitudes near the equator, where the sun's ultraviolet rays (UVR) are strongest. UVR levels vary according to the time of day and time of year and are greatest when the sun is highest in the sky. UVR levels are greatest on clear days, but cloud cover does not effectively block UVR, which can be reflected and scattered by various surface materials, including water. Wind dries the skin and — along with water — removes urocanic acid (a substance that forms naturally in the skin and protects against sunburn); this makes skin more susceptible to sunburn and causes "windburn," an additional irritation of skin that already is sunburned.[64]

Symptoms of sunburn include reddened skin, itching and pain. If the sunburn is severe, it is called sun poisoning; symptoms include vomiting, weakness, headache, chills and fever.

"Severe sunburn is a risk for people in life rafts."

Treatment includes analgesics (pain-relief medications) such as aspirin or ibuprofen, and soothing sunburn lotions, which may be included in life raft first aid kits.

Wearing clothing of tightly woven fabrics and application of a sunblock such as zinc oxide or a sunscreen lotion with a high sun-protection factor (SPF), if available in the life raft, can protect against sunburn. Sunscreen should be applied not only to exposed skin but also to skin beneath clothing made of loosely woven fabrics, because UVR can penetrate these materials.[65] Taking shelter whenever possible beneath the life raft's canopy can provide protection against direct UVR; nevertheless, the canopy is not as effective in protecting against indirect UVR reflected from the water's surface. In addition, the canopies of most aviation life rafts are made of translucent ripstop nylon material that provides only limited UVR protection.

Ken Burton, president of STARK Survival Co., said that survivors also should ensure that their heads are covered. Those without hats should dampen something — perhaps underwear, he suggested — with water and put that on their heads. Clothing also can be dampened with water to help in cooling.[66]

UVR exposure also can damage the eyes, causing a variety of ailments, including photokeratitis (sunburn of the cornea, the transparent tissue over the front of the eye). This condition is temporary and occurs after a few hours in bright sunlight, often in sunlight that is reflected off water. Photokeratitis can be painful for one or two days and can cause a temporary loss of vision. Other ailments, including cataracts (the clouding of small regions of the normally transparent tissue in the eye's lens, located behind the colored part of the eye) generally result from long-term exposure to UVR.[67]

People who are not wearing appropriately designed sunglasses (with lenses that protect against damaging UVR and sidepieces that extend beyond the hinges) should avoid looking directly at the water. Survival specialists suggest that survivors might limit eye damage by placing a bandage or other loosely woven fabric in front of their eyes or by partially closing their eyelids.[68]

Treatment of photokeratitis or other minor sun-related eye irritations includes rinsing the eyes several times a day with small amounts of fresh water and covering them with a bandage to exclude light for at least two days.

'When You're Thirsty, Drink'

Dehydration is the excessive loss of water from the body, sometimes because of inadequate consumption of liquids but also as a result of a number of other factors, including exposure to hot weather, vomiting or diarrhea — conditions that would be likely for people in ocean-survival situations, either inside life rafts or floating in a life vest in ocean waters.[69]

About two-thirds of an individual's body weight is water, and water is essential in replicating cells, carrying nutrients through the body, eliminating waste from the body and regulating body temperature.

Medical specialists recommend that people drink about two quarts of water every 24 hours to replenish the amount excreted in urine and perspiration and to prevent decreases in blood volume and in blood electrolytes. Nevertheless, people can survive by drinking as little as 3.7 ounces to 7.4 ounces (110 milliliters to 220 milliliters) of water a day.[70]

The amount of water in the body and the concentration of electrolytes in the blood are related, and both must be maintained at proper levels for the body to function properly.[71]

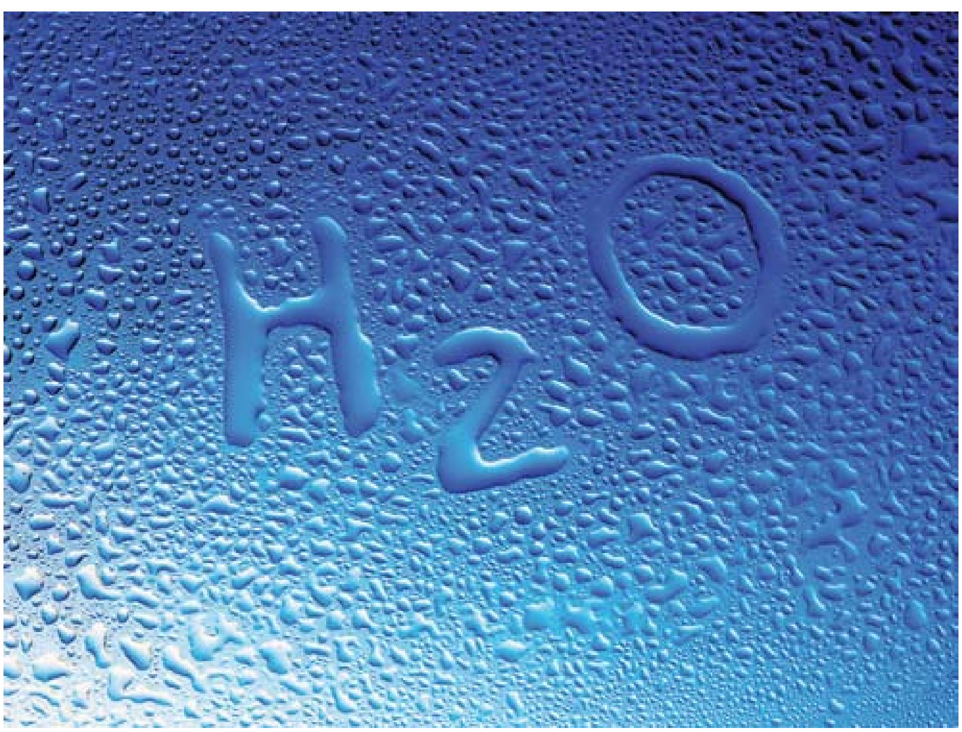
If someone becomes thirsty (the first noticeable symptom of dehydration) but does not drink enough to compensate for the body's loss of water, the kidneys excrete less urine and the amount of perspiration decreases. Water in the body's cells begins to replace water in the bloodstream, and the cells no longer function properly. Eventually, movement of water from the cells into the blood also slows.

As dehydration becomes more severe, symptoms include fatigue, nausea, emotional instability, clumsiness, headache, elevated body temperature and respiratory rate, dizziness, slurred speech, weakness, confusion, swollen tongue, circulatory problems, decreased blood volume and kidney failure. After the body has lost about 8.5 quarts (9.0 liters) of water, symptoms may include inability to swallow and cracked skin. If a loss of 11.3 quarts (12.0 liters) of water occurs, death usually is imminent.

Dehydration is exacerbated by consumption of alcoholic beverages and caffeinated beverages, because they have diuretic effects, and also by spending time in a pressurized aircraft, where the low humidity accelerates the body's loss of water.

Because of these conditions, many aircraft crewmembers and passengers may be slightly dehydrated even during a normal flight; for them, dehydration may become noticeable very quickly in a survival situation.

In a modern life raft equipped with a reverse-osmosis water pump, supplies of drinking water should be adequate, survival specialists say (see "Water, Water, Everywhere, Nor Any Drop to Drink …" page 177).



These specialists generally agree that people in a life raft should not ration water and should not delay taking their first sips of water but should drink when they are thirsty.

"Plain H_2O is going to take good care of you," said Burton, who has taught water-survival classes to flight crews, cabin crews, frequent flyers and business executives. He prescribes a course of cautious consumption.

"When you're thirsty, drink," he said. "You don't want to gorge, but … taking only a sip of water is equivalent to putting a thimbleful of gasoline in an empty [vehicle] tank."

Ray E. Smith, a U.S. Navy survival-training specialist, said that people in life rafts should "use common sense" about drinking water.[72]

"They definitely should not get dehydrated," Smith said. "Don't ration water, but if you're thirsty, drink."

Paul D. Russell, a maritime safety specialist and accident investigator, and a retired U.S. Coast Guard captain with more than 5,000 flight hours in fixed-wing and rotary-wing aircraft, said that in the high-stress environment of a life raft, people generally feel an increased need for water. Russell said that those who are fully hydrated should try to delay 12 hours to 18 hours before drinking. (If someone is dehydrated, the tissues inside the mouth begin to appear white instead of pink, and urine becomes darker.)[73]

"If you drink a lot of it right away, your body can't process it; you'll pee it away," Russell said. "Don't overdo it."

People who are sick or injured, however, should be urged to drink whenever they feel thirsty, he said.

Other safe sources of drinking water include collected rainwater or condensation.[74]

One controversial alternative method of acquiring fluid is to use nonpotable fresh water (water that is undrinkable because of its unpleasant taste) or fresh water that has been contaminated by ocean water for a water-retention enema. Lyn Robertson, a nurse who spent 38 days on a life raft in the Pacific Ocean with her husband, their three teenage children and a deckhand in 1972 after a whale attacked and sank their 43-foot (13-meter) schooner, administered water-retention enemas to compensate for their shortage of drinking water; all five survived.[75]

Nevertheless, in most ocean-survival circumstances, water-retention enemas are unlikely to be very effective, medical specialists say. Although the large intestine absorbs about two quarts of water daily, most of that amount is absorbed at a site so far from the anus that it would not be reached by a typical water-retention enema.[76]

Because of the high salt content, specialists believe that ocean water cannot safely be used in water-retention enemas because both water and salt are absorbed by the body through the intestinal wall, and the additional salt exacerbates dehydration. In addition, a 1969 study found that water absorption ceased when the salt concentration was about 20 percent higher than the typical concentration of salt in the body.[77]

People in life rafts should 'use common sense' about drinking water.

In circumstances in which an individual is unconscious or is vomiting because of seasickness and is unable to retain even small amounts of water (for example, one teaspoon [five milliliters] every five minutes to 10 minutes) by mouth, a water-retention enema of nine parts fresh water to one part ocean water (administered with plastic tubing that might be included in a customized first aid kit) might have some value.

Some survival-training specialists, including Storey, consider water-retention enemas an "extreme alternative. We don't teach that as a useful technique," he said.

Jeffrey Isaac, a physician's assistant and instructor in emergency medicine and wilderness rescue, described water-retention enemas as generally useful in treating dehydration, although "I would have a pretty hard time envisioning this on a life raft."[78]

Nevertheless, he said, "There are no rules. … You need to have several different options, and an enema is one option that might work."

Some specialists say that drinking fluids other than water can be beneficial, including the blood of captured turtles, fish eyes and spinal fluid, and fluids squeezed from the bodies of fish.[79]

"Fish eyes contain fresh water; they are as sweet as grapes when you are half-crazed by thirst," Gill said. "After cleaning the flesh off any fish you've caught, snap the spine and suck out the spinal fluid; it contains fresh water, glucose and protein. You can squeeze a few drops of potable fluid out of any fish or other marine life. … Section the fish, fold it up in a cloth and squeeze the fluid out of the flesh by twisting the ends of the cloth. You also can carve holes in the side of a large fish and allow lymphatic fluid to accumulate in the holes."

Golden and Tipton said, however, that the "energy expended and body fluid lost in undertaking the work to squeeze a small amount of fluid from fish flesh can outweigh the benefits."[80]

In addition, the process of squeezing fluid from a fish may make some people queasy, Storey said.

"If they've got a strong stomach, it's OK," he said. "Otherwise, it's a last-case scenario."

In the past, at least one researcher said that people could survive by drinking limited amounts of ocean water. In 1952, Alain Bombard, a French physician, sailed an inflatable boat first across the Mediterranean Sea and then across the Atlantic Ocean to prove his theory that survivors on life rafts could — under some conditions — safely consume ocean water. Those conditions were that they begin consuming ocean water early, before they became dehydrated or thirsty; that they match their intake of ocean water with the body's maximum need for sodium chloride and, accordingly, consume only small amounts of ocean water; and that they not drink ocean water for longer than six days or seven days — enough time, Bombard calculated, for them to have developed a plan for obtaining other sources of drinkable water.[81]

In his description of the Mediterranean voyage, Bombard said:[82]

> *From 25th to 28th May, we drank seawater: for four days, in my case, and three days, in [a companion's case]. During this period, our urine was perfectly normal, and we had no sensation of thirst, but it should be remembered that it is essential not to wait for dehydration before drinking seawater. … Two days on sea perch [fish] then provided us with food and drink, but care had to be taken not to compensate too quickly for our fast. Six more days of seawater followed, bringing us to the safety limit, and then two more days of fish, without any internal complications. In other words, out of 14 days, we drank fish juice for four and seawater for 10. By interrupting the consumption of seawater, we were able to double what I considered the safety limit. …*
>
> *I noticed none of the effects normally associated with the consumption of seawater, and neither [the companion] nor I vomited or had diarrhea. On the contrary, we were subject to persistent constipation, without pain, coating of the tongue or mucus membranes or bad breath, and this lasted 12 days. However, we both suffered continuously from [flatulence].*

Nevertheless, most specialists — at the time of Bombard's journey and today — dispute his theory and strongly advise against drinking ocean water.

"People can die from drinking salt water," Bowman said. "The salt in seawater takes more fluid out of us. It's so salty that our body uses its stored fluids (in cells and fat) to make the seawater more like our body fluids. You dehydrate yourself even more by drinking seawater."

In addition, the high mineral content of seawater can lead to diarrhea and delirium.[83]

Lewis Haynes, M.D., a doctor on the *USS Indianapolis*, a U.S. Navy heavy cruiser that sank after being struck by Japanese torpedoes in the Pacific Ocean during the final days of World War II, said that drinking seawater was a major problem during the five days that the survivors spent in the water awaiting rescue.[84]

In excerpts of interviews for a book about the sinking, Haynes gave the following account:

> *You get dehydrated because you don't drink. And you're exercising and losing fluid. I remember fighting with guys to keep them from drinking salt water. It was one of my jobs: to make the group not drink. Because if you drink it, you get diarrhea — and that dehydrates you more. You get delirious, like somebody with a high fever. In the beginning, someone would drink salt water and thrash around and raise hell. The two guys holding him down would get exhausted, and they'd die, too. So you lost three men for one guy who drank salt water.*
>
> *We had hallucinations. Guys would see the ship underneath them. They'd think they could dive down and get water out of the scuttlebutt [water fountain]. They'd see it. And then you'd think you could see it.*

In the past, some survival specialists have recommended that people drink their own urine. Today, they generally agree that because of the high concentration of minerals and waste material, drinking urine will increase thirst, draw fluid from the cells and exacerbate dehydration.[85]

The digestive process increases the body's requirements for water, and specialists advise people to eat only if they are well supplied with drinking water. The body will convert stored fat and protein into glucose, allowing most people to survive for several weeks without food.

Life Raft's Movements Contribute to Seasickness

Dehydration is aggravated by seasickness (motion sickness). Symptoms include sensations of dizziness and/or falling, sweating, headache, drowsiness, weakness, increased salivation, nausea, and vomiting.

Charles Oman, Ph.D., director of the Man Vehicle Laboratory in the Center for Space Research at the Massachusetts (U.S.) Institute of Technology, who has conducted considerable research on motion sickness, said that seasickness occurs when the cerebellum (the part of the brain that controls balance), receives "inconsistent, unexpected" combinations of signals from the eyes, inner ear, muscles and joints.[86]

"The basic hypothesis is that, over a lifetime of living ashore, the 'balance brain' has learned to predict exactly what sensory signals it should receive from moment to moment each time an active body movement is made, particularly from the vestibular organs in the inner ear," Oman said. "The balance brain probably computes a 'sensory conflict' signal — the difference between actual and anticipated sensory information received. 'Sensory conflict' signals represent the unanticipated portion of sensory information and are thought to trigger corrective postural reflexes and help stabilize gaze. In everyday life ashore, sensory cues arrive in consistent, anticipated patterns, and sensory-conflict signals are small. However, when you go out on the ocean, the motion of the boat continuously disturbs your posture, increasing the level of conflict signals.

"When conflict signals increase and are sustained, signals in the 'balance brain' spill over to the 'emetic [causes vomiting] brain,' and symptoms may occur."

Seasickness can be made worse by a number of factors, including the emotional stress of a ditching; claustrophobia caused by confinement in a small, closed space, such as a life raft; noxious odors, such as those emitted by aircraft fuel, some life raft materials or other people vomiting; an inner ear injury or infection; and the unusual motions of a life raft.

Golden and Tipton said that, for most people, an inflatable life raft is a "provocative device" for inducing seasickness.

"On a large ship, with a high vantage point and open visual reference of a distant, relatively stable horizon (achieved by counterbalancing movements of the head and body), the nausea-inducing sensation from the balance organs is usually overridden," they said. "But within the confines of a raft, with its peculiar motion (it twists and turns as it rises and falls with every swell), no stable visual reference is present to counter the central input from the ears. The result is nausea and vomiting, even in habituated sailors."[87]

Oman agreed with their assessment.[88]

"Even the best-designed life rafts available today are incredibly strong seasickness-makers," Oman said. "Even experienced yachtsmen who have to get into a raft usually get queasy and often frankly sick, primarily due to the herky-jerky motion of the raft and secondarily to the lack of visual cues caused by the closed canopy."

Dag Pike, a sailor who said that he has been rescued at sea at least 10 times, said that seasickness medication is among the first items he grabs in preparing to abandon ship.[89]

Describing a 1985 incident in which he abandoned a 65-foot (20-meter) catamaran after it struck a submerged object and began taking on water during an attempted crossing of the Atlantic Ocean, Pike said, "It [having the seasickness medication] saved my sanity. From previous life raft training, I knew how bad the motion can be in a raft. When you are seasick, survival is no longer a strong instinct; you just give up."

"When you are seasick, survival is no longer a strong instinct."

Oman said that although seasickness sometimes is limited to one episode of vomiting, in other cases, especially in bad weather and rough seas, repeated episodes of vomiting and retching (dry heaves) are common.[90]

"Sufferers usually are able to respond physically to real emergencies for a day or so," Oman said. "However, if you vomit repeatedly and don't eat because you feel nauseous, eventually you will … become weak, confused and eventually incapacitated."

Russell said that, to avoid seasickness or reduce its severity, medication should be administered to everyone before symptoms have time to develop — preferably, in the airplane, before the descent to the water (Table 2, page 204). Trying to treat seasickness after it has begun is difficult because repeated vomiting will rid the body of any medication taken by mouth, he said.

Oman said that early administration of medication would be ideal, because most oral anti-seasickness medications (which typically are effective for between four hours and 12 hours) don't take effect for 30 minutes to 45 minutes after they are administered, and medication administered in transdermal patches and absorbed through the skin (typically effective for between 48 hours and 72 hours) may not be fully effective for several hours.

"But in an airplane, you don't usually have that much warning," Oman said. "Usually, you have to plan the ditching and leave the aircraft in a big hurry before it sinks and deal with the injured. Thinking about taking seasickness pills just isn't a priority at that point."

Table 2
Useful Anti-motion-sickness Drugs

Generic Name/Brand Name (Manufacturer)	Form	Duration of Action (hours)
Dimenhydrinate/Dramamine (Searle)	Tablet	4–6
	Liquid	4–6
	Injection	4–6
Dramamine (Richardson) Gravol (Horner)	Chewable	4–6
	Time-released Capsule	6
	Suppository	6
Meclizine HC1/Bonine (Leeming)	Chewable Tablet	6–12
Antivert (Roerig)	Tablet	6–12
Meclizine (Geneva)	Tablet	6–12
Cinnarizine/Stugeron (Janssen)	Tablet	6–12
Cyclizine/Marezine (Burroughs)	Capsule	4–6
	Injection	4–6
Transdermal Scopolamine/ Transderm-Scop (Novartis)	Skin Patch	48–72
Promethazine/Phenergan (Wyeth)	Tablet	6–12
	Suppository	6–12
	Injection	6–12
Promethazine and Ephedrine/ Phenergan plus Ephedrine (Wyeth)	Tablet	6–12

Source: Charles Oman, Ph.D.

Later, in the life raft, some people will adjust within 36 hours to 72 hours to the sensory conflicts that cause seasickness; others will be sick much longer.[91]

During the adjustment period, survivors may have access to seasickness medication from the life raft first aid kit — the supply might last for a day or two — and possibly from the aircraft first aid kit. Oman recommended including a variety of seasickness medications in a variety of forms — tablets to be taken orally, transdermal patches and suppositories.

"Some of the more effective drugs, such as scopolamine, have significant side effects and should only be taken if prescribed by your physician," he said. "If someone is planning a significant overwater flight where there is a risk of ditching and they are buying anti-motion-sickness drugs which might be taken … in an emergency, best to discuss ahead of time what people should take with a physician who knows their medical condition [medical history]."

In addition, because different medications work in different ways and may have different side effects, survivors should read and follow directions for their use.

Suppositories may be most effective for those with severe vomiting. In other cases, medication administered by mouth is most effective. If an individual already is seasick, he or she may benefit from trying to let seasickness medication dissolve beneath the tongue, to allow at least some of the medication to be absorbed into the body through the lining of the mouth.[92]

Other products sometimes used to treat seasickness include a watchlike device that uses electrical signals to stimulate the nerves in the wrist and thereby disrupt nausea and a wristband that administers acupressure (application of pressure to specified points on the wrist) to relieve nausea.[93,94] Some people also believe that relief can be obtained through alternatives such as drinking ginger ale or eating a small amount of crystallized ginger or ginger cookies, because of ginger's effectiveness in soothing upset stomachs; applying specific herbal oils behind the ears to calm the inner ear; tightening a belt around the waist to relieve nausea; wearing a patch over one eye to decrease signals being received by the brain; or drinking lemonade or lemon juice. Others are skeptical about the effectiveness of some or all measures that do not involve traditional medication; in addition, some nontraditional items probably have not been tested in a life raft and/or will not be available on a life raft.[95]

Oman said that several techniques may help relieve symptoms, including avoiding reading and other tasks that require focusing the eyes on an object on the life raft and, if possible, sitting upright and keeping the upper body balanced over the hips as the raft moves.

"Open the canopy if conditions permit, so you can see out, and ventilation improves," Oman said. "Some canopies on the better rafts afford a relatively wide view, which probably helps. Sleep when you can — you are less susceptible while asleep.

"Having a strategy for treating chronic sickness is also important. Suppositories or [transdermal patches] can help here. If someone vomits repeatedly, keep them sipping fluids, even though they don't want to. If they don't replace the water, electrolytes and glucose they lose, in 12 to 24 hours, they'll hit the wall, become listless and unresponsive. Some say that in World War II, chronic vomiting was one of the real killers in life rafts."

Oman also recommended having an ample supply of seasickness bags to "help the afflicted contain things without having to hang their heads overboard, which can be dangerous. And it keeps the smells under control."

Russell said that, generally, if one person in a life raft becomes seasick, others also become ill.

"Almost everybody gets sick," Russell said. "If one person pukes [vomits], everybody's going to puke. You've got to take the anti-seasickness medicine immediately, preferably before the aircraft is ditched."

Marine Bacteria Can Infect Skin, Digestive System, Sinuses

Ocean water contains several types of bacteria that can cause serious infections. Of these, the most dangerous is *Vibrio vulnificus,* one of a number of forms of *Vibrio* bacteria found in shallow waters and estuaries in temperate waters worldwide. The bacteria also are found in contaminated shellfish and in the mouths of sharks.[96]

Vibrio vulnificus and some other forms of *Vibrio* can cause serious infections in any wound that is exposed to ocean water — even in superficial cuts — and in people who eat contaminated seafood. (People who eat raw oysters are especially at risk.)[97]

Vibrio vulnificus infections of wounds can lead to ulceration of the skin. The bacteria can cause cellulitis, an infection in the skin and in tissues just beneath the skin, can destroy body tissues and can spread into the bloodstream and into muscles. People with weakened immune systems, especially those with chronic liver disease, are at an increased risk of having the infection spread into the blood and of developing potentially fatal complications. About 50 percent of *Vibrio vulnificus* blood infections are fatal.

Symptoms of *Vibrio* skin infections include redness, swelling and the appearance of bloody blisters.[98,99]

Treatment includes cleaning cuts and other small wounds with an antiseptic solution and applying antibiotic ointment, if these items are included in the life raft first aid kit; otherwise, wounds may be washed with nonpotable fresh water. (Ocean water can be used for quickly rinsing wounds but — because of the presence of *Vibrio* and other bacteria — not for a more thorough cleansing involving rubbing or soaking.) Larger wounds also should be cleaned with antiseptic solution and all foreign particles should be removed; administering antibiotics, which usually are not included in a standard life raft first aid kit, is advisable. Without them, and without other advanced medical care, *Vibrio vulnificus* infections within deep wounds are considered life threatening.

Gastrointestinal infections caused by *Vibrio vulnificus* and some other forms of *Vibrio* can cause vomiting, diarrhea and abdominal pain in healthy people; in those with weakened immune systems, the infections can spread to the blood and can cause fever, chills, decreased blood pressure and skin lesions.

Vibrio also can cause ear infections and sinus infections.

One recent victim of *Vibrio vulnificus* was retired U.S. Air Force Gen. Charles McDonald, who contracted an infection during a sailing trip off the Florida coast in the Gulf of Mexico in 2002. McDonald received scratches and minor cuts on his legs while transporting an anchor and anchor chain in a dinghy to his sailboat. Later, when the line connecting the dinghy and his sailboat broke, he swam out to retrieve the dinghy, spending about an hour in the warm water.[100]

His experience was described in a letter to the editor of the Seven Seas Cruising Association *Commodores' Bulletin*:[101]

> *The following day, [McDonald and his wife] noticed swelling in his feet and legs. His wife noticed black lines moving up his legs. Sores started developing on his legs, chest and forearms. He was vomiting and getting very weak. Fortunately, they had a cell phone and called 911 for a rescue. …*
>
> *At the hospital, a sore on his chest had to be lanced. He was put on antibiotics. … His normal weight of 172 [pounds; 78 kilograms] had ballooned to over 200 pounds [91 kilograms] from the severe infectious fluid buildup. The general's situation went from bad to worse as the doctor was forced to amputate both of his legs above the knees.*
>
> *His doctor said of the five cases [of Vibrio vulnificus] he had treated, General McDonald was the only survivor. The general's case was made worse by the fact that he had a preexisting liver condition.*

Two other types of bacteria — *Mycobacterium marinum* and *Erysipelothrix rhysopathiae* — cause skin infections that, with time, usually heal without treatment.[102]

Mycobacterium usually enters the body through a cut or puncture wound and infects skin on the hands and feet, and often causes cellulitis in the surrounding skin. The infection, which may become apparent as long as three weeks to four weeks after exposure to the bacteria, may spread to nearby bones and joints.

Symptoms include the formation of red nodules on the skin and peeling skin.

If the infection is correctly identified in its early stages, it can be treated with antibiotics that probably will not be included in the life raft first aid kit. Without treatment, the nodules heal in about two years to three years.

Erysipelothrix bacteria usually enter the body through cuts and puncture wounds on the hands. Within several days, the area of the infection becomes painful, itchy, purple and swollen, and fills with pus; the area is surrounded by an infection-free area and another ring of red or purple skin. A fever also may develop.

Without treatment, the infection heals in one week to three weeks.

Saltwater boils, pustules or skin ulcers may form on the skin at pressure-points on the body, such as in areas where clothing rubs against the skin. Healing is difficult on a life raft, where the environment is damp and salty, but keeping the wounded area as dry as possible and elevated may help.[103]

Survivors who spend long periods of time in the water, including those who sit in puddles of water on a life raft that is not kept dry, develop swollen, puffy skin. Survivors who leave a life raft to cool off in ocean waters are at risk of being bitten by some of the small fish that typically gather in the shade beneath life rafts; the bites can become infected and ulcerated.

In the aftermath of some water-contact accidents, survivors may swallow or inhale fuel that has leaked from the aircraft's fuel tanks into the water; fuel also may irritate the skin and cause an inflammation of the eyes that may persist for several days. Any available cloths or paper towels should be used to gently wipe off the fuel from around the mouth, nose and eyes, and the eyes should be rinsed with sterile eyewash that may be included in the life raft first aid kit. (Rinsing the eyes with ocean water would further irritate the eyes.) If bath soap is available, the area also may be washed.[104]

Small amounts of fuel are not toxic but may cause vomiting if swallowed or aspiration pneumonia if inhaled.

"First aid for occupants of a life raft … is limited."

Body's 'Fight or Flight' Defense May Influence Responses

The hormone epinephrine (adrenaline), which is secreted by the adrenal glands in response to sudden stressful or frightening situations, and other hormones known as catecholamines may aid in the body's physical response to some aspects of a survival situation, such as exiting a sinking aircraft, boarding a life raft or fighting off the effects of hypothermia.[105]

These hormones help the body prepare for whatever is to come — the so-called fight-or-flight syndrome — by causing the heart to beat harder and faster, breathing to quicken and the digestive system to slow its activity to allow blood to be sent from the digestive system to the muscles. Epinephrine also causes a reduction in perception of pain.[106,107]

Nevertheless, the secretion of epinephrine that follows sudden immersion in cold water sometimes results in abnormal heart rhythms. In addition, an individual who feels a sense of relief after realizing that rescue is imminent may experience a reduction in secretion of catecholamines and an end to their protective effect.[109]

Although catecholamine secretions may enhance an individual's performance in stressful survival situations, their physical and mental capacities may at the same time be diminished by physical injuries, fatigue, shock and use of alcohol or drugs, including some prescription medications.

First Aid Kits Often Include Only Basic Items

Because medical supplies in a life raft are limited, first aid for occupants of a life raft also is limited.

Regulations are vague about which items should be included in life raft first aid kits and in what quantities. For example, Part 135 ("Commuter and On-demand Operations") says, "Some of the items which could be included in the survival kit are triangular cloths, bandages, eye ointments, water disinfection tablets, sun-protection balsam, heat retention foils, burning glass, seasickness tablets, ammonia inhalants [and] packets with plaster."[109]

Typical life raft first aid kits include small quantities of these items and may also include compresses; antibiotic ointment; pain-relief medication such as aspirin, ibuprofen or acetaminophen; gloves made of latex or a similar material; space blankets; and a small first aid book. Some kits also include eyewash, a splint or a tourniquet.

If, while evacuating an aircraft, a designated person retrieves the aircraft first aid kit, survivors on the life raft will have access to additional supplies. For example, Part 135 aircraft with more than 19 passenger seats are required to be equipped with first aid kits that contain "at least the following appropriately maintained contents in the specified quantities:" 16 one-inch (2.5-centimeter) adhesive bandage compressors, 20 antiseptic swabs, 10 ammonia inhalants, eight four-inch (10-centimeter) bandage compresses, five 40-inch (102-centimeter) triangular bandage compresses, one noninflatable arm splint, one noninflatable leg splint, four four-inch roller bandages, two one-inch standard rolls of adhesive tape, one pair of bandage scissors and one pair of protective nonpermeable gloves or their equivalent.[110]

Joan Sullivan Garrett, president of MedAire, which supplies first aid and medical kits for aircraft built by several manufacturers, said that aircraft crewmembers should be aware of the location of the aircraft first aid kit in relation to the exit and should ensure that someone in the aircraft is responsible for transferring the kit to the life raft.[111] The materials in the aircraft first aid kit would greatly enhance those in the life raft kit, Garrett said.

Aircraft first aid kits are packed in water-resistant cases to ensure that crewmembers and passengers "will have the kinds of things that they're likely to need most in case of an accident or ditching," Garrett said. "It's kind of a first-response kit."

MedAire's aircraft first aid kits include a number of items not required by Part 135: a CPR mask, non-latex examining gloves, a manual suction device, eyewash, a chemical "cold pack" containing substances that become cold when the pack is squeezed,[112] tablets to relieve digestive disorders, antihistamine for treating allergic reactions and sometimes for aiding sleep, a stethoscope, a blood-pressure cuff, a digital thermometer and tweezers.[113]

The first aid kits can be modified to include additional items requested by the aircraft operator — such as prescription medication and extra pairs of prescription eyeglasses for regular passengers. One item often added by request to MedAire first aid kits is nitroglycerin, which is used to treat or prevent angina (chest pain) that occurs with heart disease, Garrett said.

"A bottle of vitamins is the least of your worries."

One item usually not recommended or requested for inclusion in first aid kits is vitamins because, Bowman said, "a bottle of vitamins is the least of your worries."

Survival-training specialists said that some of the items in the aircraft kits are those that they would recommend adding to the supplies in a life raft first aid kit, such as required prescription medications; additional eyeglasses or contact lenses; ciprofloxacin, a powerful oral antibiotic often prescribed for a variety of infections; and elastic stretch (compression) bandages for applying pressure to wounds.

"A good first aid kit increases your chances of survival," Storey said. "Without having anything, you just have to depend on luck."

Nevertheless, the most important element of first aid on a life raft is enough medical knowledge to be prepared for the situation, he said.

Although aircraft crewmembers — flight crews and cabin crews alike — might receive training on how to use the materials included in aircraft first aid kits, that training likely is not comprehensive, and developing plans on how to cope with every eventuality would be impossible. Instead, crewmembers and other survivors must do what they can to respond to life-threatening problems.

Bowman said that the most immediate medical concern would be stopping all obvious bleeding by covering the wound with any available piece of material or a hand to apply direct pressure to the wound and — if possible — by elevating the area of the injury.

Next, broken bones should be splinted as soon as it becomes practical to do so, Bowman said.

Although some illnesses — dehydration, sunburn and seasickness, for example — are likely to occur on a life raft, almost any illness or injury that occurs on land also can occur on a life raft. Specialists said that, in those situations, their best advice would be for survivors to cope in the best way they could within the limitations of their medical supplies and medical knowledge.

Kasman said that a guiding principle for people in this situation is "you should do what's within your ability and knowledge to help."

If someone on the life raft has a condition that requires more treatment than is available on the life raft, "you just administer comfort and care in any capacity you can," she said. "For everybody, that's different: Hold them, talk, write down their last words. One of the things people are most afraid of about dying is dying alone. Sometimes it's pain, but most of the time, it's being alone. Hence, administering care is potent and significant."

Survivors of ditchings and other water-contact accidents must cope with a number of potentially life-threatening medical challenges. Their success depends in large part on how well they have prepared for the situation and how resourceful they can be in using medical equipment on the life raft and the knowledge of those on board. ■

The bottom line, in our opinion ...

- **No refills on a life raft; secure prescription drugs or over-the-counter medication against water damage or loss.**
- **Ensure that the aircraft first aid kit is taken aboard the life raft.**
- **Survivors must do the best they can with the supplies and skills they have.**
- **Sometimes, nothing can be done to save a person's life.**

Notes

1. A ditching is defined as a deliberate emergency landing on water.
2. Storey, Roger. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S., July 10, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
3. Golden, Frank; Tipton, Michael. *Essentials of Sea Survival*. Champaign, Illinois, U.S.: Human Kinetics. 2002.

   For most healthy people, sudden immersion in warm water (water nearly the same as the normal body temperature) presents no risk. For people with heart ailments, however, the slight increase in pressure against the body that occurs with immersion increases the volume of blood pumped by the heart, reduces air space in the lungs and makes breathing more difficult.
4. Gill, Paul G. Jr. *The Onboard Medical Handbook: First Aid and Emergency Medicine Afloat.* Camden, Maine, U.S.: International Marine, 1997.
5. Golden, Tipton.
6. Transport Canada. *Survival in Cold Waters: Staying Alive.* TP13822E. Ottawa, Ontario, Canada, 2003.
7. Gill.
8. Ibid.
9. Golden, Tipton.
10. The name of the airport was changed in 1998 to Ronald Reagan Washington (D.C., U.S.) National Airport.
11. U.S. National Transportation Safety Board (NTSB). *Aircraft Accident Report: Air Florida Inc. Boeing 737-222, N62AF, Collision With 14th Street Bridge, Near Washington National Airport, Washington, D.C., January 13, 1982.* NTSB-AAR-82-8. The airplane was destroyed; and 69 of the 74 people in the airplane and four people on the ground were killed. One of the airplane passengers, who received minor injuries when the airplane struck the bridge and the river, drowned after he repeatedly passed the helicopter's rescue rope to others in the water.

    The report said that the probable cause of the accident was the flight crew's "failure to use engine anti-ice during ground operation and takeoff, their decision to take off with snow/ice on the airfoil surfaces of the aircraft, and the captain's failure to reject the takeoff during the early stage when his attention was called to anomalous engine instrument readings." Contributing factors were "the prolonged ground delay between deicing and the receipt of ATC [air traffic control] takeoff clearance, during which the airplane was exposed to continual precipitation, the known inherent pitch-up characteristics of the B-737 aircraft when the leading edge is contaminated with even small amounts of snow or ice, and the limited experience of the flight crew in jet transport winter operations."
12. Duncan, Kelly. Duncan was interviewed in "Accidents and Incidents," a videotape written and produced by Ken Clagett, Video Support Services, Eastern Airlines, for flight

attendant training by Eastern Airlines Inflight Services. The date of production (in the early 1980s) was not available.

13. Moore, Kelly [Duncan], as told to Beverly, Joy. "Twice Rescued: Why Had I Survived the Crash of Air Florida Flight 90?" *Today's Christian Woman.* January–February 1999.

14. "Nine Drown in Icy Potomac in Marine Training Exercise." *The Washington Post.* March 8, 1968.

15. American Canoe Association. *Off-season Boating, Cold Shock and Hypothermia.* <www.enter.net/~skimmer/coldwater.html>. April 3, 2003.

16. U.K. Civil Aviation Authority (CAA). *General Aviation Safety Sense: Ditching* (Leaflet 21A). 2000.

17. Golden, Tipton.

18. Fenner, Peter. E-mail correspondence with Werfelman, Linda. Alexandria, Virginia, U.S. July 4, 2003; July 9, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

19. Cheng, David. *Drowning.* <www.emedicine.com/aaem/topic166.htm>. July 2, 2003.

20. Ibid.

21. Ibid.

22. Golden, Tipton.

23. Gill.

24. Bowman, J. Russell. Telephone interview and e-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., July 3, 2003; Sept. 9, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

25. Golden, Tipton.

26. Ibid.

27. Ibid.

28. Berkow, Robert (editor). "Near Drowning." *Merck Manual of Medical Information — Home Edition.* Section 24, Chapter 283. Whitehouse Station, New Jersey, U.S.: Merck Research Laboratories. 1997.

29. Craighead, Frank C.; Craighead, John J.; Smith, Ray E.; Jarvis, D. Shiras. *How to Survive on Land and Sea.* Annapolis, Maryland, U.S.: Naval Institute Press, 1984.

30. Kasman, Deborah. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S., Aug. 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

31. U.K. CAA.

32. Gill.

33. U.S. Coast Guard. *Cold Water Survival.* <www.uscg.mil/hq/gm/mse4/pfdcold.htm>. April 3, 2003.

34. Tipton, Michael; Eglin, Clare; Gennser, Mikael; Golden, Frank. "Immersion Deaths and Deterioration in Swimming Performance in Cold Water." *The Lancet* Volume 354 (Aug. 21, 1999): 626–629.

35. U.S. National Weather Service Office of Climate, Water and Weather Services. *Wind Chill Terms and Definitions.* <www.nws.noaa.gov/om/windchill/windchillglossary.shtml>. Sept. 8, 2003.

36. Auerbach, Paul S. *Medicine for the Outdoors.* Guilford, Connecticut, U.S.: The Lyons Press, 2003.

37. Golden, Tipton.

38. Ibid.

The storm, which included winds of 60 knots to 70 knots, caused the abandonment of 19 yachts, 14 of which later were recovered. Rescuers picked up 136 race participants. Of the 15 people who died, three died during rescue and seven died after they had safely boarded their life rafts.

39. Gill.

40. Golden, Tipton.

41. *Honolulu* (Hawaii, U.S.) *Star-Bulletin.* "Big Surf Keeps Rescuers Busy." <http://starbulletin.com/2003/06/19/news/story1.html>. Sept. 10, 2003.

42. U.S. National Oceanographic Data Center. *Hawaiian Island Coast: Water Temperatures in Degrees Fahrenheit.* <www.nodc.noaa.gov/dsdt/cwtg/hawaii.html>. Sept. 10, 2003.

43. Search and Rescue Society of British Columbia. *Hypothermia — Physiology, Signs, Symptoms and Treatment Considerations.* <www.sarbc.org/hypo1.html>. Aug. 8, 2003.

44. Golden, Tipton.

45. Ibid.

46. MayoClinic.com. *What Is Hypothermia?* <www.mayoclinic.com>. April 4, 2003.

47. Ibid.

Hospitals administer varying treatments for hypothermia, including intravenous delivery of warm fluids and hemodialysis, in which an artificial kidney is used to filter the blood, thereby removing extra fluids, chemicals and wastes from the blood.

48. *Land/Shark Instant Survival Shelter.* <www.land-shark.com>. Oct. 8, 2003.

49. Auerbach.

50. U.K. CAA.

51. Golden, Tipton.

52. Russell, Paul D. Interviews by Werfelman, Linda. Hollywood, Florida, U.S., April 22, 2003, and Alexandria, Virginia, U.S., May 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

Russell is a maritime safety specialist and accident investigator, and a retired U.S. Coast Guard captain with more than 5,000 flight hours in fixed-wing and rotary-wing aircraft. In the U.S. Coast Guard, Russell conducted more than 200 water landings and served in various positions, including commander of two air stations, chief of the Aviation Training Center Training Division and chief of search-and-rescue operations in the Northwest Region, before retiring in 1984 with the rank of captain. He is chief engineer, aviation system safety, Boeing Commercial Airplanes, and a maritime safety and accident investigator for Safety Services International.

53. Golden, Tipton.

54. Ibid.

55. United Nations World Health Organization (WHO). "Medical Care of Castaways and Rescued Persons." *International Medical Guide for Ships.* Chapter 12. Geneva, Switzerland: WHO, 1988.

56. Berkow. "Cold Injuries." *Merck Manual of Medical Information — Home Edition.* Section 24, Chapter 281.

57. Aquatic Network. *Howard Blackburn: Fisherman Hero.* <www.aquanet.com/features/blackburn/blackburn1.htm>. March 9, 2004.

58. WHO.

59. Berkow. "Cold Injuries."

60. WHO.

61. Golden, Tipton.

62. Berkow. "Heat Disorders." *Merck Manual of Medical Information — Home Edition.* Section 24, Chapter 280.

63. Golden, Tipton.

64. Tilton, Buck. *Destination Outdoors: Sun Care.* <www.destinationoutdoors.com/textarticles/suntext.html>. Sept. 8, 2003.

65. Golden, Tipton.

66. Burton, Ken. Interview by Werfelman, Linda. Hollywood, Florida, U.S., April 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

67. Rash, Clarence E.; Manning, Sharon D. "For Pilots, Sunglasses Are Essential in Vision Protection." *Human Factors & Aviation Medicine* Volume 49 (July–August 2002).

68. Golden, Tipton.

69. FSF Editorial Staff. "Dehydration Presents Unique Risks for Pilots." *Human Factors & Aviation Medicine* Volume 48 (July–August 2001).

    Excessive loss of water from the body also can result from fevers, use of diuretics (substances that increase the production and excretion of urine) and diseases such as diabetes.

70. Golden, Tipton.

71. FSF Editorial Staff.

72. Smith, Ray E. Telephone interview and e-mail communications with Werfelman, Linda. Alexandria, Virginia, U.S., April 18, 2003; June 17, 2003; June 23, 2003; Flight Safety Foundation, Alexandria, Virginia, U.S.

73. Russell.

74. Craighead et al. "Preparedness and Priorities." Chapter 11. *How to Survive on Land and Sea.*

75. Robertson, Dougal. *Survive the Savage Sea.* New York, New York, U.S.: Praeger Publishers, 1973.

76. Binder, H.J.; Sandle, G.I.; Rajendian, V.M. Chapter 7, *The Large Intestine: Physiology, Pathophysiology and Disease.* (S.F. Phillips et al., editors). New York, New York, U.S.: Raven Press, 1991.

77. Billich, C.O.; Levitan, R. "Effects of Sodium Concentration and Osmolality on Water and Electrolyte Absorption from the Intact Human Colon." *Journal of Clinical Investigation* Volume 48 (1969): 1336–1347.

78. Isaac, Jeffrey. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S., Oct. 23, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

79. Gill.

80. Golden, Tipton.

81. Robin, Bernard. *Survival at Sea.* Camden, Maine, U.S.: International Marine Publishing Co., 1981.

82. Ibid.

83. Gill.

84. Haynes, Lewis. *In Conversation With Doug Stanton and Survivors of the USS Indianapolis.* <www.ussindianapolisinharmsway.com/qa.htm>. June 10, 2003.

    Stanton is the author of *In Harm's Way: The Sinking of the USS Indianapolis and the Extraordinary Story of Its Survivors.* The "conversation" is on an Internet site maintained by the book's publisher, Henry Holt and Company, New York, New York, U.S.

85. Smith.

86. Oman, Chuck. "Offshore Health: In Search of a Cure for Seasickness." *Cruising World.* December 1991.

87. Golden, Tipton.

88. Oman, Charles. E-mail correspondence with Werfelman, Linda. Alexandria, Virginia, U.S. Oct. 7, 2003; Oct. 15, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

89. Goddard, JoAnn W. "In Depth: Feeling Seasick? You're Not Alone." *Soundings* Volume 41 (September 2003).

90. Oman. "Offshore Health: In Search of a Cure for Seasickness."

91. Jacobs, Michael. "Seasickness." *Wilderness Medicine Letter.* Volume 19 (Summer 2002).

92. Golden, Tipton.

93. *ReliefBand Device.* <www.reliefband.com>. Sept. 25, 2003.

94. *Sea-Band.* <www.sea-band.com>. Sept. 25, 2003.

95. Goddard, JoAnn W. "Remedies: The Tried and the Truly Odd." *Soundings* Volume 41 (September 2003).

96. Gill.

97. U.S. Centers for Disease Control and Prevention (CDC). *Vibrio vulnificus.* <www.cdc.gov/ncidod/dbmd/diseaseinfo/vibriovulnificus_g.htm>. Oct. 8, 2003.

98. Ibid.

99. Gill.

100. Pope, Charlie; Pope, Chris. Letter to Seven Seas Cruising Association *Commodores' Bulletin.* August 2002.

101. Ibid.

102. Gill.

103. Golden, Tipton.

104. Ibid.

105. Ibid.

106. Berkow. "Anatomy." *Merck Manual of Medical Information — Home Edition.* Section 1, Chapter 1.

107. Panzarino, Peter J. Jr. *Diseases and Conditions: Stress.* University of Miami School of Medicine Glossary. <www.med.miami.edu/patients/glossary/art.asp?print=yes&ArticleKey=488>. Sept. 15, 2003.

108. Golden, Tipton.

109. U.S. Federal Aviation Administration (FAA). Advisory Circular 120-47. June 12, 1987.

110. FAA. U.S. Federal Aviation Regulations Part 135, "Commuter and On-demand Operations," 135.177, "Emergency Equipment Requirements for Aircraft Having a Passenger Seating Configuration of More Than 19 Passengers."

111. Garrett, Joan Sullivan. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S. Sept. 9, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

112. A chemical "cold pack" contains substances — often water and the chemical ammonium nitrate — which are packed in separate compartments but which mix together when the pack is squeezed. The chemical process that occurs when the ammonium nitrate mixes with the water is an endothermic process — a process that absorbs heat (becomes cold).

113. MedAire. *Aircraft First Aid Kit Contents.*

What's Eating You? It's Probably Not a Shark

Encounters with sharks are dramatic, widely publicized and frightening. Nevertheless, the dangers from sharks and other predators rank low on the scale of threats to survivors of water-contact accidents, compared with more common risks such as hypothermia and dehydration.

— FSF EDITORIAL STAFF

Although sharks, jellyfish and other ocean fish and mollusks can harm humans by biting or by injecting toxic venom through spines or tentacles, serious injuries from encounters with most of these creatures are relatively rare.

For survivors of an aircraft ditching or other water-contact accident, sharks and other ocean creatures "are really of no concern at all" — as long as the survivors are in a life raft, said George Burgess, director of the International Shark Attack File (ISAF), which investigates reports of shark-human interactions and maintains records of sharks that have bitten humans worldwide dating from the mid-1500s.[1]

"Food, water, communication with whoever's going to save you — not to mention the health and safety of people on the raft — would all be of greater concern than a shark attack," Burgess said. "The shark would be at the bottom of the page, as a footnote."

Steven Webster, senior marine biologist at the Monterey Bay Aquarium in Monterey, California, U.S., agreed.

"The most likely thing to happen, so far as marine animals are concerned, is nothing," Webster said.[2] Webster said that, for example, in the mid-Atlantic Ocean, days might pass without encountering any marine animals, while in tropical waters near northern Australia, especially near shore, encounters would be more likely, especially with jellyfish or a Portuguese man-of-war.

Without a life raft, however, the situation might be different, Burgess and Webster said.

"Once you're in the water, there is concern," Burgess said. "Sharks can, and occasionally do,

Sharks are attracted by shiny jewelry that resembles the sheen of fish scales and by bright colors, including the "yum-yum yellow" of life vests.

Specialists say that three fatal shark attacks were reported worldwide in 2002.

damage human beings. Humans can be attractive targets, especially if they're bleeding."

Nevertheless, even an injured person in the ocean without a life raft should be "far more concerned about drinking water, exposure and any injuries than about a shark attack," Burgess said.

ISAF said that shark bites are a "potential danger that must be acknowledged by anyone that frequents marine waters, but it should be kept in perspective." (Although most sharks live in oceans, some species live in fresh water, or spend some of their time there.)

For example, Burgess said, every year, 15 times more people are killed when they are hit by falling coconuts than are killed by sharks.[3]

In addition, ISAF said, "Bees, wasps and snakes are responsible for far more fatalities each year. In the United States [with a population of more than 280 million], the annual risk of death from lightning is 30 times greater than that from shark bites. For most people, any shark-human interaction is likely to occur while swimming or surfing in near-shore waters. From a statistical standpoint, the chances of dying in this area are markedly higher from many other causes (such as drowning and cardiac arrest) than from shark bites. Many more people are injured and killed on land while driving to and from the beach than by sharks in the water. Shark-bite trauma is also less common than such beach-related injuries as spinal damage, dehydration, jellyfish [stings] and stingray stings, and sunburn. Indeed, many more sutures are expended on seashell lacerations of the feet than on shark bites."[4]

Although any shark longer than about seven feet (two meters) should be considered a potential threat to humans, the largest of all species of sharks — the whale shark, which can grow as long as 66 feet (20 meters) and can weigh as much as 90,000 pounds (40,824 kilograms)[5] — has been cited in only two reports. Of the approximately 350 species of sharks found in the world's oceans — and occasionally in fresh water — ISAF data show that about 40 species have bitten humans. Of those 40 species, the great white shark has been cited far more often than all others, followed by the tiger shark and the bull shark.[6]

ISAF data show that in most years, there are between 70 and 100 instances worldwide in which sharks bite humans and that those bites result in between five and 15 deaths.

In 2002, ISAF investigated 86 reports of shark bites that resulted in three deaths.[7] Of the 86 reports, 60 were classified as unprovoked incidents in which "an attack on a live human by a shark occurs in [the shark's] natural habitat without human provocation of the shark." Fourteen of the 86 reports were classified as provoked incidents in which "a human initiated physical contact with a shark, e.g., a diver [is bitten] after grabbing a shark or a fisher [is bitten] while removing a shark from a net." Three reports involved sharks biting marine vessels, and three reports were determined not to have been shark bites; six reports included insufficient information to determine whether a shark bite actually occurred.[8]

About 80 percent of the 60 unprovoked bites occurred in North America, mostly in U.S. waters off the coast of Florida; the remaining unprovoked bites occurred in Australia, Brazil, Costa Rica and South Africa.

In a typical year, most bites occur in waters near the shore, either between a sandbar and the shore; between two sandbars, where sharks often feed and where they sometimes become trapped at low tide; or in areas with steep drop-offs, which also are the sharks' feeding grounds.

Unprovoked shark bites are grouped into three categories:[9]

- "Hit-and-run" bites, in which the shark bites a human while apparently perceiving that the human is one of the shark's customary food sources — for example, a seal. These bites usually occur in the surf in turbulent water conditions that include poor visibility for the shark. ISAF specialists say that the shark probably recognizes immediately upon biting that the human is not the food it was seeking, and then releases the human and does not return;

- "Bump-and-bite" bites, in which the shark circles and bumps its victim before biting. These bites usually occur in deeper water and may involve repeated bites and/or sustained bites, and severe injuries; and,

- "Sneak" bites, which occur without warning. These bites, like bump-and-bite bites, usually occur in deeper water and may involve repeated bites and/or sustained bites, and severe injuries.

Bites involving survivors of aircraft accidents and marine-vessel accidents typically are either bump-and-bite bites or sneak bites, which ISAF said are — unlike hit-and-run bites — a result of "feeding or antagonistic behaviors" by the shark.

Sharks Attracted by Some Aircraft, Ship Disasters

Sharks show apparent curiosity about unusual sounds and unusual activities in the water — such as the commotion of an aircraft impacting the water. Their acute senses of hearing and smell, their sometimes-excellent eyesight (although some species of sharks do not see as well as others) and their electro-sensory system, which enables them to detect the weak bioelectric currents generated by living things, help them locate their prey and other objects of interest.[10]

"You can count on sharks making an appearance after a disaster," Burgess said. "They won't all be there to eat you. Some will come just to look around."

Ray E. Smith, a U.S. Navy survival-training specialist, said, "Historically, if there's been a major aircraft crash and there's lots of activity in the water … sharks are attracted."[11]

A study of 2,500 accounts by military airmen of their survival at sea after bailing out or ditching during the 1940s and early 1950s found that only 38 accounts mentioned any type of contact — including visual contact — with sharks; 12 of those 38 contacts resulted in injury or death.[12]

Nevertheless, George Albert Llano, Ph.D., author of a report on the study, said, "As these figures are based only on the accounts of survivors, they can be misleading. When sharks are successful, they leave no evidence, and the number of missing airmen who may have succumbed to them cannot be estimated."

One of the accounts included in Llano's study was that of an Ecuadorian flight officer who — with two companions — ditched an aircraft in the Pacific Ocean off the coast of Ecuador. All three men removed their clothes before donning life vests and entering the water. (Removing clothing was once a common recommendation.) After the first of his colleagues died, about five hours after the ditching, the flight officer pushed the floating corpse ahead of him in the hope of "taking it out [for burial on land] if we managed to reach land." Instead, the flight officer said, "a strange force dragged the body, and I did not see it again."

After his second colleague died, the flight officer again tried to push the corpse ahead of him. The following is his description of what happened next:[13]

> *As it was a [moonlit] night and during some moments very clear, I was able to observe that strange figures crossed very close to us, until at a given moment, I felt that they were trying to take away the corpse, pulling it by the feet, on account of which I clutched desperately the body of my companion, and together with him, we slid until the tension disappeared. …*
>
> *Once refloated, with despair I touched his legs and became aware that a part of them was lacking … and continued swimming with the now-mutilated corpse until the attack was repeated two times more and then, terrorized at feeling the contact of fish against my body, turned loose the corpse, convinced that I would be the next victim. … As soon as it was light, I could see the coast at a great distance, but I had no hopes of reaching it because with the light*

Sharks show apparent curiosity about unusual sounds and unusual activities in the water.

"One by one, sharks began to pick off the men ..."

of day, I could clearly see that various sharks were following me. … When I moved my legs slowly, with the object of resting, I touched with my feet the bodies of these animals, which were constantly below mine in order to attack me. I would then thrash the water, and thus for a few moments, the danger would pass. I continued swimming all day Friday until at sundown, I found myself some four [hundred meters] or 500 meters [1,312 feet or 1,641 feet] from the rock on the coast, and as I was already tired … because of the undertow which existed, I could not reach the rocks until after making a superhuman effort.

In another incident, the pilot of a U.S. Navy Grumman S2N Tracker encountered sharks after an engine failure forced him to ditch the airplane over the Pacific Ocean. He lost consciousness during the impact, and his radioman pulled him from the airplane and put on the pilot's life vest. The two men tied themselves together with dye marker cords.

The following is the pilot's description of what happened during the 16 hours before his rescue:[14]

It was within a very short time (about one-half hour) when sharks were quite apparent swimming around us. … An hour later, we heard aircraft, and I said … 'Let's kick and splash around to see if we [can] attract their attention.' It failed, but suddenly [the radioman] said he felt something strike his right foot and that it hurt. I told him to get on my back and keep his right foot out of the water, but before he could, the sharks struck again, and we were both jerked under water for a second. I knew that we were in for it, as there were more than five sharks around and blood all around us. He showed me his leg, and not only did he have bites all over his right leg, but his left thigh was badly mauled. He wasn't in any particular pain, except every time they struck, I knew it and felt the jerk. I finally grabbed my binoculars and started swinging them at the passing sharks. It was a matter of seconds when they struck again. We both went under, and this time I found myself separated from [the radioman]. I also was the recipient of a wallop across the cheekbone by one of the flying tails of a shark. From that moment on, I watched [the radioman] bob about from the attacks. His head was under water, and his body jerked as the sharks struck it. As I drifted away … sharks continually swam about, and every now and then, I could feel one with my foot. At midnight, I sighted a … boat and was rescued after calling for help.

Perhaps the most notorious shark-bite incidents involved survivors of the *USS Indianapolis*, a U.S. Navy heavy cruiser that was struck by Japanese torpedoes in the Pacific Ocean during the final days of World War II. Of the 1,197 people on the *USS Indianapolis*, about 880 survived the sinking just after midnight July 30, 1945. Of the 880 survivors, many were seriously injured. Five days later, when rescuers arrived, only 317 men were still alive.[15] Two hundred men are believed to have been killed by sharks.[16]

Patrick J. Finneran, former executive director of the *USS Indianapolis* CA-35 Survivors Memorial Organization, wrote in his history of the ship that sharks began appearing at daylight, several hours after the ship sank, among the hundreds of men who were in the water wearing life vests — or sharing life vests with others:

One by one, sharks began to pick off the men on the outer perimeter of the clustered groups. Agonizing screams filled the air day and night. Blood mixed with the fuel oil [that had entered the water from the ship's fuel tanks]. The survivors say the sharks were always there by the hundreds — swimming just below their dangling feet. It was a terror-filled ordeal — never knowing if you'd be the next victim.[17]

Woody Eugene James, a coxswain on the USS Indianapolis who was in the water without a life vest after giving his life vest to an officer, said years later that the sharks had numbered in the hundreds.[18]

"You'd hear guys scream, especially late in the afternoon," James said. "Seemed like the sharks were the worst late in the afternoon, [worse] than they were during the day. Then they fed at night, too. Everything would be quiet, and then you'd hear somebody scream, and you knew a shark had got him."

Capt. Charles B. McVay III, commanding officer of the *USS Indianapolis*, who was on one of the ship's few life rafts (most of the rafts sank along with the ship), described a different experience with a shark:

> *We had a shark that adopted us. … We couldn't get rid of him. [Some sailors] were scared to death of this shark because he kept swimming underneath the raft. You could see his big dorsal fin, and it was white, almost as white as a sheet of paper; apparently (the shark) spent most of his time on the surface, and this fin had bleached out, so he didn't blend in with the water at all. …*
>
> *We were trying to get some fish to use as bait. … Every time we caught a little one and used that for bait, the shark got it before we could get any other fish.*[19]

The experiences of the *USS Indianapolis* survivors are not typical, however.

"With [an accident involving] a small helicopter or airplane, it's extremely rare to have any problem with a shark, or even any contact with a shark," Smith said.

Although sharks may be attracted to life rafts, they generally are more interested in the fish that congregate beneath a life raft than in the humans inhabiting the raft.

"Most sharks will not cause any grief to a floating vessel, including a life raft," Burgess said. "But there's a little bit of concern that, if things get too lively among the creatures underneath your vessel, there might be an accidental bite at the life raft [by a shark chasing something else]."

Paul D. Russell, a maritime safety specialist and accident investigator, and a retired U.S. Coast Guard captain with more than 5,000 flight hours in fixed-wing and rotary-wing aircraft, said that sharks would be more likely to bump into ballast bags attached to the underside of a life raft than to bump into a raft itself, and that such contact probably would be enough for the shark to recognize that the ballast bags — and the life raft — would not yield food. As a result, a shark would be extremely unlikely to bite at a life raft, he said.[20]

"It's not that it can't happen, but it isn't likely," Russell said.

Burgess said that ISAF data show that when sharks have bitten at boats, the boats generally have been metal vessels used in fishing operations. In those events, the shark — using its electro-sensory system — presumably has mistaken the signals from the boat's electromagnetic field for the electric signals generated by its usual prey and has taken an exploratory bite, often of a boat's propeller.

"They get confused by the presence of metal," Burgess said. "A life raft probably wouldn't be as interesting."

Bright Colors, Fishing Activities Appeal to Sharks

Sharks are attracted by shiny jewelry, which — to their eyes — resembles the sheen of fish scales, by uneven tanning and by bright colors, including the bright orange and yellow used in life vests.

"The safety orange/yellow used in [life vests] is referred to as 'yum-yum yellow' by shark biologists," said Burgess, who noted that although studies have indicated sharks' attraction to bright and/or contrasting colors, there are no data to show that sharks have been attracted to — and bitten — people because of their yellow or orange life vests. "But it's a trade-off. To be readily seen by rescue folks in the air or from a vessel, you also must be seen by sharks."

> **"It's extremely rare to have any problem with a shark, or even any contact with a shark."**

Sharks also are attracted to waters where fishing activity is in progress and to waters containing effluents (liquids discharged as waste by sewers), human waste or blood. (There are no data to show that menstrual blood increases the risk of a shark bite, but many specialists believe that sharks can sense the presence of menstrual blood.)[21] They are more likely to bite a solitary individual than a member of a group and more likely to be active — and therefore more likely to bite — during darkness or twilight.

The U.S. Army says, in its *U.S. Army Field Manual No. 21-76*: *Survival*, that sharks that live in tropical and subtropical oceanic waters typically are more likely to bite than those living in cooler waters. The manual includes the following caution:

> *[Sharks'] normal diet is live animals of any type, and they will strike at injured or helpless animals. Sight, smell or sound may guide them to their prey. … They are also sensitive to any abnormal vibrations in the water. The struggles of a wounded animal or swimmer, underwater explosions, or even a fish struggling on a fish line will attract a shark.*[22]

Advice originally developed for use by U.S. Navy personnel and later published in the book *How to Survive on Land and Sea* warns against dangling hands or feet in the water when sharks are nearby and against "flopping about on the surface," which could sound to a shark like a wounded fish. If sharks approach, they are not necessarily going to bite but may instead be on "an investigative foray," the book says. "A sharp poke on the snout may send the shark on to less troublesome prey."[23]

Smith, one of the book's authors, said that he has complied with that advice and has hit or kicked sharks on the snout when they approached while he was diving.

"It worked," he said. "Common sense says 'do something' — hit as hard as you can to defend yourself. I think the snout would be the most likely and easiest target. The eyes would be harder to hit but probably as effective."

Someone wearing a life vest and keeping his or her head out of the water probably would not see clearly enough to observe a shark's underwater behavior, but even a close observation would not necessarily enable the person to assess the shark's intentions, Smith said.

"The only thing that can be said about sharks that will be true and right in all cases is that they are unpredictable," Smith said. "If the shark is close enough to kick or punch, it's time to kick or punch. Doing nothing is not recommended."

As for concerns that a kick or punch might further provoke a shark, Smith said, "if they are about to take a bite of you, they don't need to be provoked."

The following actions are recommended if you observe sharks while in a life raft:[24,25]

- Do not fish. If a fish has been hooked, let it go. Do not clean fish in the water;
- Do not let arms, legs or equipment dangle in the water. Remain quiet and still; and,
- Bury the dead as soon as possible by pushing the bodies into the ocean.

If you are floating in the water and observe sharks, the following actions are advised:[26,27,28]

- Survivors should float vertically and move as little as possible. Someone lying horizontally in the water is more likely to resemble sharks' typical prey, said Erich Ritter, chief scientist with the Shark Research Institute's Global Shark Attack File;[29]
- Remain in a group "at all costs" and gather together as much floating material as possible, Burgess said;
- Do not remove any clothing, including shoes. Sharks generally bite unclothed people — and those with bare feet — before they bite those wearing clothing. Clothing also protects against cuts and scrapes from the shark's rough skin — injuries that might occur if a shark brushes against a human;
- Do not urinate or defecate while sharks are in the area; and,
- If you are injured and bleeding, stop the bleeding as quickly as possible. If a group of people is in the water, form a circle around the bleeding survivor.

"The … thing that can be said about sharks … is that they are unpredictable."

Ritter said that, if a shark actually bites and does not let go, "the best thing to do … is to not fight the shark, besides trying to get its mouth open. Any motion, such as jerking away from the shark, will lead to much more severe wounds and can be much more devastating than the actual bite. Opening a shark's mouth should not be attempted by hitting the animal, since that reflects a 'prey action.' I consider it the best to go after the gills or the eyes and poke them, if reachable."[30]

Ritter was himself the victim of a shark bite on April 9, 2002, while he was working with a film crew on a documentary about sharks. He was standing in waist-deep water in The Bahamas, wearing tan shorts, a tan shirt, black footwear and black gloves, when an 8.0-foot (2.4-meter) bull shark swam up behind him, bumped him and bit into his left leg; after Ritter raised his leg toward the water's surface, the shark let go and swam away. The bite removed much of the calf muscle and severed a major artery in the leg. Ritter described the pain as "excruciating."[31]

"I had the impression that everything had slowed down around me," he said. "I was not angry, upset or anything like that, but I just understood what had happened and what had to be done.

"On my way to the hospital, I started to get cold, and I felt disconnected to what had happened to me. Then I found some form of peace and acceptance that I may die."

Blood Loss, Drowning Are Most Serious Risks to Shark-bite Victims

Wounds inflicted by a shark's rough skin or its multiple rows of sharp teeth can be relatively minor, such as skin abrasions after a shark's body brushes against a victim or relatively small cuts from bites — usually on the legs — that are inflicted during a hit-and-run bite.[32] The bites often are crescent-shaped or a series of parallel cuts.[33]

A shark also can break human bones if it hits a person while traveling at speeds up to 25 miles (40 kilometers) per hour.[34]

Other bites, especially those inflicted during bump-and-bite and sneak encounters, can result in more serious injuries.

Paul S. Auerbach, M.D., clinical professor of surgery in the Stanford (California, U.S.) University Medical Center Division of Emergency Medicine, said that when a shark bites a human, the shark most frequently bites the legs, arms and hands, as the victim tries to fight off the shark. In more severe bites, a shark often "shakes its head and forebody in an effort to tear flesh from the victim," Auerbach said.[35]

"Severe shark bites result acutely in massive tissue loss, hemorrhage, shock and death," he said. "Even a smaller [shark] can bite with bone-crushing force. The potential for rapid destruction is unparalleled in the animal kingdom."

If the wound severs major arteries, the victim may suffer a "torrential" hemorrhage; injuries also can include broken bones and massive internal injuries, Auerbach said. "Because the victim is generally far from medical assistance, blood loss may be profound. The wounds have historically been fatal in 15 [percent] to 25 percent of attacks, with major causes of death listed as hemorrhage and drowning."

Hypovolemic shock (shock resulting from loss of blood) usually is the greatest threat to life, he said. Recommended treatment, while a victim is in the water, includes manual compression of wounds (covering the wound with any piece of material or even a hand while applying firm, constant pressure to stop the bleeding). After a victim is out of the water, "all means available must be used to ligate [tie off] large, disrupted blood vessels or to apply compression dressings," Auerbach said.

Wounds inflicted by sharks often contain a variety of contaminants, including ocean water, sand, shark teeth and marine organisms. Ideally, the wounds should be washed and bandaged, and a victim should receive antibiotics to prevent infection. This may be difficult on a life raft, where supplies of fresh water for washing the wounds might be limited and antibiotics might not be available. (Ocean water, which contains bacteria, can be used for quickly rinsing wounds to expel foreign particles but should not be used for a more thorough cleansing.)

Nevertheless, infection probably would not develop for at least 24 hours to 36 hours — perhaps longer — after a shark bite and the probable lack of effective antibiotics would not be the most immediate risk to a shark-bite victim, Auerbach said.[36]

For a shark-bite victim in the water without a life raft, Auerbach said, "the number-one problem is that they're going to drown. … They may not be able to stay afloat."

The prognosis for a shark-bite victim who spends days in a life raft or in ocean waters before receiving emergency medical treatment depends on the extent of the blood loss and wounds, he said.

He said that including tablets of the antibiotic ciprofloxacin among medical supplies that are packed into life rafts or ditch bags would be useful in treating not only an infection resulting from a shark bite but also a variety of other infections that could afflict people on a life raft (see "Is There a Doctor Aboard the Life Raft?," page 187). Use of prescription medications should be discussed with medical personnel during training, and printed information about how to administer the medications should be included in the personalized medical kit.

Researchers Continue to Seek Reliable Shark Repellents

Researchers have attempted for years to develop devices to repel sharks.

During World War II, the U.S. Navy developed one of the first shark repellents — a combination of black dye and chemicals intended to resemble both the defensive secretions of squid and octopus and decomposing shark flesh. The crew of the *USS Indianapolis* was not equipped with the repellents, which later were found to be ineffective.[37,38]

More recently, scientists have tested methods of repelling sharks by using substances derived from other ocean animals, such as sea cucumbers and crocodiles, and from decomposing shark flesh.

An Australian company has designed two devices — one intended for use by divers and the other, by swimmers or surfers — that generate a protective electrical field to overwhelm the sharks' electro-sense and to keep them away. A device weighs about 3.0 pounds (1.4 kilograms) and is worn on the thigh or the ankle.[39]

Jellyfish stings can cause pain and itching and — depending on the species — serious injury or death.

Webster said that, although some developments, especially the electronic repellent, are promising, no chemical shark repellent has been found effective in the environment of open ocean waters.

Jellyfish Stings Can Cause Minor Pain — or Death

Survivors of a water-contact accident who are floating in the water or who leave a life raft temporarily to cool off in ocean water may encounter jellyfish or other related species, whose stings cause pain and itching and — depending on the species and the individual victim's sensitivity to the jellyfish venom — can cause serious injury or death.

Depending on a number of factors, including the location of the ditching or other water-contact accident, the season and the availability of the jellyfish's prey, "you could land in a jellyfish soup, or you could be there for days and not see one," Webster said.

Although jellyfish usually are found near coasts, some species also live in open ocean waters, he said.

Worldwide, in all ocean regions, there are thousands of species of jellyfish and related ocean creatures, called cnidarians or coelenterates.

Each of these creatures has thousands — some species have millions — of nematocysts (stinging cells) on the outer surfaces of the tentacles or near the mouth. When something (the jellyfish's prey or a person who has crossed the jellyfish's path, for example) brushes against a jellyfish, the trigger hairs on the outside of the nematocysts are released. This, in turn, releases coiled-thread tubes inside each nematocyst; the tubes puncture the skin of the victim and release venom that can paralyze or kill prey (or sting a human).[40] A jellyfish sting usually involves the release of venom from many nematocysts.

Three main classes of jellyfish can deliver stings that present risks to humans:

- Scyphozoans or "true" jellyfish — including sea nettles and moon jellyfish — vary in color. Their bodies (bells) may be blue, green, pink, red, brown or clear; they often are difficult to see in the water. They also vary in size; some species are smaller in diameter than one inch (2.5 centimeters) while others may grow to more than 10 feet (three meters) in diameter with tentacles more than 100 feet (31 meters) long.[41] Their bodies generally are balloon-like in appearance, with dangling tentacles. Webster said that although some species of true jellyfish do not have tentacles, all species sting their prey. (Some have stinging cells too small to sting humans, however.)

  Most true jellyfish are active night and day, whenever food is available, Webster said. Some species migrate to the ocean surface at night, when surface waters have a more plentiful supply of food, and descend hundreds of feet during the day to the relative safety of the dark waters well below the surface;

- Cubozoans including "box" jellyfish, which are considered the most deadly of all jellyfish, are found in parts of the Pacific Ocean and Indian Ocean — usually near coastlines and reefs — from Australia north to southern Japan and southern India. Data show that, in recent years, at least one death a year in Australia is a result of a box jellyfish sting; from 1883, when record keeping began, through March 2003, 68 deaths were attributed to box jellyfish.[42,43]

  The Australian Institute of Marine Science says that a box jellyfish has a transparent, pale blue, box-shaped bell, measuring up to about eight inches (20 centimeters) on each side, with as many as 15 tentacles extending from each of the four corners; the tentacles are up to about 10 feet long.[44]

  "In clean ocean waters, they are almost invisible, and for years, it wasn't known what was actually causing such excruciating pain, often followed by death," the museum says in its description of box jellyfish. "If a swimmer makes contact with the box jellyfish's tentacles, perhaps only six [meters] or seven meters [20 feet or 23 feet] of them, death may result. … The severity of the sting is relative to the size of the box jellyfish, the sensitivity of the victim's skin and the amount of tentacle that has come into contact."

  The stings of several species of very small box jellyfish (whose bodies have diameters of less than one-half inch [13 millimeters]) have been identified as the cause of Irukandji syndrome, in which the victim initially is aware of only minor skin irritation but, after about 30 minutes, experiences other symptoms, including generalized pain; nausea, vomiting and abdominal cramps; headache; severe back pain; and "a feeling of impending doom," said two researchers in the Tropical Australian Stinger Research Unit at James Cook University.[45] The stings of some of these small box jellyfish also have caused hypertension (elevated blood pressure), other heart problems, breathing difficulties and — rarely — death;[46] and,

- Hydrozoans, or "other" jellyfish, including Portuguese man-of-war (also called bluebottle), technically are not jellyfish but — because of some similar behaviors — typically are considered with them.

  The Portuguese man-of-war, which resembles a true jellyfish, actually is a colony of four kinds of individuals (polyps) found primarily in tropical waters. The floating portion (bell) of the man-of-war, which usually is blue, is one individual, which supports the other three, including the tentacles. Although the sting rarely is fatal, it can be extremely painful.[47]

Most jellyfish stings result in a small, raised rash that appears on the skin as a series of lines. An area of reddened skin sometimes surrounds the rash. The area often itches, and may be painful. The rash may develop into pus-filled blisters. The sting may result in other symptoms, including weakness, nausea, headache, muscle pain and/or muscle spasms, watering eyes and nose, sweating, changes in the heart rate, and chest pains.[48]

Peter Fenner, M.D., a specialist in jellyfish envenomation and an Australian designated aviation medical examiner, said that survivors of an aircraft ditching or other water-contact accident in the open ocean would have only a remote chance of being stung by jellyfish, unless the aircraft landed "in an armada of Portuguese man-of-war."[49]

"[Survivors'] best protection is that they are in clothing, which prevents being stung, except in exposed areas," Fenner said. "Stings to exposed areas would not be sufficient to cause a threat to life and would only cause local skin pain, which, although uncomfortable, would not usually be sufficient to worry about treatment."

The stings of all jellyfish should be treated by cleaning the area of the sting with ocean water — not fresh water, which can stimulate the release of additional toxin.

Specialists do not agree on some other elements of treatment.

Fenner said that, for all but box jellyfish stings, he recommends rinsing the area of the sting with ocean water and, if possible, applying ice or a chemical "cold pack," which becomes cold when squeezed. This should relieve pain and itching within 20 minutes.[50]

Most jellyfish stings result in a small, raised rash that appears on the skin as a series of lines.

Barracuda attacks often occur as they try to steal fish from people spearfishing.

Some other specialists say that the stings of all jellyfish except box jellyfish can be treated by applying vinegar, a weak solution of ammonia, window cleaner, meat tenderizer, urine or other substances to relieve pain;[51,52] others, including Fenner, say that these substances — in addition to being generally unavailable on a life raft — are ineffective or, in some cases, harmful.

Some specialists also say that medical care administered under ideal circumstances (not on a life raft) includes removal of visible tentacles using forceps or another similar instrument or by hand, with precautions to protect the person removing the tentacles. The area of the sting is soaked again in a solution of water and vinegar; and the wound is covered with shaving cream, which is scraped away with a sharp knife or razor blade to remove unseen tentacles. (On a life raft, if a knife or razor blade is not available, some specialists say that the edge of a credit card or similar item can be used to brush off remaining tentacles.)[53] The area of the sting is soaked in the water-vinegar solution again before administration of an antihistamine, a pain-reliever and an anti-itch ointment — which might be included among some life raft medical supplies.[54]

Fenner said that, for box jellyfish stings, treatment should begin with cardiopulmonary resuscitation, if necessary, followed by application of vinegar to help deactivate nematocysts on any tentacles remaining on the skin. Victims with severe stings may require administration of antivenom (antivenin); without it, they may stop breathing within minutes of the sting, and death can occur quickly. For example, Fenner said, a victim who needed antivenom probably would die before reaching the life raft.

Smith said that, because people entering the water from an aircraft presumably would be clothed, packing a life raft to include the materials generally required for treatment probably would not be necessary.

Fenner said, however, that chemical cold packs might be useful in treating jellyfish stings. Nevertheless, he said, "These would be low on a list of priorities in favor of other more urgent medicine, food, water and survival gear."

Barracuda Would Rather Bite Your Catch Than You

Other animals found in the open ocean (and sometimes closer to land) that sometimes present risks include the following:

- Barracuda, which generally swim near shorelines in tropical and subtropical waters and in open ocean waters, have bitten humans, but the bites are rare. When bites have occurred, usually the barracuda are trying to steal fish from people using spears to fish, or they observe shiny objects such as divers' knives and mistake them for small, shiny fish. The bites, which typically are not fatal, usually result in cuts and a loss of tissue.[55] Ideally, these wounds should be cleaned with fresh water — if the supply on the life raft is sufficient — to remove debris, including embedded teeth. Jagged cuts may require sutures; if tape is available on the life raft, taping the wound shut may be an acceptable alternative.[56]

  Sometimes, the wounds are more severe. Barracuda — with two parallel rows of teeth — can tear human flesh and can sever blood vessels.[57] In these cases, treatment requires controlling bleeding by pressing directly on the wound with a piece of cloth or even a hand. This may be difficult while the victim is in the water; in such cases, the best action, if possible, might be to tie a strip of cloth around a bleeding arm or leg. After the victim is out of the water, the cloth should be removed and bleeding should be controlled by direct pressure on the wound.[58] Auerbach said that treatment of bleeding and tissue damage is foremost; if antibiotics, such as ciprofloxacin, are available, they can be administered for infection;

- Sea snakes, which are found in tropical and subtropical waters of the Indian Ocean and the western Pacific Ocean, are venomous and sometimes bite if they are provoked. Most victims are believed to be fishermen who are bitten while handling nets that have captured sea snakes along with fish. Although the sea snakes' venoms are potent, about 80 percent of bites do not contain enough venom to result in serious harm to their victims. Under ideal circumstances (not in a life raft), treatment includes application of a pressure bandage over the bite to prevent the venom from spreading through the body, keeping the victim as still as possible and administering antivenom as soon as possible. Before the development and use of antivenom, about 10 percent of sea snake bites were fatal; today, with prompt treatment, the death rate is much lower. Precise data are not available, however;[59]

- Estuarine crocodiles, which generally live in saltwater bays in tropical areas, may also be found as far as 40 statute miles (60 kilometers) from shore in open ocean waters. Crocodile bites typically kill several people each year;[60,61] and,

- Electric rays, also called torpedoes, are found in tropical and temperate open ocean waters and closer to shore, along sandy or muddy ocean floors. Although humans rarely encounter them, they are capable of producing paralyzing electric shocks.[62]

Other ocean animals that can inflict painful stings or cuts — usually if they are stepped on or brushed against — live close to shore or around reefs. They include the following:

- Stingrays, which generally are found in sand or muddy areas near shore in tropical, subtropical, warm and temperate regions, have venomous barbed tail stingers. They are not aggressive, but if stepped on, their stingers can penetrate the foot. Immediate treatment involves rinsing the sting with fresh water, if possible, or ocean water; removing parts of the embedded stinger; and applying pressure to stop bleeding. Wounds may become infected and may ultimately require hospital treatment or — if the stingray was very large — may be fatal;[63,64]

Stingrays have venomous barbed tail stingers that can cause injury if stepped on.

Sea snakes, which have potent venom, sometimes bite if they are provoked.

- Moray eels, which usually live in holes or beneath rocks and coral in tropical and subtropical waters, sometimes bite when disturbed. The bites are rare but potentially severe and can damage nerves or tendons in the hands and feet. The wounds should be rinsed with fresh water, if available, embedded teeth should be removed, and pressure should be applied to stop bleeding;[65,66]

- Anthozoans, including sea anemones and some corals, are among the coelenterates related to jellyfish. They typically are found on reefs and ocean bottoms. Anemones usually have minimal toxicity, and their stings should be treated by rinsing with ocean water to remove tentacles and applying ice or a cold pack, if available, to reduce pain. Cuts from brushing against corals sometimes result in serious infections; the cuts should be treated by removing embedded coral; rinsing with fresh water, if available, and pressing on the wound to stop bleeding;[67,68] and,

- Other venomous marine creatures include some species of fish — often those living around coral reefs — with venomous spines in their fins or tails or on their backs and some cone shells and auger shells — generally those found in the Indian Ocean and Pacific Ocean — with venomous stinging barbs. Sea urchins also can emit venom through their spines; the most frequent wounds are to the feet or hands of people who inadvertently step on them while walking in shallow near-shore waters or pick them up. The spines should be pulled out, although embedded spines usually either come out through the skin or are absorbed by the body; most wounds heal within a month.[69,70]

Although many ocean creatures can inflict serious injuries on humans, specialists say that the risk of an encounter with a dangerous predator is relatively slight for survivors of a water-contact accident. Nevertheless, not all dangers can be eliminated. ■

The bottom line, in our opinion …

Despite the rarity of shark encounters, we know that shark facts are of special interest. …

- **Human encounters with sharks are rare, and worldwide data show that each year, between three and 15 people are killed by sharks.**

- **Survivors floating in the water — not in life rafts — are more likely to be targeted by sharks.**

- **Survivors should avoid activities that attract sharks. In life rafts, this means not dangling arms or legs in the water and not fishing when sharks are visible nearby. In the water, survivors should remain fully clothed, stay in groups and float vertically — not horizontally like sharks' typical prey.**

- **If a shark does bite, the best response is to punch it or kick it in the snout, eyes or gills.**

- **Survivors in cold waters of the North Atlantic might not encounter any dangerous animals; in the warm waters off the southeastern United States, they would be more likely to encounter sharks; and near the Australian coast, they could find themselves amid box jellyfish, whose sting can kill within minutes.**

Notes

1. Burgess, George. Telephone interview and e-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., May 5, 2003; May 6, 2003; May 8, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

2. Webster, Steven. Telephone interview and e-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., May 28, 2003; June 17, 2003; June 20, 2003; June 30, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

3. "Experts: There Will Be Shark Attacks, But Consider the Odds." *The Daytona Beach* (Florida, U.S.) *News-Journal*. May 22, 2002.

4. International Shark Attack File (ISAF). *Shark Attacks in Perspective*. <www.flmnh.ufl.edu/fish/sharks/attacks/perspect.htm>. April 21, 2003.

5. John G. Shedd Aquarium. *Fishes: Frequently Asked Questions*. <www.sheddnet.org/ani_faqs_04.html#b>. Sept. 2, 2003.

6. ISAF. *How, When and Where Sharks Attack*. <www.flmnh.ufl.edu/fish/sharks/attacks/howwhen.htm>. April 21, 2003.

7. Conversely, humans kill about 100 million sharks, skates and rays every year through fishing and unintentional catching of the creatures in fishnets, Burgess said.

   The U.S. National Parks Conservation Association said that the worldwide population of each of the 350 or more species of sharks is unknown but that shark populations in many areas have declined in recent years. (U.S. National Parks Conservation Association. *Sharks*. <http://npca.org/marine_and_coastal/marine_wildlife/sharks.asp>. Aug. 20, 2003.)

   A 2003 report on a study by Canadian scientists said that, of 17 species of sharks found in the North Atlantic, populations of 15 species had declined rapidly between 1986 and 2003; the greatest decline was the 89 percent reduction in the population of hammerhead sharks (Baum, Julia K.; Myers, Ransom A.; Kehler, Daniel G.; Worm, Boris; Harley, Shelton J.; Doherty, Penny A. "Collapse and Conservation of Shark Populations in the Northwest Atlantic." *Science* Volume 299 (Jan. 17, 2003): 389–392).

8. ISAF. *International Shark Attack File 2002 Shark Attack Summary*. <www.flmnh.ufl.edu/fish/sharks/statistics/2002attacksummary.htm>. April 21, 2003.

9. ISAF. *How, When and Where Sharks Attack*.

10. Oceanic Research Organization. *Sharks and How They Live*. <www.oceanicresearch.org/sharkspt.html>. June 19, 2003.

11. Smith, Ray E. Telephone interview and e-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., April 18, 2003; June 17, 2003; June 18, 2003; June 23, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

12. Llano, George Albert. *Airmen Against the Sea*. Arctic, Desert, Tropic Information Center (ADTIC), Research Studies Institute, U.S. Air Force. ADTIC Publication G-104. 1955. The preface said that the report was "the fourth in a series of ADTIC studies to determine how military personnel survived under emergency conditions in various parts of the world." The series included *999 Survived* (Southwest Pacific tropics), *Sun, Sand and Survival* (African deserts) and *Down in the North* (Arctic). Most of the information in *Airmen Against the Sea* was obtained from records of the U.S. Air Force and the U.S. Navy; the publication also includes information from records of the air forces of Australia, Britain, Canada, Germany and New Zealand, and from other sources. The report is based on information gathered from airmen who survived ditching or bailing out of airplanes mostly during World War II and to a lesser extent during the Korean War and the early 1950s. "The most valuable and informative material was found in the firsthand accounts written by the survivors themselves," the report said.

13. The date of the incident was not included in Llano's report.

14. The date of the incident was not included in Llano's report.

15. Finneran, Patrick J. *The Tragedy of the USS Indianapolis*. <www.ussindianapolis.org/pfinnstory.htm>. May 12, 2003.

16. Stanton, Doug. *In Harm's Way: The Sinking of the USS Indianapolis and the Extraordinary Story of Its Survivors.* New York, New York, U.S.: Henry Holt and Co., 2001.

17. Finneran.

18. James, Woody Eugene. *A Survivor's Story*. <www.ussindianapolis.org/woody.htm>. May 13, 2003.

19. McVay, Charles B. III. *Oral History: The Sinking of USS Indianapolis, Recollections of Capt. Charles B. McVay III, USN, Commanding Officer of USS Indianapolis (CA-35), which was sunk by Japanese submarine I-58 on 30 July 1945 near the Philippines*. (McVay's recollections are included in a series of World War II interviews at the Naval Historical Center.) <www.history.navy.mil/faqs/faq30-7.htm>. May 13, 2003.

20. Russell, Paul D. Interviews by Werfelman, Linda. Hollywood, Florida, U.S., April 22, 2003, and Alexandria, Virginia, U.S., May 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S. In the U.S. Coast Guard, Russell conducted more than 200 water landings and served in various positions, including commander of two air stations, chief of the Aviation Training Center Training Division and chief of search-and-rescue operations in the Northwest Region, before retiring in 1984 with the rank of captain. He is chief engineer, aviation system safety, Boeing Commercial Airplanes, and a maritime safety and accident investigator for Safety Services International.

21. Mowatt-Larssen, Eric. *Shark Bite*. <www.emedicine.com/aaem/topic534.htm>. June 18, 2003.

22. U.S. Army. "Sea Survival." Chapter 16 in *U.S. Army Field Manual No. 21-76: Survival*. June 1992.

23. Craighead, Frank C. Jr.; Craighead, John J.; Smith, Ray E.; Jarvis, D. Shiras. "Environmental Hazards at Sea." Chapter 13, in *How to Survive on Land and Sea, Fourth Edition*. Annapolis, Maryland, U.S.: Naval Institute Press. 1984.

24. ISAF. *Reducing the Risk*. <www.flmnh.ufl.edu/fish/sharks/attacks/relariskreduce.htm>. April 21, 2003.

25. U.S. Army.

26. Ibid.

27. ISAF. *Reducing the Risk*.

28. Smith.

29. Ritter, Erich. Ritter was interviewed in *Anatomy of a Shark Bite*, a Discovery

Channel television program first shown Aug. 10, 2003.

30. Ritter, Erich. *Shark Week: Ask the Expert.* <http://dsc.discovery.com/convergence/sharkweek/ask/ask.html>. Aug. 21, 2003.

31. Ritter, Erich. Interviewed in *Anatomy of a Shark Bite*.

32. ISAF. *How, When and Where Sharks Attack*.

33. Mowatt-Larssen.

34. Ritter, Erich. Interviewed in *Anatomy of a Shark Bite*.

35. Auerbach, Paul S. "Shark Attacks." *NewsShare: Newsletter of the International Society of Travel Medicine* March–April 2002: 2–5.

36. Auerbach, Paul S. Telephone interview by Werfelman, Linda. Alexandria, Virginia, U.S. July 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

37. Stanton.

38. Sisneros, Joseph A.; Nelson, Donald R. "Surfactants as Chemical Shark Repellents: Past, Present and Future." *Environmental Biology of Fishes* Volume 60 (2001): 117–129.

39. SeaChange Technology. *SeaChange Shark Shield: How It Works.* <www.sharkshield.com/howitworks.html>. June 30, 2003.

40. Fenner, Peter J.; Williamson, John A. "Worldwide Deaths and Severe Envenomation From Jellyfish Stings." *The Medical Journal of Australia* Volume 165 (1996). <www.mja.com.au>. April 29, 2003.

41. Jeffress, Dorothy; Steimle, Frank. "Common Jellyfish of the Middle Atlantic." *Underwater Naturalist* Volume 19 (June 1990).

42. Fenner and Williamson.

43. "Boy's Death From Box Jellyfish 'Avoidable,' Says Expert." *Sydney* (Australia) *Morning Herald*. March 24, 2003. <www.smh.com.au/articles/2003/03/24/1048354533747.html>. June 17, 2003.

44. Australian Institute of Marine Science. *Dangerous Marine Animals of Northern Australia: Sea Wasp*. <www.aims.gov.au/pages/research/project-net/dma/pages/seawasp-01.html>. April 17, 2003.

45. Carrette, Teresa; Seymour, Jamie. *Jellyfish Responsible for Causing Irukandji Syndrome*. <www.jcu.edu.au/interest/stingers/information.htm>. June 18, 2003.

46. Fenner, Peter J.; Hadok, John C. "Fatal Envenomation by Jellyfish Causing Irukandji Syndrome." *Medical Journal of Australia* Volume 177 (7): 362–363.

47. Australian Museum Online. *Australian Museum Fact Sheets: the Bluebottle or Portuguese Man-of-War*. <www.amonline.net.au/factsheets/bluebottle.htm>. May 23, 2003.

48. Berkow, Robert (editor). "Marine Animal Stings and Bites." Section 24, Chapter 287 in *The Merck Manual of Medical Information — Home Edition*. Whitehouse Station, New Jersey, U.S.: Merck Research Laboratories. 1997.

49. Fenner, Peter. E-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., June 25, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

50. A chemical "cold pack" contains substances — often water and the chemical ammonium nitrate — which are packed in separate compartments but which mix together when the pack is squeezed. The chemical process that occurs when the ammonium nitrate mixes with the water is an endothermic process — a process that absorbs heat (becomes cold).

51. Berkow.

52. Tucker, Jeffrey. *Coelenterate and Jellyfish Envenomations*. <www.emedicine.com/emerg/topic104.htm>. May 21, 2003.

53. Virginia Poison Center at the Medical College of Virginia Hospitals at Virginia Commonwealth University. *The Poisons of Summer*. <www.vcu.edu/mcved/iframe/tox/pdf/poison_summer.pdf>. July 1, 2003.

54. Tucker.

55. Florida Museum of Natural History. *Biological Profiles: Great Barracuda*. <www.flmnh.ufl.edu/fish/education/bioprofile.htm>. April 17, 2003.

56. Thomas, Craig; Scott, Susan. *All Stings Considered: First Aid and Medical Treatment of Hawaii's Marine Injuries*. <www.aloha.com/~lifeguards/alsting1.html>. July 1, 2003.

57. Virtual Naval Hospital. "First Aid for Bites and Stings." Chapter 6 in *FM21-11 First Aid for Soldiers*. <www.vnh.org/FirstAidForSoldiers/Fm211_6.html>. July 1, 2003.

58. Thomas, Scott.

59. Foster, James; Bolger, Angela. *Snake Envenomations, Sea*. <www.emedicine.com/emerg/topic543.htm>. May 21, 2003.

60. U.S. Army. "Dangerous Fish and Mollusks." Appendix F in *U.S. Army Field Manual No. 21-76: Survival*. June 1992.

61. Britton, Adam. *Crocodilian Species List*. <www.flmnh.ufl.edu/cnhc/csl.html>. May 21, 2003.

62. Craighead et al., p. 313–317.

63. Ibid.

64. Thomas, Scott.

65. Ibid.

66. Florida Museum of Natural History.

67. Tucker.

68. Thomas, Scott.

69. Ibid.

70. U.S. Navy. *U.S. Navy Diving Manual*, SS521-AG-PRO-010, Revision 4, Change A, March 2001. Appendix 5C, "Dangerous Marine Animals."

Crewmembers from the U.S. Navy ship *Spica* transferred sailor Brian King and two of their rescue swimmers from a life raft to the rigid inflatable boat, which was hoisted to the ship's deck.

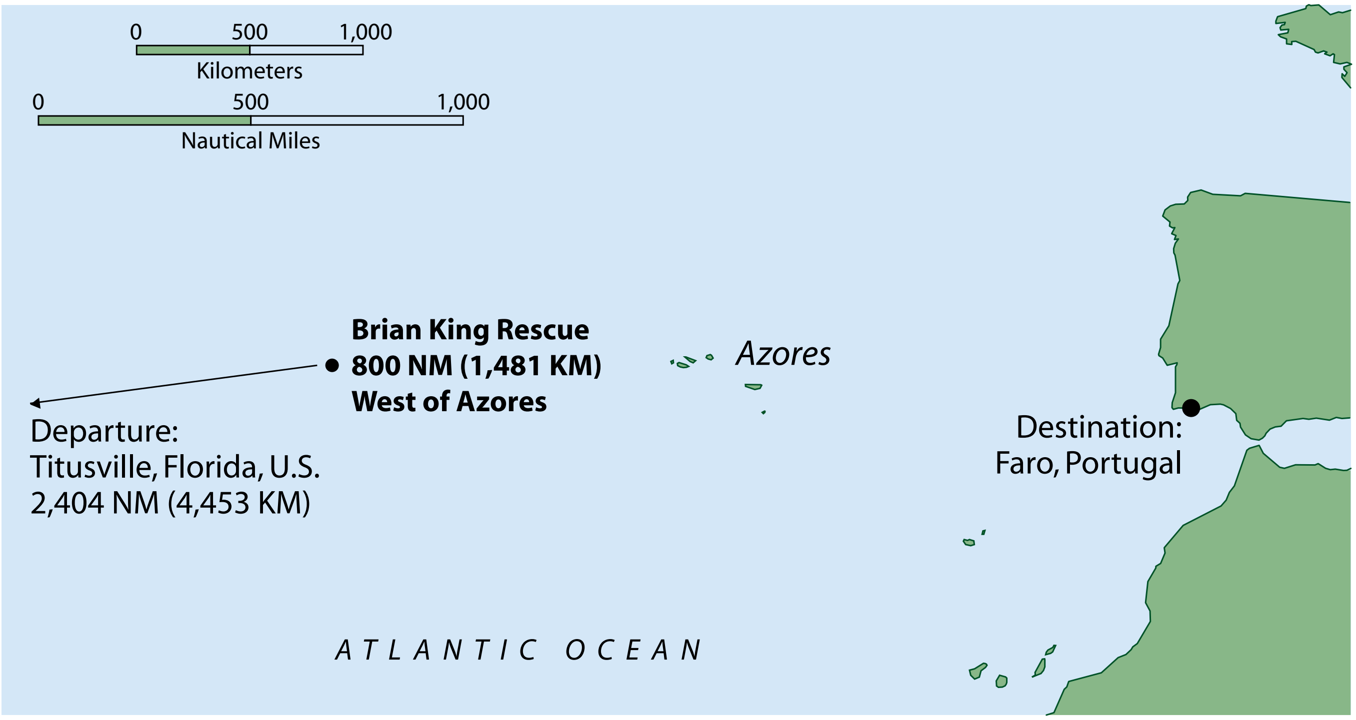
Aviators and Sailors in the Water Depend on the Same Rescue Resources

Rescues at sea are perilous and present opportunities for success and failure.

— FSF EDITORIAL STAFF

Finding people in distress is just the beginning of the problem for rescuers, based on a Canadian sailor's story of his emergency transfer from a sailboat to a U.S. Navy ship in summer 2003. Brian King, 57, a retired firefighter from Toronto, Ontario, with a weakened heart had volunteered to assist, his friend Tony Collingridge, 67, as a crewmember for a voyage across the Atlantic Ocean from Titusville, Florida, U.S., to Faro, Portugal, with a stop in the Azores.[1] Collingridge was the owner and skipper of a 36-foot (11-meter) Moody 36 sailboat.

"It's very common for sailors to be volunteer crew on long-distance voyages," King said. "Tony was returning to his home port in England, and I had asked him to give me a shout if his son-in-law could not make the voyage as planned. I always had wanted to sail across the Atlantic Ocean, but had abandoned my dream because of health concerns. I



The crewmember became ill after 22 days at sea and was rescued near the Azores.

was being treated for heart enlargement from a viral infection in 2001, which left my heart working at 20 percent efficiency. I knew it could be a roll of the dice to do this adventure, but I had no symptoms and no trouble sailing from Lake Erie to Florida a few weeks earlier. In preparation to go with Tony, I carried enough blood-thinning medication for the voyage and an extra month's supply."

The sailboat was 800 nautical miles (1,481 kilometers) west of the Azores — about a week's sailing time — after 22 days at sea, when King recognized that he might have a serious medical condition. Collingridge attempted to obtain information to treat King's symptoms — moderate pain and urination of blood for more than a day — first by broadcasting a medical urgency message by very-high-frequency (VHF) marine transceiver.[2] No response was received. Without long-range communication capability and concerned about a possible life-threatening emergency, he then activated a 406-megahertz (MHz) emergency position-indicating radio beacon (EPIRB) to notify search-and-rescue (SAR) authorities.

The voyage involved 24-hour watchkeeping with alternating three-hour sleep periods at night, which was difficult to sustain for three weeks. They encountered winds and waves that were higher than expected for the time of year, including two gales (on the Beaufort Wind Scale, a gale involves a wind speed of 34–40 knots [63–74 kilometers per hour]) and 20-foot (six-meter) waves. King said that motion of the sailboat had been moderate to heavy for about 70 percent of the voyage.

"Because of constant motion, I found that I was more tired than expected, and two gales at sea forced us to stop twice for one and a half days," King said. "Reducing sail for the gale conditions was exhausting. The weather knocked the stuffing out of us during the first three weeks. We were a week away from medical assistance, and we knew we needed medical advice beyond our first aid training." They could not find information about King's symptoms in the medical guides carried in the boat, Collingridge said.

Beacon Registration Helps Confirm Voyagers' Distress

The EPIRB, registered to Collingridge, enabled U.S. Coast Guard Rescue Coordination Center (RCC) Norfolk (Virginia, U.S.) to verify with family members that the sailboat was on a sea voyage and to learn details of its float plan. RCC Norfolk coordinated the SAR response by requesting assistance from nearby commercial ships that participated in the Amver (Automated Mutual-assistance Vessel

Rescue) ship-reporting system and from the U.S. Navy (see "The Search-and-rescue System Will Find You — If You Help," page 111).

The crew of the U.S. Navy Ship (USNS) *Spica* rescued King on June 25, 2003, provided shipboard medical care and enabled him to return with the ship six days later to Norfolk. In the following excerpts from his journal, King described his experience:

"I still have what appears to be nothing but blood in my urine, and so we activated the EPIRB at 0130 local time [and kept the VHF marine transceiver on]. We just want to talk to someone and try and get some medical advice on my condition. We got a call on our VHF radio from a nearby tanker ship just 4.5 hours later that a naval vessel with a doctor was on the way to our position. The Greek tanker *Niriis* is standing by a mile off our port side and will remain in radio contact and visual contact until the naval vessel has us in sight. Pretty damned impressive results so quickly in the middle of the Atlantic Ocean!

"By 0830, a U.S. Navy helicopter flew over, and the crew spoke to us [by VHF marine transceiver], and then returned to the *Spica* to get more crew. A rescue swimmer will deploy from the helicopter and swim over to our boat and come aboard and assess the situation. The Navy ship is about 30 nautical miles [56 kilometers] away.

"The helicopter returned and the rescue swimmer jumped off and swam over. Once the rescue swimmer was aboard, we quickly told him about the blood in my urine — but not about my heart condition — and the rescuers decided it was best for me to return immediately to their ship. Unfortunately, the only way to get on the helicopter was to retrace the rescue swimmer's movements. I was to put on a life vest and rescue harness, jump into the water with him and swim over to the helicopter, and we'd be hoisted aboard by their winch and cable. He said that I may not be returning to the sailboat.

"I was wearing my rain-gear jacket and a pair of shorts. Knowing I may not be returning to the sailboat, I put my wallet, credit cards and … passport … into a small Ziploc bag and stuffed it into one pocket and closed the pocket with a Velcro

The crew of the U.S. Navy Ship *Spica* responded to the request by the U.S. Coast Guard for an open-ocean rescue.

Deployed from a helicopter after the malfunction of a winch, a life raft is retrieved after it provided flotation and shelter to Brian King and two rescue swimmers from the U.S. Navy Ship *Spica*.

fastener. I put my important heart medications into another Ziploc bag and, along with my two latest urine samples for the doctor, jammed them into the other pocket and sealed it tight. I put my sandals on as I'd need shoes to get home.

"I jumped into the water with the rescue swimmer off the back of the boat. From there, we swam toward the helicopter and the hoist cable. As we approached the helicopter, the rotor downwash and engine noise were incredible.

"We were floating up and down on the four-foot [1.2-meter] swells, and at the same time we were being hammered with spray from the rotor downwash. (I later learned from the pilots that close surface helicopter activity actually attracts sharks with the water disturbance and sound waves.) The rescue swimmer finally was able to grab the dangling cable, and he fastened us together and gave the sign to hoist us.

"Nothing was happening. No upward movement occurred. Then a little up movement occurred, but we could feel the cable slipping. Back down in the water we went. Then the helicopter moved backward with the two of us still attached at water level.

"With the speed that we were being dragged through the water, I was taking in a lot of salt water and was starting to panic. I slapped my hand hard on the rescue swimmer's shoulder to indicate trouble, and finally the helicopter stopped. The swimmer released his harness and left just me attached to the cable hoping that the hoist would raise me alone.

"Now I was being dragged around again, gulping more water. The cable started to raise me, but I could still feel it slipping, and over the next 10 minutes or so — who the hell knows? — I was up and down like a bungee cord, sometimes getting close to the helicopter and then being dropped again into the water."

Helicopter Rescue Fails

"At some time during this failed attempt to hoist me aboard, I lost … my underwear, shorts and one sandal. (Later, the pilot told me that she saw my shorts floating by down below.) I could feel myself slipping from the harness under my armpits. The harness prevented me from looking down to see how far off the water surface I was. I didn't start to slip right away, but only after several attempts at raising me up. Perhaps I was losing strength and not able to hold on properly. I elected to release myself from the harness — I didn't fall out — after being dragged one more time into the ocean. I realized by that time that the winch wasn't working and I was not going to reach the helicopter.

"By this time, I had lost sight of the first rescue swimmer who was with me; the helicopter came down close and a second rescue swimmer jumped in the water to be with me. So now he and I were floating in the swell trying to find the first swimmer. This second rescue swimmer who was with me had a radio — the first rescue swimmer didn't. I told him to radio his helicopter crew to get Tony back here to rescue us because clearly the damned cable hoist wasn't working. He did that and said that Tony was returning. So while we were in the water, we looked around and could see the mast of the boat getting closer, and I could also see the Navy ship heading toward us a long way off.

"Then, nearby us, we saw a smoke flare in the water and what turned out to be an upturned inflatable life raft dropped by the helicopter. [The crew of the helicopter had descended close to the surface to deploy the life raft and to deploy the second rescue swimmer without using the hoist cable, Collingridge said.] As the life raft got closer, we saw the first rescue swimmer with it, and then both rescue swimmers grabbed onto it and flipped it upright. The first rescue swimmer struggled aboard and then helped me. It was easy to gain access by crawling first onto an inflatable platform in front of the doorway. Then the second rescue swimmer climbed on. One of the swimmers started to feel seasick because of the motion of the life raft on four-foot swells for about 30 minutes.

"By this time, Tony had arrived, but we were safe on the life raft. As Tony went by, we yelled to him (because the second rescue swimmer's radio became inoperative) to throw me a pair of shorts. When Tony did the next drive by, I yelled to him to get my luggage ready because the rescuers would return for it after taking me to the ship. [Collingridge also provided drinking water to King and the rescue swimmers.]

"Now the *Spica* was nearby … a supply vessel for the U.S. Navy. They lowered their rigid inflatable speedboat, and it came over with some crew to rescue me and their two rescue swimmers. We quickly got to the ship, and a long ladder was lowered over the side. The crew climbed aboard the ship up the ladder and asked if I could climb the ladder.

"I looked up and said, 'My wife would kill me now if I had a heart attack and died half way up,' so I declined. Anyway, I was supposed to be sick and had already gone through the most challenging thing I've ever had to do. So they raised … the speedboat and me and some of the crew up to the deck rail, and I climbed aboard and … the ship's medical professional greeted me and whisked me off to an already-prepared warm bath and dry clothes in the sick bay. [The crew of the rescue boat returned to the sailboat to retrieve King's luggage.]

"After a quick interview, [the medical professional] was on the satellite phone talking to a physician about my symptoms and medications I was on. Turns out that my prescription blood thinner taken with the over-the-counter [nonprescription] laxative on board the sailboat was the cause of the bleeding.

"For the first time in my life — even after 30 years on the fire department — this was the first time I ever genuinely felt like I could die … I was really scared, and when I was dangling from the cable out there and being dragged

"I realized by that time that the winch wasn't working and I was not going to reach the helicopter."

through the water, I feared that I may not make it out of this one and never see my family and friends ever again. What an exhausting and emotional experience!"

The helicopter crew primarily was assigned to transfer cargo from the *Spica* to U.S. Navy marine vessels in the Mediterranean Sea, King said, and the crew was trained to conduct ocean rescues but had not conducted an actual rescue. Investigation of the helicopter hoisting problem revealed that the clutch had a mechanical problem that was not identified during normal preflight checks, King said.

In retrospect, King said that despite 27 years of sailing experience, he underestimated the physical demands of the voyage and the health-related limitations.

"Because I had no heart-related symptoms and did not 'max out' [exhaust myself] day to day during the previous voyage, I believed that I was fit for this adventure," he said. "After the first week, I knew that I did not belong there."

Collingridge sailed solo uneventfully for six days to Portugal, where he was met by a friend who helped to crew the sailboat to England. ■

The bottom line, in our opinion ...

- **The signal from an up-to-date registered 406-MHz emergency radio beacon with built-in GPS position reporting enables SAR authorities to confirm that the beacon probably is at the position detected by satellite.**
- **A 406-MHz beacon with built-in GPS position reporting can dramatically reduce the time to launch a rescue.**
- **A commercial ship and/or a military ship may be diverted to carry out a rescue — rather than launching SAR aircraft or SAR marine vessels — at a distress scene far out in the ocean.**
- **The rescue phase can be hazardous, under the best of conditions.**
- **Survivors must follow instructions of SAR personnel and must provide complete information about any condition that could affect the rescue.**
- **A VHF marine transceiver — carried by survivors or dropped by rescuers — makes communication more effective during on-scene SAR operations.**

Notes

1. King, Brian. E-mail communication with Rozelle, Roger, and telephone interviews by Rosenkrans, Wayne. Alexandria, Virginia, U.S. July 3, 2003; Aug. 27, 2003; Oct. 7, 2003; and Oct. 8, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
2. King. E-mail communication with Rozelle, Roger. Alexandria, Virginia, U.S. Nov. 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

Equipment and Training

Equipment and Training

This frog-like photographer ensured that both still images and video images were captured in the wave pool during the 2002 life raft evaluation.

A Life Raft Primer: Guidelines for Evaluation

— DOUGLAS S. RITTER WITH FSF EDITORIAL STAFF

An aircraft operator has a wide choice of aviation life rafts of different designs, construction and features. Nevertheless, these differences — and their influence on life raft performance — are not always readily apparent. For example, life rafts that meet the minimum standards required by a national civil aviation authority can vary considerably in their life-saving effectiveness. All life rafts are not created equal.

The parameters of the 2002 evaluation of aviation life rafts (and marine life rafts), and previous evaluations in 1993, 1996 and 2000, all of which were conducted in Arizona, U.S., by Douglas S. Ritter (and his wife, Sue), executive director of the Arizona-based Equipped to Survive Foundation, are described below. The 2002 evaluation, which was conducted with Flight Safety Foundation, August 23–25, reflects similar parameters under which the previous evaluations were conducted.

Moreover, the data in the evaluation (see "Life Raft Evaluation: Pooling the Resources," page 258) are a compilation of the results of the evaluations of aviation life rafts since 1993. As this article goes to press, some of the life rafts may not be in production (although they are likely to continue to be in use by aircraft operators for many years); current features and auxiliary equipment may be different than those tested; and the products were evaluated without regard to manufacturers' rankings of top-of-the-line vs. their most basic offerings. Nevertheless, the evaluations provide a practical means of understanding the range of designs, construction and features of life rafts offered by various manufacturers.

Although a wide range of aviation life rafts was evaluated in 2002, the Foundation focused on aviation life rafts with rated capacities of six occupants or more.

With the exception of the 1993 evaluation, which was conducted in a conventional swimming pool, the in-water evaluations were conducted in a large indoor wave pool with a trained lifeguard staff at the Kiwanis Park Recreation Center in Tempe. The wave-pool generates 3.0-foot to 4.0-foot (0.9-meter to 1.2-meter) waves, and provides a more realistic condition for probing the effectiveness of boarding devices, righting aids and some other features.

Still photographs and videotapes were made of deployments, boardings, capsizings and other actions associated with the life rafts. Two, and sometimes three, still photographers and three video photographers were positioned poolside to capture events as they unfolded throughout the evaluation. Under water, two scuba (self-contained underwater breathing apparatus)-equipped divers used a still camera and a video camera to capture images to allow evaluation of stability systems, boarding devices and capsizing effects. The divers were readily available during capsizing tests to assist volunteers in an emergency, which has never occurred in any of the evaluations.

After the in-water evaluation was completed, the life rafts were moved to a warehouse where each was inflated and was mounted on boxes to dry. Then each life raft was moved to a stand that allowed accurate measurement and photography. Each life raft's design, construction and features were noted. Some life raft components, such as sea anchors and manually operated inflation pumps, were removed from the life rafts and the performance of each component was assessed separately. Each survival equipment pack (SEP), often referred to as a "survival kit," was opened and the contents were recorded, examined and photographed.

Many of the volunteers with an array of aviation life rafts included in the evaluation.

Volunteers

The in-water evaluation was conducted with a diverse group of about 35 volunteers, typical of past evaluations (see "Life Rafts: Ask the Person Who's Tried One," page 293). They included men and women with a wide range of body types, heights, weights, physical conditions and ages.

Some volunteers had no previous water-survival training or any other experience with life rafts, while other volunteers had received water-survival training and/or had other experiences with life rafts in the military, aviation training or recreational boating. Reasons for participating in the three-day evaluation varied, but several of the volunteers wanted to use the experience as an opportunity to examine a variety of life

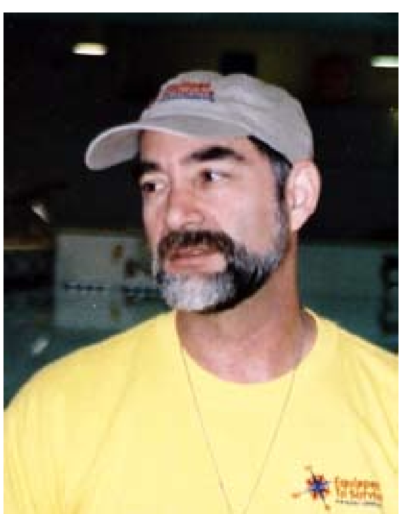
Modest simulation of heavy rain was far less than an ocean storm of heavy rain, high winds and breaking waves.

rafts to determine which products they wanted to purchase for use aboard aircraft or boats.

During the in-water evaluation, the volunteers wore long pants, shirts and shoes, in addition to an inflated life vest, to approximate how a person might be dressed and equipped to abandon an aircraft.

After each life raft was deployed in the water — usually by a poolside volunteer with no previous life raft experience — a mixed group of volunteers was assigned to jump into the pool, swim to the life raft, board it, sit in it, capsize it and right it. Where applicable, they located and retrieved the SEP, sometimes inside the life raft or sometimes on a line underneath the floating life raft, and they assembled and erected manual canopies. They were on the life raft when it was sprayed by water from a fire hose to simulate heavy rain, and when a buoyancy tube was deflated and freeboard (the distance from the water to the top of the remaining buoyancy tube) was measured. Immediately after each life raft evaluation, each volunteer recorded on waterproof paper comments about the experience and noted general and specific impressions of the life raft and his interaction with it, including things such as an irritating interior color; an unpleasant odor; a difficult or easy boarding experience; torn fabric; and ease of operation of zippers. Moreover, observing the volunteers and how they coped with the life rafts provided additional information for the evaluation.

Douglas S. Ritter's evaluations of life rafts have influenced the industry that builds them and educated the people who buy them.



Volunteers were instructed not to abuse the life rafts and the associated equipment, which should be expected to remain functional during the evaluation, a far less demanding environment than an actual survival event at sea.

Manufacturer Participation

Representatives from life raft manufacturers were excluded from the evaluation. Although most argued that they should be on site to respond to specific queries about their respective products, several volunteers who had participated in previous evaluations said that the representatives would have interfered with an already demanding, but carefully organized,

Life rafts were carefully stowed and checked for damage overnight between the daily sessions with volunteers in the wave pool.

three-day evaluation. They agreed that the presence of the representatives could influence the volunteers' enthusiasm to be the "experts" in the evaluation. Thus, their absence ensured that the volunteers could proceed without bias — intentional or unintentional — being injected by representatives rightfully eager to present their products as positively as possible.

In discussions with six of the seven manufacturers, most told FSF staff that improvements had been made to their products as a result of the previous evaluations, but that they wanted more input in evaluations of their products. And some people in the industry said that Ritter's evaluations inappropriately favored Winslow LifeRaft Co.

"We listen to anyone who suggests product improvements for our life rafts, including Douglas S. Ritter," said Fred Shoaff, an entrepreneur who in 1989 bought what later became Winslow LifeRaft Co. "Ritter has a lot of good ideas, and we have implemented some of them — not all of them — just those that made practical sense to us. Of course, any of the other manufacturers can choose to implement them, too. We have to be reasonable, however. We can't overdo redundancy, and we can't build a floating hotel, because the life raft would be too heavy to get out of the aircraft and too expensive to sell.

"As far as I'm concerned …[Ritter's evaluations] have been to the benefit of everybody out there, whether they like them or not. If he stops [conducting evaluations] somebody would need to take that up for the benefit of the industry. I don't know who that would be."

Ritter acknowledges that he could conduct his evaluations differently, but said that he treats each manufacturer's products the same and that the gold standard of independent consumer evaluations is that they are conducted without manufacturer involvement. Volunteers provide practical feedback, and manufacturers see innovations in their competitors' products.

A promotional photo, from the archives of Winslow LifeRaft Co., reflects a 1950s era of life rafts and how they were marketed.

"If we had an unlimited budget, we might do things differently," said Ritter. "But I think … we get a lot of valid data. In some cases, it's just a gross comparison, but the differences are gross enough that they are relevant. People can see them and understand them."

Regardless of evaluations, nearly all the life raft manufacturers described a common sales dilemma: The aircraft operators usually are interested in hearing about the latest life raft developments and in seeing the manufacturers' best products, but when it's time to purchase one, the operators often said, "Sell me the least expensive life raft you have that meets the [government] requirements."

Hoover Industries and Winslow LifeRaft Co. provided their products for the 2002 evaluation. Despite previous agreements to provide their life rafts, Air Cruisers and Goodrich elected not to provide their products for evaluation; Eastern Aero Marine declined to participate; Survival Products did not respond to repeated solicitations to participate.

Arrangements were made to purchase or to borrow life rafts marketed by these other manufacturers to use in the evaluation. Some models were no longer marketed but they differed little from current models (see Table 1, page 238, for current specifications of 10-person aviation life rafts offered by the manufacturers whose products were included in the 2002 evaluation).

Evaluating by the Regulations

While conducting the evaluation, an effort was made to confirm that the life rafts and their auxiliary equipment met applicable U.S. Federal Aviation Regulations (FARs) and Technical Standard Orders (TSOs) (see "Regulations, Judgment Affect Overwater Equipment Decisions," page 387). Those criteria establish minimum standards (although most manufacturers produce products that exceed the minimum standards). Moreover, the FARs closely mirror life raft requirements of other national civil aviation authorities, as demonstrated by manufacturers who have products that meet multiple requirements, such as Joint Aviation Requirements (JARs) and FARs (see "For Ditching Survival, Start With Regulations, But Don't Stop There," page 395).

Alternate means to meet some standards may be allowed, if the manufacturer demonstrates to the satisfaction of the regulatory authority — the U.S. Federal Aviation Administration (FAA), for example — that the alternate means provide an equivalent level of safety and performance. In assessing some TSO deviations, this principle was considered.

The life raft's functional criteria that affect survivability of the occupants were of most concern; these criteria include ease of deployment and operation; stability; ease of entry; protection from the environment; functionality; livability/comfort; auxiliary equipment; and quality of the life raft and its auxiliary equipment. Some criteria are more critical than others, but all should be considered when selecting a life raft.

Alternate means to meet some standards may be allowed.

Some contend that the most essential criterion is survival, so livability/comfort is less important or even unnecessary. Survival specialists and survivors counter that livability/comfort are of greater importance than others recognize.

Survival literature is replete with admonitions that the most important survival tool is a survivor's brain. The ability to take clear and rational decisions is essential in any survival situation. Particularly in water survival, the survival equipment must mitigate the effects of hypothermia, seasickness and dehydration in cramped, wet and cold conditions, which will influence any survivor's state of mind and the ability to take decisions (see "Is There a Doctor Aboard the Life Raft?," page 187). Weight and size of the packed life raft are important, too. If a life raft is too heavy to be easily lifted and to be launched from the floating aircraft, survivors could be robbed of its use.

All aspects of a practical evaluation do not lend themselves to objective measurement. For example, although no exact measurement was taken of the amount of water that entered each life raft when it was sprayed with water from a fire hose, the relative leakage rate of a life raft could be compared with the leakage rates of other life

Continued on page 242

Table 1

Specifications of 10-person Aviation Life Rafts, Approved Under FAA TSO-C70a, Type I[1]

For acronyms, references and an important note, see page 241.

Air Cruisers Co.
P.O. Box 180, Belmar, NJ 07719 U.S.
Telephone: +732-681-3527; Fax: +732-681-9163
Internet site: <www.aircruisers.com>

Excel 10-person

Life raft approval: FAA TSO-C70a; JAR-OPS 1.
Service life: Indefinite with proper maintenance.
Maintenance: Interval — Inflatable raft, six years; inflation system, three years.
Typical cost — US$400; shipping not included.
ELT options: 406 MHz; 121.5 MHz (standard). ELT maintenance interval: three years to five years (battery).
Katadyn Survivor-06 hand-operated water maker: Standard.
Vacuum packing: Optional.
SEPs offered: FARs Part 91; Part 121; Part 125; Part 135; JAR-OPS Part 1; CARs; custom.
Air Cruisers aviation models range from rated capacities of four to rated capacities of 56.

Certificated Repair Stations[2]

United States: Chino, California; Wall, New Jersey. Outside the United States: Ars, France; Mitry Mory, France.

Model no.	Cost (US$)[3]	Rated/ Overload Capacity	Buoyancy Tube Diameter (inches/ centimeters)	Canopy	No. of Water-ballast Bags x Freshwater Capacity (pounds/ kilograms)	Packed Dimensions (inches/ centimeters)	Floor Insulation	Weight (pounds/kilograms) Without SEP	With FARs Part 91 SEP	With FARs Part 135 SEP
Excel 10-person	7,700	10/15	9.1/23	Automatically inflatable	4 x 62.4/28.3 = Total 249.6/ 113.2	7 x 14 x 31/ 18 x 36 x 79	No	40/18	46/21	50/23
PaxAir 10-person	9,900	10/15	12/30	Automatically inflatable	4 x 62.4/28.3 = Total 249.6/ 113.2	15 x 10 x 33/ 38 x 25 x 84	Foam	62/28	72/33	72/33

Eastern Aero Marine
5502 N.W. 37th Avenue, Miami, FL 33142 U.S.
Telephone: (800) 843-7238 (U.S.); +305-871-4050; Fax: +305-871-7873
Internet site: <www.theraft.com>

VIP T1OAS

Life raft approval: FAA TSO-C70a.
Service life: Indefinite if raft passes periodic maintenance inspection.
Maintenance: Interval — three years. Typical cost — US$450–600; shipping not included.
ELT options: 406 MHz; 121.5 MHz/243 MHz. ELT maintenance interval: four years to five years, depending on model.
Katadyn Survivor-06 hand-operated water maker: Standard with FARs Part 135 SEP and JAR-OPS 3 SEP.
Vacuum packing: No.
SEPs offered: FARs Part 121; Part 135; Part 135/JAR-OPS 1; Part 121/JAR-OPS 1; Part 121/JAR-OPS 3/CARs; Part 135/JAR-OPS 3.
Eastern Aero Marine aviation models range from rated capacities of four to rated capacities of 46.

Certificated Repair Stations

United States: Anchorage, Alaska; Valencia, California; Van Nuys, California; Miami, Florida; Thunderbolt, Georgia; Hudson, Michigan; North Oakdale, Minnesota; Las Vegas, Nevada; Hackensack, New Jersey; San Juan, Puerto Rico; Houston, Texas. Outside the United States: Brisbane, Australia; Goussainville, France; Rome, Italy; Colonia Martin, Carrera, Mexico; Madrid, Spain; Stockholm, Sweden; Tokyo, Japan.

Model no.	Cost (US$)[3]	Rated/ Overload Capacity	Buoyancy Tube Diameter (inches/ centimeters)	Canopy	No. of Water-ballast Bags x Freshwater Capacity (pounds/ kilograms)	Packed Dimensions (inches/ centimeters)	Floor Insulation	Weight (pounds/kilograms) Without SEP	With FARs Part 121 SEP	With FARs Part 135 SEP
VIP T10AS[4]	5,230	10/15	11.25/29	Automatically inflatable	5 x 99.8/45.3 = Total 499/ 226.3	32 x 17 x 8/ 81 x 43 x 20	Inflatable floor (optional)	N/A	53.5/24	64.5/29
VIP Deluxe T10AS[4]	6,050	10/15	11.25/29	Automatically inflatable	55 x 99.8/45.3 = Total 499/ 226.3	32 x 17 x 9.5/ 81 x 43 x 24	Inflatable floor	N/A	67/30	78/35

Table 1
Specifications of 10-person Aviation Life Rafts, Approved Under FAA TSO-C70a, Type I[1] *(continued)*

Goodrich Corp.
Aircraft Interior Products
3414 South 5th Street
Phoenix, AZ 85040 U.S.
Telephone: +602-243-2200; Fax: +602-243-2300
Internet site: <www.aip.goodrich.com>

10-person

Life raft approval: FAA TSO-C70a.
Service life: Indefinite if passes periodic maintenance inspection.
Maintenance: Interval — initially two years, then annually.
Typical cost — US$300–$400; shipping not included.
ELT options: 406 MHz; 121.5 MHz/243 MHz. ELT maintenance interval: three years (121.5 MHz/243 MHz); five years (406 MHz).
Katadyn Survivor-06 hand-operated water maker: Standard.
Vacuum packing: SEP only.
SEPs offered: FARS Part 91; Part 121; Part 135; CARs; JAR-OPS 1; U.K. CAA AR-43.
Goodrich aviation models range from rated capacities of four to rated capacities of 12.

Certificated Repair Stations[2]
United States: Phoenix, Arizona; Van Nuys, California; Colorado Springs, Colorado; Riviera Beach, Florida; Thunderbolt, Georgia; Hudson, Michigan; Teterboro, New Jersey; Dallas, Texas; Houston, Texas; Seattle, Washington. Outside the United States: Eagle Farm, Queensland, Australia; Quebec, Canada; Dorval, Stansted, England; Paris, France; Singapore; Basel, Switzerland.

								Weight (pounds/kilograms)		
Model no.	Cost (US$)[3]	Rated/ Overload Capacity	Buoyancy Tube Diameter (inches/ centimeters)	Canopy	No. of Water-ballast Bags x Freshwater Capacity (pounds/ kilograms)	Packed Dimensions (inches/ centimeters)	Floor Insulation	Without SEP	With FARs Part 91 SEP	With FARs Part 135 SEP
10-person	8,800	10/15	9.5/24	Automatically inflatable	4 x 92.8/42.1 = Total 371.2/ 168.4	34 x 14 x 10/ 86 x 36 x 25	Inflatable floor	N/A	59/27	68/31

Hoover Industries
7260 N.W. 68th Street, Miami, FL 33166 U.S.
Telephone: +305-888-9791; Fax: +305-883-1925
Internet site: <www.hooverindustries.com>

FR-10

Life raft approval: FAA TSO-C70a.
Service life: Unlimited with proper maintenance.
Maintenance: Interval — two years. Typical cost — US$200–300; shipping not included.
ELT: Optional. Automatic-deploying 121.5 MHz /243 MHz. ELT maintenance interval: five years.
Katadyn Survivor-06 hand-operated water maker: Optional.
Vacuum packing: No.
SEPs offered: FARs Part 91; Part 121; Part 135.
Hoover Industries aviation models range from rated capacities of two to rated capacities of 46.

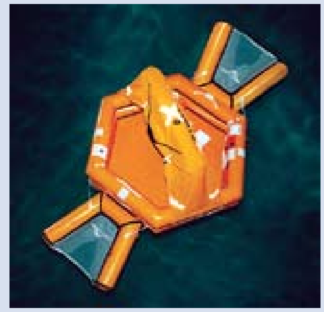
Certificated Repair Stations[2]
United States: Phoenix, Arizona; Cerritos, California; Miami, Florida; Honolulu, Hawaii; Belmar, New Jersey; Trenton, New Jersey; Bristol, Pennsylvania; Seattle, Washington. Outside the United States: Victoria, Australia; Rio de Janeiro, Brazil; Sofia, Bulgaria; Santiago, Chile; Bogotá, Colombia; Larnaca, Cyprus; Kent, England; Merseyside, England; Athens, Greece; Cangkareng, Indonesia; Belfast, Ireland; Tokyo, Japan; Mexico City, Mexico; Schiphol Airport, Netherlands; Panama City, Panama; Santiago, Rep. of Cabo Verde; Moscow, Russia; Singapore; Johannesburg, South Africa; Madrid, Spain; Palma de Mallorca, Spain; Basel, Switzerland.

								Weight (pounds/kilograms)		
Model no.	Cost (US$)[3]	Rated/ Overload Capacity	Buoyancy Tube Diameter (inches/ centimeters)	Canopy	No. of Water-ballast Bags x Freshwater Capacity (pounds/ kilograms)	Packed Dimensions (inches/ centimeters)	Floor Insulation	Without SEP	With FARs Part 91 SEP	With FARs Part 135 SEP
FR-10	4,877.48	10/15	12.5/32	Manually erected	3 x 4.9/2.2 = Total 14.7/6.7	14 x 26 x 10.5/ 36 x 66 x 27	No	47/21	64/29	74/33

Table 1

Specifications of 10-person Aviation Life Rafts, Approved Under FAA TSO-C70a, Type I[1] *(continued)*

RFD/Revere
3 Fairfield Crescent
West Caldwell, NJ 07006 U.S.
Telephone: +973-575-8811; Fax: +973-575-1788
Internet site: <www.reveresupply.com>



Aerolite 10

Life raft approval: FAA TSO-C70a; U.K. CAA BCAR A-4-8.
Service life: 15 years minimum.
Maintenance: Interval — one year. Typical maintenance cost — US$400; shipping not included.
ELT options: 406 MHz; 121.5 MHz. ELT maintenance interval: five years.
Katadyn Survivor-06 hand-operated water maker: Optional.
Vacuum packing: No.
SEPs offered: FARs Part 91; Part 135.
RFD/Revere Aerolite aviation models range from rated capacities of four to rated capacities of 11; "R" reversible series aviation models range from rated capacities of seven to rated capacities of 18.

Certificated Repair Stations[2]

United States: Cerritos, California; Fort Lauderdale, Florida; Thunderbolt, Georgia; Hudson, Michigan; Moonachie, New Jersey; South Hackensack, New Jersey; West Caldwell, New Jersey; Houston, Texas. Outside the United States: Through RFD Aviation network.

Model no.	Cost (US$)[3]	Rated/ Overload Capacity	Buoyancy Tube Diameter (inches/ centimeters)	Canopy	No. of Water-ballast Bags x Freshwater Capacity (pounds/ kilograms)	Packed Dimensions (inches/ centimeters)	Floor Insulation	Weight (pounds/kilograms) Without SEP	With FARs Part 91 SEP	With FARs Part 135 SEP
Aerolite 10	5,770	11/17	10.8/27	Arch tubes automatically inflatable	4 x 37.8/17.1 = Total 151.2/ 68.6	33 x 18 x 9/ 84 x 46 x 23	Inflatable floor	N/A	57.5/26	66.8/30
F10R (Reversible)	6,458	10/15	10.8/27	Manually erected	None	32 x 18 x 8/ 81 x 46 x 20	Single floor is between tubes	N/A	76/34	85/39

Survival Products
5614 S.W. 25th Street
Hollywood, FL 33023 U.S.
Telephone: +954-966-7329; Fax: +954-966-3584
Internet site: <www.survivalproductsinc.com>

10-Man

Life raft approval: FAA TSO-C70a.
Service life: Indefinite if properly maintained.
Maintenance: Interval — one year. Typical cost — US$205; shipping not included.
ELT Options: 406 MHz; 121.5 MHz/243 MHz. ELT maintenance interval: One year to two years.
Katadyn Survivor-06 hand-operated water maker: Optional.
Vacuum packing: No.
SEPs offered: FARs Part 91; Part 121; Part 135.
Survival Products aviation models range from rated capacities of four to rated capacities of 12.

Certificated Repair Stations[2]

United States: Honolulu, Hawaii; San Juan, Puerto Rico; St. Thomas, U.S. Virgin Islands. Outside the United States: Castle Hill, Australia; St. Johns, Newfoundland, Canada; Winnipeg, Canada; Santa Cruz de Tenerife, Canary Islands; Roskilde Airport, Denmark; Thistead, Denmark; Saumur, France; Banzin, Germany; Castenedolo, Italy; Tokyo, Japan; Edinburgh, Scotland; Celje, Slovenia; Fahrwangen, Switzerland; Caracas, Venezuela.

Model no.	Cost (US$)[3]	Rated/ Overload Capacity	Buoyancy Tube Diameter (inches/ centimeters)	Canopy	No. of Water-ballast Bags x Freshwater Capacity (pounds/ kilograms)	Packed Dimensions (inches/ centimeters)	Floor Insulation	Weight (pounds/kilograms) Without SEP	With FARs Part 91 SEP	With FARs Part 135 SEP
10-Man	4,112	10/15	10/25	Manually erected	2 x 124.8/ 56.6 = Total 249.6/113.2	7 x 14 x 19/ 13 x 36 x 48	No	32/14	43/19	48/22

Table 1

Specifications of 10-person Aviation Life Rafts, Approved Under FAA TSO-C70a, Type I[1] *(continued)*

Winslow LifeRaft Co.
11700 Winslow Drive, Lake Suzy, FL 34269 U.S.
Telephone: (800) 838-3012 (U.S.); +941-613-6666; Fax: +941-613-6677
Internet site: <www.winslowliferaft.com>

Super-Light Ultima

Life raft approvals: FAA TSO-C70a; U.K. CAA BCAR-B-4-8; DGAC QACI-144.

Service life: 10–15 years.

Maintenance: Interval — three years. Typical cost — US$450 (raft only); shipping not included.

ELT Options: 121.5 MHz/243 MHz; 121.5 MHz/406 MHz;121.5 MHz/243 MHz/406 MHz with full speech capability. ELT maintenance interval: five years.

Katadyn Survivor-06 hand-operated water maker: Standard.

Vacuum packing: Standard.

SEPs offered: FARs Part 91/121; Part 135; JAR-OPS 1; JAR-OPS 1/FARS Part 135; CARs.

Winslow aviation models range from rated capacities of four to rated capacities of 15.

Certificated Repair Stations[2]

United States: McNeal, Arizona; La Mirada, California; Van Nuys, California; Lake Suzy, Florida; Miami, Florida; Riviera Beach, Florida; Thunderbolt, Georgia; Oakdale, Minnesota; South Hackensack, New Jersey; Dallas, Texas; Houston, Texas; Tukwila, Washington. Outside the United States: Wayville, South Australia, Australia; Dartmouth, Nova Scotia, Canada; Stansted Airport, England; Mereuil le Meaux, France; Goroka, Papua New Guinea; Basel Airport, Switzerland.

Model no.	Cost (US$)[3]	Rated/ Overload Capacity	Buoyancy Tube Diameter (inches/ centimeters)	Canopy	No. of Water-ballast Bags x Freshwater Capacity (pounds/ kilograms)	Packed Dimensions (inches/ centimeters)	Floor Insulation	Weight (pounds/kilograms) Without SEP	With FARs Part 91 SEP	With FARs Part 135 SEP
Ultra-Light 1015FAUL	7,414	10/15	9/23	Automatically inflatable	5 x 79.2/36 = Total 396/180	9 x 18 x 32/ 23 x 46 x 81	Inflatable floor	N/A	54/24	64/29
Super-Light Ultima 1015FASL	7,414	10/15	11.25/28.58	Automatically inflatable	5 x 79.2/36 = Total 396/180	9 x 18 x 34/ 23 x 46 x 86	Inflatable floor	N/A	66/30	75/34

Note: This table presents specifications of similarly sized life rafts by the manufacturers whose life rafts were evaluated in 2002 (see "Life Raft Evaluation: Pooling the Resources," page 258). Most models of the life rafts in this table were not included in the 2002 evaluation; contact manufacturers for the most current specifications and costs. Any specifications or opinions given in the evaluation may not apply to current models.

CARs = Canadian Aviation Regulations DGAC = French Direction Générale de L'Aviation Civile ELT = Emergency locator transmitter
FAA = U.S. Federal Aviation Administration FARs = U.S. Federal Aviation Regulations JAR-OPS = Joint Aviation Requirements — Operations
N/A = Not applicable SEP = Survival equipment pack TSO = Technical Standard Order U.K. CAA = United Kingdom Civil Aviation Authority

[1]Type is based on requirements of U.S. Federal Aviation Administration Technical Standard Order (TSO)-C70a. Type I life rafts are approved for any category of aircraft. They must be of independent-double-tube construction. Type II life rafts are approved for nontransport-category aircraft. They may be of single-tube construction but the tube must contain two independent chambers. For the full text of TSO-C70a, see page 396.

[2]Maintenance must be performed at repair stations certificated by a civil aviation authority such as the European Joint Aviation Authorities, FAA or U.K. CAA. If certificated by FAA, the repair station must also have a limited rating to repair specific items of emergency equipment (FARs Part 145.61). Manufacturer-authorized repair stations meet the manufacturer's qualifications for service and repair. Those qualifications may include training, manufacturer-specified tools and a current copy of the manufacturer's Component Maintenance Manual.

[3]Costs are based on each TSO-C70a Type I life raft equipped with a canopy (inflatable or mechanical), floor insulation, valise pack, and FARs Part 91 SEP. If any of these features are absent, they are noted in the table.

[4]Cost includes a Part 121 SEP.

Source: Manufacturers, January 2004, with FSF editorial staff

Volunteers were uniformly surprised that the wave pool created conditions that so dramatically influenced boarding life rafts and floating in life vests.

rafts that were evaluated. The occupants provided first-hand observations about how much water was entering the life raft and where the leaks were occurring — along a sewed seam or zipper, or at points where fabric had been torn during boarding. The interiors of some of the life rafts remained relatively dry, but others were described as being in a "waterfall." Which life raft would you prefer to be aboard? Thus, subjective judgments were made of how much water was leaking into the life raft.

Many of the stenciled instructions and placards on these life rafts were difficult to read. Some manufacturers make excellent use of easily understood pictograms. Readily available information, quickly identified and easily understood, is essential for survivors— most of whom, will be having their first experience with a life raft.

No Experience Required?

In conducting these evaluations, an important assumption is made, based on reviews of survival incidents and interviews with survivors: The survivor is assumed to have no familiarity with a life raft and its auxiliary equipment.

Informal polls conducted by Ritter at several National Business Aviation Association (NBAA) Annual Meeting & Convention venues have shown that aircraft crews — pilots and flight attendants — often lacked familiarity with life rafts aboard their aircraft. Surprisingly, these polls reflected similar unfamiliarity among FARs Part 135 aircraft crews. Moreover, aircraft crewmembers who have been trained to use life rafts may have had minimal training or they may have been trained with equipment not carried aboard their aircraft. Even if a crew is well trained, the crew may not survive a ditching, so the untrained passengers will be responsible for determining how to exit the aircraft and how to deploy the life raft. Similar informal polls by FSF editorial staff at the Foundation's 2003 annual Corporate Aviation Safety Seminar echoed Ritter's findings.

A life raft and its auxiliary equipment should be as foolproof as possible. Opportunities to further threaten survival should be eliminated, and how to use the equipment should be obvious/intuitive to the average-intelligence, non-mechanically-inclined person. The life raft should be designed and equipped to take care of the survivor; it should demand little or nothing of the survivor who may be unable to do much in his behalf: The worst-case scenario is a lone and injured survivor. How well do the life raft and its auxiliary equipment fulfill their roles in this scenario?

While no life raft of reasonable size, weight and cost will be ideal in every scenario, large minorities of people are not "average." Moreover, in today's population — especially in the United States — the average does not represent a particularly healthy or physically able person; observing a variety of people struggle into life rafts has proved this. Significantly smaller-than-average persons; heavy individuals — especially those who are bottom heavy; and those without adequate upper-body strength are at a life-threatening disadvantage because they often have difficulty boarding some life rafts.

Life raft performance is, for the most part, gender neutral, although some physical traits affecting performance may be more likely among one gender than the other. For example, when we refer to sizes and weights of the volunteers in relation to life raft performance, we are considering the average volunteer to weigh 170 pounds (77 kilograms) and to be five feet, six inches (1.7 meters) tall, regardless of gender. "Short" volunteers are less than five feet, six inches tall and represent a greater proportion of female volunteers than of male volunteers. Typically, those who are considerably shorter will have more difficulty boarding life rafts than those who are slightly shorter.

Some claim that adrenaline will provide survivors with the necessary strength to overcome the obstacles of boarding a life raft. In many situations, this has been true, but other things can mitigate the influence of this performance-enhancing hormone, which sometimes allows super-human effort. Shock, age, injuries, extreme cold and exhaustion can diminish overall physical — and mental — capacities. Passengers may also be under the influence of illness, fatigue, alcohol or drugs (prescription and over-the-counter). Although adrenaline fuels the "fight-or-flight response" by raising metabolic rates to meet a physical challenge, in its aftermath, a survivor may be left with a significantly reduced reserve of energy to meet additional challenges. This will be exacerbated if a survivor is required to perform a demanding physical activity only made possible by the adrenaline boost. Moreover, sudden stress and the accompanying flood of hormones can initiate incapacitating levels of shock. The design of lifesaving equipment must not assume extraordinary effort or fortunate circumstances.

Sum of Its Parts

Most of the life rafts included in this evaluation have at least a few features that are better than average compared with the others. Some have several such features. Many have features that, although not outstanding, offer an acceptable level of performance for a specific use. But a few good features, or even many good features, do not guarantee a good life raft.

A life raft, especially a well-designed and well-constructed model that boasts many desirable features, is similar to an aircraft in that it is the sum of its parts. Consider the various parts and features of a life raft as a system on an aircraft. If a

Fifteen people — the overload capacity of a 10-person aviation life raft — may be a laughing matter for some people in the pool evaluation, but when floating on an ocean everything would be would focused on survival.

Inexperienced volunteers were selected to deploy the life rafts. They were allowed to read the directions and to deploy the life raft from the side of the pool, as if they were standing at an open cabin door.

critical system does not function well or does not function well in combination with other systems, it may overcome other — perhaps many other — positive attributes. A life raft is more than a lifesaving device: A life raft is a lifesaving system.

Basics

At its simplest, a life raft is a device to support survivors out of the water to improve the likelihood of their survival. With the rate of heat exchange for a person floating in water generally accepted to be 25 times that of a dry person in still air, the advantage of being out of the water is obvious. The life raft also serves as a refuge from marine life (see "What's Eating You? It's Probably Not a Shark," page 211).

Providing survivors a platform out of the water can be accomplished with a simple design: an inflatable ring (buoyancy tube) glued to a fabric floor that will support a specific number of occupants. Some unapproved life rafts are no more sophisticated than that, and they are used in light recreational aircraft. Regulatory authorities, however, have established requirements for approved life rafts, which require additional features to enhance survivability. Nevertheless, at the low end of the market, even an approved life raft may not be much more sophisticated than its unapproved sibling.

Stowage

The life raft is packed in a valise (often called a "soft pack") or a hard case that provides more protection from the environment (e.g., water, sun, dirt, spills), rough handling and inadvertent deployment. Weight is an essential element in the design and operation of an aircraft, and may result in the selection of smaller and less capable life rafts. Moreover, the interiors of some aircraft are installed without adequate consideration of such equipment as life rafts, evidenced by the oddly shaped custom-packed life rafts produced for some specific aircraft configurations. The more capable life rafts tend to be larger packages than the less capable life rafts so stowage constraints can limit lifesaving capabilities.

Most aircraft manufactures specify a standard available life raft or life rafts; some offer options from among different life raft manufacturers. That is not to say that an operator cannot specify a particular life raft. Most aircraft manufacturers will accommodate such requests if the product fits in the available space, or if it can be accommodated by reasonable changes in interior configuration or by some other means, such as custom packaging by the life raft manufacturer.

Deployment

Deployment requires that the life raft must be retrieved and moved — dragged or carried — from stowage to an exit, where a crewmember or a passenger must locate, read and understand the instructions printed on the valise or hard pack, possibly with minimal illumination. Then the life raft must be moved outside the aircraft cabin and deployed (see "Prepare to Ditch," page 20).

Stored-gas inflation systems are installed on these life rafts. A high-pressure cylinder — typically constructed of aluminum, steel or a composite material — usually is charged with carbon dioxide and a smaller amount of nitrogen, the conventional industry practice. Faster inflation can be accomplished by using nitrogen as the primary inflation gas with a lesser amount of carbon dioxide. Moreover, nitrogen is not affected significantly by cold-weather temperatures. Carbon dioxide, on the other hand, may barely meet the TSO-

C70a one-minute requirement that the life raft be "rounded out" at the temperature specified by the manufacturer, typically –30 degrees Fahrenheit (F; –34 degrees Celsius [C]) (see "FAA Technical Standard Order (TSO) C70a, *Life Rafts (Reversible and Nonreversible),*" page 396).

On the high-pressure cylinder, a valve is activated by pulling a lanyard (via the mooring/inflation line or an immediate-inflation handle). Thus, the gas is released to inflate the life raft's buoyancy tube(s), and on some life rafts, canopy supports and boarding aids.

Shapes, Fabrics and Construction

Aviation life rafts are constructed in three basic shapes: round or nearly so — hexagonal (six sides), octagonal (eight sides) or decagonal (ten sides)— square and rectangular (with rounded ends). Round life rafts comprise the majority of aviation life rafts in service.

Round or nearly round life rafts favor no particular side and exhibit little of the fishtailing, bending and twisting associated with rectangular life rafts, and to a lesser degree, square life rafts, but survivors may be uncomfortable sitting against the inside rim of the life raft with their legs intertwined in the center.

Square and rectangular shapes, which can be more easily produced and provide more usable room for survivors, have corners that can dig into the waves, which can trip the life rafts and lead to capsizing.

The square and rectangular shapes have fewer joints to fail, but technology has made such failures a rarity. Octagonal and decagonal life rafts are inherently stiffer than round, square or rectangular shapes, because spliced sectional construction increases their strength and rigidity. Seams should overlap — butt joints are undesirable — and should be taped on both sides — inside and outside. Depending on the material, seams may be glued or welded using heat and pressure.

Sea Anchor

A major key to the stability of a life raft — regardless of shape — is the sea anchor, an essential component for stabilizing the life raft in the water and reducing drift. The typical life raft sea anchor — a fabric parachute-like drag device — is attached ideally to a swivel at the end of a line not less than 25-feet (7.6-meters)-long that is secured to the life raft. The swivel allows the sea anchor to rotate freely so the bails (shroud lines), which help hold the shape of the sea anchor when it is deployed in the water, will not become entangled and reduce the sea anchor's effectiveness. Studies have shown that without a swivel, frequent twisting of the sea anchor line can result in its failure and the loss of the sea anchor.

If the sea anchor is deployed automatically with the deployment of the life raft, survivors are relieved of an essential task, while added life raft stability is available immediately. Advocates of manual deployment of sea anchors claim that entanglement of the sea anchor with the ditched aircraft is prevented, but evidence of such entanglements has not been reported. Manual deployment enables survivors to ensure that the sea anchor line is not tangled during deployment; tangled sea anchor lines have occurred with auto-deployments. Survivors, however, must know how to deploy the sea anchor, and instructions frequently are absent or incomplete. Ideally, the life raft's primary entrance will be downwind — protected from the wind and waves — from the sea anchor deployed on the opposite side of the life raft, which will help prevent the life raft from lifting above the water

A volunteer is surrounded by the variety of sea anchors that were removed from the life rafts during the evaluation in the wave pool.

and allowing wind under the life raft to precipitate a capsizing.

Sea anchors were evaluated independently from the life rafts. The sea anchors were towed through the water in the wave pool to allow underwater observation and underwater photography. With the assistance of the U.S. Coast Guard Auxiliary, Division 10, the sea anchors were deployed and were towed slowly behind a powerboat in calm weather conditions on Saguaro Lake in Arizona. In turn, each line was attached to a spring scale to measure its relative drag and the effect of increasing and decreasing the length of the sea anchor line.

Of particular concern is what happens if the sea anchor is lost or is improperly deployed, neither of which is an uncommon experience, as documented by the reports of many survivors and by studies by maritime safety organizations. Without a functioning sea anchor, a rectangular life raft turns quickly broadside to the swells and waves, a position that is more vulnerable to capsizing of rectangular life rafts than other shapes.

Nevertheless, Earl Hinz, an well-known sailing author and retired aerospace engineer, wrote, "An octagonal (or nearly circular [life] raft), which loses its sea anchor, is highly susceptible to a phenomenon known as 'carouseling' where the [life] raft rotates rapidly (as a carousel) causing dizziness in the occupants." Hinz was unable to cite first-hand details about specific incidents of carouseling and said that his information "came from a series of … Internet forums."[1].

A naval architect disagreed with the carouseling theory.

"Carouseling — rapid spinning of a life raft that would cause dizziness as in a carnival ride— makes no sense with basic physics. Such a thing is laughable," said Prof. Dr. Ing. Fen-Dow Chu, a naval architect at the State University of New York Maritime College.[2] He and Hinz agreed that some survivors might become nauseous even during the most benign movements while in a life raft.

No substantive data were found to suggest that carouseling exists, but there were some reports that round-type life rafts (and other configurations) without a sea anchor may rotate randomly in the water, which could orient the life raft's primary entrance to face the wind and waves.

Steve Callahan, another sailing author and naval architect who survived 76 days adrift in a six-person marine round-type life raft, said, "My own [life] raft would have [rotated] had I not stabilized it, first with a drogue [sea anchor]… ."[3] Callahan said that he believes that after the loss of a sea anchor, a life raft equipped with an asymmetrical ballast system could continue to orient the life raft's primary entrance downwind. This, he said, would prevent any rotation from allowing the primary entrance's exposure to breaking waves.

Stability of the life raft is essential.

Sunny Side Up

Stability of the life raft is essential. Survivors' accounts often report that their life rafts capsized repeatedly, frequently losing supplies, equipment and other survivors. A sea anchor and life raft ballast are the two principal devices that help to prevent the life raft from capsizing, but the shape of the life raft and center of gravity also contribute to keeping the life raft right side up in rough seas. Individually, they do not prevent capsizing as well as when they function together as a system.

Life raft ballast includes the survivors and equipment in the life raft, and water contained in ballast bags, which are attached to the bottom of the life raft and provide the most effective ballast. Weights are sometimes used in the bottom of the water-ballast bags to ensure that they function as quickly as possible to enhance stability after deployment of the life raft. Openings — usually in the highest part of each bag — allow water to fill the bags, and ensure that if the bags are lifted from the water, the water ballast does not drain from the bags.

When submerged, water-ballast bags have neutral buoyancy; they become effective ballast only when the life raft begins to lift the water-ballast bags from the water. Water-ballast bags are intended to help the life raft resist lifting, which allows the wind to blow under the life raft. The more of the underside that is exposed, the greater the opportunity for the wind and the waves to combine to capsize the life raft.

Some manufacturers have attached lines to the water-ballast bags so that survivors can pull the bags upward, allowing far less room for the collection of water and creating less drag. In some conditions, this might allow the life raft to be blown faster with the wind or water current, or to be "sailed" by using the canopy as a sail.

To provide a means of comparing water ballast bags among the life rafts, the water ballast bags were measured (as accurately as was practical considering their flexible construction), and the approximate volume and the weight of fresh water each could hold was calculated. Although the measurements are not precise, they provide a comparison of gross differences in water-ballast capacity. Too little water ballast, and the life raft can be capsized more easily. Too much water ballast in poorly constructed fabric bags could cause a fabric failure when the bags will be needed most. None of the water-ballast bags was determined to be too large for its construction, though there was some tearing of fabric and seams. Simply stated, life rafts with effective water-ballast bags are more difficult to capsize than those with less effective water-ballast bags or no water-ballast bags. Volunteers capsized each of the life rafts to evaluate the effectiveness of the ballast and to assess the effect of capsizing on the life raft's structure and its occupants. Essentially, this provided a gross comparison of how easy or how difficult it was to capsize a life raft, and that allowed comparison with other life rafts. Combined with our measurements of the water-ballast bags, test of the sea anchor, the shape of the life raft, and appropriate numbers of volunteers assigned to each life raft, a subjective estimate of stability and resistance to capsizing was possible.

Survivor ballast is secondary to water ballast, and the value of survivor ballast diminishes with fewer than the maximum capacity of the life raft (i.e., only one survivor or two survivors in a life raft rated for six or more survivors). The heaviest single piece of equipment is usually the inflation cylinder and its associated hardware, which is most often mounted on the outer side of the life raft, but the ballast effect of this equipment is negligible.

The stability of most life rafts depends on water-ballast bags and a sea anchor. Without these essential aids, an aviation life raft of any shape is at the mercy of wind, waves and swells, and in rough sea conditions, survivors will be guaranteed a brutally uncomfortable experience that will include dramatic movement in every axis. And you can be sure that dizziness and nausea will be part of the experience for many survivors in such conditions.

Construction Material

Late 1995 marked the introduction of polyurethane-coated fabric (PCF) into the U.S. general aviation life raft. The life raft manufacturers claimed extended service life for the material, which has the potential of saving operators money; other claimed advantages, such as increased abrasion and puncture resistance, and light weight, appealed to operators.

Nevertheless, these aviation life rafts were all single-coated PCF (i.e., applied to only one side of the nylon fabric substrate); marine life rafts use double-coated fabric. The single coating could compromise the life raft's integrity under some conditions. Some manufacturers fabricated their life rafts with the coated side outside and others fabricated their life rafts with the coated side on the inside. The coat-

The stability of most life rafts depends on water-ballast bags and a sea anchor.

ing provides the air seal on the buoyancy tube. If the coating is damaged, the air can leak out. The coating also provides virtually all the abrasion and puncture resistance, while the nylon fabric provides most of the material's strength.

Manufacturers' samples of the fabrics used in the buoyancy tube(s) and canopies were tested against claims of PCF's improved resistance to puncture and abrasion, compared with a more traditional material — nylon fabric coated on both sides with neoprene, a synthetic rubber, which has proven itself as a durable and reliable material for many years for marine life rafts (and inflatable boats); in lighter-weight fabrics, the coated neoprene material is used for aviation life rafts. Hazardous solvents and glues are used to construct life rafts from this neoprene, which requires construction by hand.

Lacking access to sophisticated testing methods, practical tests were used that would demonstrate any significant advantages of the products but might not reveal minor differences.

To measure puncture resistance, samples were placed under very light tension and attempts were made to puncture and slice the fabric using a large fishhook (puncture) and a knife (puncture and slice). PCF was noticeably more difficult to puncture, compared with traditional fabric, when PCF was tested on the coated side. When tested on the uncoated side, as used by some manufacturers, there was noticeably less resistance to puncture, and PCF performed about equal to, or perhaps slightly better than, traditional fabric.

The coated side of the PCF was much more resistant to slicing. The uncoated side, was easily sliced — much more easily than the traditional material. Thus, exposing the uncoated side appears to negate some of the advantages of PCF.

To test abrasion resistance, 180-grit sandpaper attached to a convex sanding block was used to sand through the PCF. The coated side proved more resistant than traditional fabric. The uncoated side of PCF was less resistant than the traditional fabric.

For 2000, we had developed a more objective test apparatus to test fabric resistance to puncture and abrasion, made more important by a greater diversity of fabrics for marine life rafts and the manufacturers' sometimes conflicting claims about their benefits, including a longer useful life. Unfortunately, some of the manufacturers declined to provide samples because they said that consumers would not be able to make value judgments about the relative importance of

PCF performance in the tests vs. the light weight of aviation life rafts.

A significant amount of the performance advantage of PCF is lost when used with the uncoated side outside, because damage to the coating allows air to leak from a buoyancy tube. This problem would not be a concern if double-coated PCF were used, but then it would be much heavier, an undesirable quality in aviation life rafts.

For the manufacturers, PCF has been attractive because it can be welded by a variety of processes, usually by the application of heat and pressure. Moreover, welding lends itself to mechanical production and cost savings.

Properly maintained and serviced, neoprene-coated life rafts have remained serviceable for as long as 20 years. Moreover, neoprene-coated material appears more resistant to fungus and environmental degradation than PCF, claims that will be proven only after PCF has additional time in the marketplace.

Material is only one element of a life raft's performance.

Material is only one element of a life raft's performance. The best materials and most advanced construction techniques will not save your life, but inadequate materials and poor construction can doom any life raft. In-use failures of life rafts seem to be most often associated with construction and maintenance.

Redundancy

While these life rafts are constructed of tough fabric that will withstand some abuse, including a small and sharp knife blade dropped point down onto the raft, the life raft remains vulnerable to puncturing. For example, a puncture can be caused by the sharp aluminum of the damaged structure of a sinking aircraft. A puncture is always possible, but redundancy will save the day.

Redundancy is accomplished by either dividing a single buoyancy tube into multiple independent compartments or by having two independent tubes. TSO-C70a, which cites the requirements for approved life rafts under the FARs, defines this distinction as a "type" of life raft. Counter-intuitively (and the source of frequent confusion), the TSO defines two types: A Type I life raft, which can be used in any category of aircraft, has two independent buoyancy tubes, one stacked and attached to the top of the other; a Type II life raft, which can be used only in non-transport category aircraft, has a single buoyancy tube constructed with internal bulkheads that divide the tube into at least two independent chambers. (None we tested had more than two.)

In all currently produced Type II life rafts, the single buoyancy tube is divided in half with vertical bulkheads within the tube. When one chamber of the life raft is deflated, survivors must gather in the remaining half circle of a tube, and the other half is open to the water across the diameter of the life raft; the deflated half floats in the water and is incapable of supporting any significant weight. It is unlikely that survivors in the life raft at its rated capacity will fit in the half life raft that remains inflated. Moreover, the survivors must fold the deflated section inward to separate the survivors from the water. The deflated section allows some buoyancy, and repairs can probably be made in this situation, but with great difficulty. Just a partially deflated chamber presented difficulty for the volunteers, and they agreed that this would be a very distressing problem in open water.

Type I life rafts are manufactured in nonreversible and reversible styles. A nonreversible life raft has the floor attached to the bottom of the lower tube; a reversible life raft has the floor sandwiched between the two tubes. As the designation suggests, a nonreversible life raft only has only one side that is designed for occupancy; if it inflates upside down or capsizes, the life raft must be "righted" — turned right side up by the survivors — before they can board the life raft. If one of the buoyancy tubes deflates, the remaining buoyancy tube freeboard will help prevent water from entering the life raft and provide the survivors a reasonable platform to make repairs.

Although reversible life rafts have no specific "upright side" for purposes of stability, the occupied side becomes the de facto upright side. A Type I reversible life raft with the floor sandwiched between the two buoyancy tubes may have a higher

This Type II four-person aviation life raft is at overload capacity with six persons; the U.S. Federal Aviation Administration has determined that it meets the minimum requirements.

center of gravity than a Type I non-reversible life raft. Thus, the reversible life raft may be more prone to capsize, all other qualities being equal. Some reversible life rafts are said to be designed to create a suction effect between the water and the life raft that is reputed to resist capsize.

Capacity

Life raft capacity is rated by factors that include floor area, seating space and buoyancy. "Rated capacity" is the number of survivors that the life raft must hold with a minimal amount of space for each survivor and a specific degree of buoyancy. TSO-C70a requires a minimum of 3.6 square feet (0.3 square meter) per person unless an alternate seating demonstration method is utilized, in which case as little as 3.0 square feet (0.3 square meter) is acceptable. (3.6 square feet is almost 23 inches x 23 inches [58 centimeters x 58 centimeters]. Mark that area on the floor, sit within the space and ponder how life could be for hours or days in that amount of space.)

Aviation life rafts have an "overload capacity." Generally, this amounts to half again more than the rated capacity: six people, for example, in a four-person life raft and nine people in a six-person life raft. Nevertheless, the overload capacity must provide no less than 2.4 square feet (0.2 square meter) per person. If the volunteers complain of a tight fit at rated capacity, at overload capacity they were packed so tightly that they experienced physical pain; movement was impractical and difficult.

We carefully measured and calculated the interior floor space of the life rafts. Only one life raft did not meet the 3.6 square feet per person standard. Some of the life rafts provide more space, and the configuration and shape can make a difference in livability/comfort. Regardless of how life rafts are measured, there is not much space for survivors. "Close" takes on new meaning in a life raft.

Although marine life rafts that are built to specifications of the International Convention for the Safety of Life at Sea (SOLAS) provide 4.0 square feet (0.4 square meter) per person, survivors remain crowded. Lack of space is a common complaint and a major detriment to the comfort and morale of survivors.

Some aircraft operators have determined that a few extra pounds and a larger package are acceptable and up-sized their life rafts to allow more space for survivors. For example, the operator of an aircraft that normally carries an eight-person life raft replaces it with a 10-person life raft or 12-person life raft. This is a good strategy if the life rafts have sufficient water ballast and an effective sea anchor, but up-sizing to increase space probably should not exceed 50 percent of the *expected* rated capacity, because the life raft's stability may be diminished in rough seas without the additional weight of the occupants.

Freeboard

Freeboard is the distance from the water to the top of the buoyancy tube(s). Generally, a higher freeboard is found on life rafts with two

Inflatable boarding ramps have made boarding much easier for volunteers.

buoyancy tubes than life rafts with a single buoyancy tube. Moreover, the diameter of the buoyancy tubes can vary within the same line of life rafts, thus changing freeboard, all other things being equal (a larger-diameter buoyancy tube increases freeboard and a smaller-diameter buoyancy tube decreases freeboard). Higher freeboard provides greater protection from waves and a more comfortable backrest for survivors. Higher freeboard is an important aid in rough seas because the survivors must brace themselves against the buoyancy tube(s) to prevent being tossed about by the motion of the life raft. Nevertheless, higher freeboard adds to the difficulty of boarding the life raft from the water. The higher the freeboard, the greater the need for very effective boarding aids. Type I reversible life rafts generally trade somewhat lower freeboard and a less comfortable backrest for a life raft that does not require righting.

During the evaluation, freeboard was measured at rated capacity and at overload capacity. The total weight in each life raft was adjusted with specific volunteers, all of whom had been weighed at poolside before the evaluation was begun. Supplemental ballast (5.0 pounds [2.3 kilograms] of lead shot in plastic bottles and/or 10.0 pounds [4.5 kilograms] of pea gravel in plastic bottles) was used to adjust the appropriate weight. Freeboard measurements were taken around the life raft, typically at each joint or at eight positions to 10 positions on round and rectangular life rafts, then averaged.

After the measurements were taken at rated capacity, the life raft was loaded to overload capacity and measured. Next, the lower buoyancy tube was deflated by removing or opening the pressure-relief valve (PRV) or topping valve to simulate a puncture, and freeboard was measured.

The PRV is designed to relieve pressure at a certain set point to prevent overinflation. Sufficient inflation gas is provided to inflate the buoyancy tube(s) at very cold temperatures, thus providing significantly more inflation gas than is required at warmer temperatures. The topping valve is designed to accept a manual inflation pump, so that the buoyancy tube(s) can be inflated.

Finally, the partially deflated life raft was unloaded to rated capacity, and freeboard was measured. All the Type I life rafts in the evaluation exceeded the freeboard requirements of TSO-C70a.

Boarding

Lifelines must be within reach of survivors — even if the life raft is capsized — so they can use them to stay with the life raft until they can right it, if necessary, and board it. Lifelines should be easy to grip and they should lead to boarding aids without large gaps that could jeopardize a survivor's hold on the life raft. Cold air and cold water can have a very rapid and debilitating effect on a survivor's strength and ability to grasp lifelines and boarding aids.

Boarding the life raft is one of the most critical phases of water survival. If a survivor cannot get into the life raft, the risk is increased dramatically that the survivor will die. Optimal entry aids allow an adult of any stature and weight to board the life raft unassisted, even with an injured leg or arm.

It is a challenge to board a life raft in a calm sea without wind; it is a much greater challenge when the life raft and the water are in motion from the wind, waves and swells. The most essential — and most difficult — entry is that made by the first survivor (and possibly the only survivor) because no one is aboard to provide assistance. The first survivor aboard the life raft can assist other survivors.

In recent years, inflatable boarding aids have become more common and when properly designed,

A ladder of nylon webbing will be on most life rafts, either as an alternate means of boarding or as a primary means of boarding, but boarding by a ladder is usually more difficult than by an inflatable boarding ramp.

they can make boarding much easier for survivors, compared with a traditional entry, such as a ladder. Some life rafts are equipped with inflatable entry aids at all entries (typically two entries), a design that could create problems. For example, if a lower buoyancy tube fails because of a puncture on a Type I life raft and each inflatable entry aid is not equipped with a check valve to prevent the boarding aid from deflating, all such entry aids will be useless. Even with a check valve to prevent deflation of the boarding aid, the entry aid may not function adequately because it is attached to a deflated buoyancy tube. When a secondary entry is equipped with a boarding ladder or similar non-inflatable entry aid, this second aid will not be affected by such a failure. When an inflatable entry aid is the primary means of boarding, redundancy is best achieved by a different means of boarding the life raft. Primary entry aids and auxiliary entry aids were evaluated for ease of use, as well as construction and susceptibility to damage.

Canopies

A canopy provides protection from the sun, wind, waves and rain; moreover, reducing ventilation in the life raft can allow body heat to generate warmth within the closed canopy. Just how much protection is provided depends upon its design, construction and materials.

A canopy that must be manually assembled and erected by the survivor(s) is not as desirable as one that erects automatically as the life raft deploys. The latter provides immediate protection without intervention by a survivor. The effort required to close the canopy openings is another area of interest.

Time and effort required by inexperienced life raft volunteers to assemble and to erect canopies that were not designed to erect automatically was evaluated. This included the consideration of instructions, the functionality of the equipment and the practicality of the task. Of special interest was determining if manually assembled and erected canopies met the TSO requirement that the canopy "must be capable of being erected by one occupant of an otherwise empty [life] raft."

The evaluations were conducted in daylight (in addition to the facility's bright overhead lighting).

Manually erected canopies demand training and coordination to erect them quickly and correctly.

was available to occupants and whether the occupants could sit upright at all positions in the life raft. Where a canopy design requires bending at the waist and/or the neck, the occupants complained quickly of being uncomfortable — some were near tears because they were so uncomfortable. Such positions will not contribute to the well-being of survivors during days — or even hours — at sea. Moreover, these positions will make bracing in position very difficult when the life raft is pitching in rough seas. If the canopy also droops from the pooling of water from rain and waves, headroom will be reduced further from the "wetting-down" phenomenon, which is particularly a problem with lightweight fabrics. For example, lightweight rip-stop nylon is used in some canopies, and the fabric's waterproof barrier is on the interior of the fabric. Thus, the unprotected exterior can absorb water, which will add weight to the canopy and result in sagging.

Remove light, and replace it with darkness, and most tasks become more difficult. Add wind, rain and rough seas, when survivors will benefit most from the protection of a canopy, and the difficulty of assembling and erecting a manually assembled canopy increases dramatically. Moreover, the integrity of the canopy should not be compromised after the capsizing and the righting of a life raft.

After ensuring that each canopy was fully and properly erected and sealed, and excepting any damage incurred thus far in the evaluation, the canopies were sprayed with a fire hose and combination nozzle set for moderate dispersion (courtesy of the Tempe Fire Department). The nozzle operator was located on a ladder about 15.0 feet (4.6 meters) above the water and about 15.0 feet from the life raft. The life raft was rotated slowly — two complete revolutions — by volunteers in the pool (not those in the life raft), while the nozzle operator directed the water on all the above-water surfaces of the life raft. This provided a modest simulation of wind and rain that was far less than a storm at sea. Nevertheless, the simulation was adequate to expose deficiencies; significant leakage was quickly signaled by shouts from the enclosed volunteers when the water made its way under the canopy.

TSO-C70a (paragraph 4.4) requires that "the canopy must provide adequate headroom," but "adequate" is not defined. We evaluated what headroom

Righting the Life Raft

Water-survival training has long taught that the nonreversible life raft has a 50 percent chance of inflating upside down, but during the life raft evaluations, such occurrences have been far less frequent than 50 percent.

Nevertheless, nonreversible life rafts do sometimes inflate upside down; therefore, they must be designed to allow survivors to right the life raft or the life raft to right itself. Self-righting life rafts are designed to right themselves without intervention by survivors. All the nonreversible life rafts that deployed right side up were capsized to evaluate the effort required to right them. During the capsize test, volunteers crowded to one side of the life raft until they managed to capsize the life raft; then they swam out the canopy openings to the surface, and they righted the life raft.

Righting is accomplished by gripping a flexible grab handle, line or flexible ladder attached to the bottom of the life raft for that purpose, then pulling oneself up and onto the overturned bottom of the life raft (on the side nearest the inflation cylinder). That same line is then used to lean outward, while sitting or standing, and to lift the opposite side of the capsized life raft from the water until it falls on top of the person performing the righting maneuver. Some smaller four-person and six-person Type II life rafts can be righted simply by grabbing a line or handle from in the water and pulling them over. Then the life raft can be boarded. We evaluated the ease of righting the life raft, and the righting instructions on the life raft were evaluated for ease of locating the instructions, clarity of instructions (text or pictogram), and the degree of visibility (size of text, contrast with the life raft's color).

Floors

An insulated floor is essential for life rafts that might be deployed in cold water, because otherwise only a thin layer of fabric separates the survivors from the cold water. Insulating the survivors from cold-water temperatures and reducing the transfer of heat from the life raft to the water combats hypothermia. Even in the 84-degree F (29-degree C) water of the wave pool, the volunteers were aware of the increased warmth provided by life rafts with insulated floors. The typical temperature of ocean water ranges from 32 degrees F (0 degrees C) in the high latitudes to temperatures above 80 degrees F (27 degrees C) in the tropics. All these water temperatures are less than the 98.6-degrees F (37.0 degrees C) temperature of the human body, so every practical aid to prevent hypothermia is essential. Inflatable insulated floors provide an additional flotation chamber, which adds to redundancy. If the floor can be inflated to a hard condition, as in an air mattress, the floor also isolates survivors from the bumping of the underside of the life raft by fish, an experience that survivors have reported as very uncomfortable. An inflatable floor that cannot be inflated to feel firm may compromise its usefulness to insulate the survivors from the water, because the air will move to wherever there is no pressure on the floor and leave survivors without the insulating barrier of air underneath them. One manufacturer has a foam floor that is said to provide insulation equivalent to 1.0 inch (2.5 centimeters) of air.

Life Raft Equipment

Each life raft includes auxiliary equipment. This equipment is essential to survival and is used to assist the survivors or is used by the survivors to maintain the life raft. Most of this equipment must be tethered — attached by a line to the life raft — to prevent losing it overboard; generally, this equipment has no backup.

Manual Pumps

A manual pump (often called a topping pump) is used to complete a soft (underinflated) deployment; to reinflate the buoyancy tubes or other inflatable chambers (e.g., floor, boarding aid, canopy support tubes) after a failure and subsequent repair; and to maintain the inflation of the buoyancy tubes, including those which will release air through the PRV as the result of expansion that occurs during the warmer periods of daylight, but leaves the tubes soft in the evening. Some life rafts include plugs or other mechanical means to seal the PRVs to prevent loss of air pressure during the day or if the PRV fails in the open mode or venting mode.

Each life raft includes auxiliary equipment … generally, this equipment has no backup.

Because survivors may require the pump immediately after deployment, it should be readily available after they board the life raft. The ease with which these tasks are accomplished depends in part on the effectiveness of the pump. The capacity of each of the manual pumps was evaluated relative to the TSO-C70a requirement and to the other pumps.

This evaluation was accomplished by measuring the water displaced from a clear graduated container that was first submerged in a much larger container to fill with water and then turned upside down with no trapped air. A short length of hose

Equipment is arranged at the entrance to the wave pool at the close of each day's evaluation.

fed air from the pump to the mouth of the submerged container. Each pump was tested several times using full strokes. The air displaced water in the graduated container, and the displacement could be compared with that of other pumps.

The evaluation also considered the ease of use and the tolerance to out-of-alignment use. For the typical bellows-type pumps, a soft buoyancy tube is inflated while applying out-of-alignment forces to the pump and its connection to the tube. Because of unfamiliarity with the equipment, rough seas or urgency, it is difficult to align the pump correctly for each stroke; this could result in breaking the pump or fitting if it isn't adequately robust. Some life rafts include a back-up oral inflator: a tube with a fitting to attach it to a topping valve.

Bailers

Considerable quantities of water are going to enter the life raft with survivors as they board from the water. In rough seas, waves can sweep across the life raft and create a floating bathtub in the time required to board and close the life raft canopy; even more time is required if the canopy must be erected manually before it can be closed. A leak or deflation can allow water into the life raft, too. No matter what the weather conditions, or the condition of the life raft, water will be in the life raft.

Particularly in cold conditions, the life raft must be dried (a relative term) as quickly as possible. The primary means of removing water is a "bailer" (sometimes referred to as a "bailing bucket"), an essential container used to scoop water from the life raft and to dump it overboard. The bailer has many other uses, such as for collecting and storing fresh water, or holding and disposing of waste, tasks which are best done with two independent, leakproof containers.

The bailer is another piece of equipment that should be immediately available upon boarding the life raft. Bailers were evaluated by bailing water to determine how easy it was to use them to scoop water and how well they retained the water for dumping.

(Some marine life rafts are equipped with self-bailers, which remove water from the life raft without effort by survivors, but no such devices were fitted to the aviation life rafts that were evaluated.)

Sponges

A bailer will remove most of the water, but sponging will be required to remove the remaining water in the life raft. A sponge that is too large will tire the hands quickly; one that is too small will frustrate the user. The sponge must be sufficiently durable to sustain repeated use. Ideally, two sponges are preferred, one for bailing and one for collecting fresh drinking water that often condenses on the surfaces of the canopy and buoyancy tubes.

Heaving Line

A "heaving line" (also called "heaving/trailing line" or "rescue line") can be thrown to survivors in the water, but anyone will be hard pressed to toss it accurately more than 25.0 feet to 35.0 feet (7.6 meters to 10.7 meters). The line must be not less than 75.0 feet (22.8 meters) for Type I life rafts and not less than 35.0 feet for Type II life rafts. Its more practical use, at least in warmer waters, is as a safety line. By placing an arm through the quoit — usually a doughnut-shaped buoyant grip at the end of the line — or tying the line to a survivor's belt or around a survivor's waist, the survivor can leave the life raft to retrieve another survivor or equipment lost overboard, without being separated from the life raft. The heaving line allows others in the life raft to pull the survivor back to the life raft. Nevertheless, the small diameter line is difficult to grip with cold, wet, numbed hands.

The "trailing" part of the nomenclature refers to allowing the heaving line to trail behind the life raft so that if someone falls out of the life raft, he may have a chance to grab the line as it trails behind the life raft. If alone, the survivor can pull himself aboard, or if others are aboard the life raft, they can use the line to pull the person back to the life raft. The heaving line must be buoyant for this to be effective. During the evaluation, all the heaving lines were thrown as they were supplied in the life raft, and they were examined for ergonomics and sturdiness of the quoit, buoyancy of the quoit and buoyancy of the line.

Raft Knife

The raft knife is used to cut the mooring/inflation line when the line is secured to the aircraft; by regulation (and design), this line is required to fail before a sinking aircraft drags the life raft under water, but that is secondary to cutting the line with the raft knife. The raft knife must be immediately available upon boarding, and it must be designed to lessen the likelihood of injury to the user in the rush to cut the mooring/inflation line by an untrained survivor. The evaluation determined the ease with which the raft knife was located and was retrieved and how easily it cut.

Lights

At least one approved survivor-locator light (see "FAA Technical Standard Order [TSO]-C85a, *Survivor-locator Lights*," page 462) must be fitted to the exterior of the life raft, and in accordance with TSO-C70a (paragraph 4.12), "the lights must be automatically activated upon [life] raft inflation in the water, and [must be] visible from any direction by persons in the water." With all the lights essentially similar among the life rafts, the evaluation focused on whether the light could be seen by a volunteer in calm water.

An interior light is a major benefit for survivors, although some lights function better than others; not all life rafts are equipped with them. Because the in-water evaluation compromised the lights' single-use batteries, the interior lighting was evaluated later using new batteries to determine the effectiveness of the lighting.

ELT

TSO-approved survival-type emergency locator transmitters (ELTs) that were included with many of the life rafts were not evaluated (see "Stay Tuned: A Guide to Emergency Radio Beacons," page 139). Nevertheless, an ELT is essential survival equipment, so some features were noted: whether an ELT was included as standard equipment or optional equipment; frequency type: 121.5 megahertz (MHz) or 406 MHz; optional capabilities, such as

After throwing the raft pack into the pool, the volunteer leaped into the pool and used his hands to pry open the life raft pack, which is not the correct method of deploying any life raft.

built-in voice communication or global positioning system-derived position reporting; manual activation or automatic activation; and means of attachment to the life raft and effect, if any, on ELT performance or livability/comfort of the volunteers. For example, if the ELT was mounted inside the life raft on a buoyancy tube, did its location cause discomfort to a volunteer who had to lean against it while seated?

Survival Equipment Packs

Life raft manufacturers pack survival equipment with their life rafts in a variety of ways. In this evaluation, the SEPs were packed with the life raft, but some SEPs were designed to remain in the deployed life raft, and other SEPs were designed to be ejected into the water as the life raft was deployed.

In some aircraft installations, where stowage space is limited, the SEP may be stowed separately from the life raft, rather than be packed with the life raft. While FARs allow the SEP to be stored "adjacent" to the life raft, adjacent is often interpreted to allow several feet — even the length of the aircraft cabin between the life raft storage location and the SEP storage location. Generally, in such circumstances, a tether and clip are provided to attach the SEP to the life raft before deployment.

All the SEPs were evaluated to determine their protection from loss and from water damage; ease of accessing their contents; and how the contents were packed inside the SEP. If the contents of an SEP were damaged during the in-water evaluation, an effort was made to determine what led to that damage. The contents of each SEP were also compared with the applicable FARs (most were Part 135) and noted any missing items or items provided in excess of the requirements.

Some equipment has a limited shelf life and must be replaced at specific intervals.

Items such as immediate action instructions, life raft manual and survival manual were evaluated as for usability, effectiveness and how well they withstood a wet environment. Also considered was whether tethers were supplied for primary items that could be lost overboard. (The evaluation includes only the primary items of survival equipment, not every item.) The primary items of survival are:

- Utility knives;
- Flashlights;
- Distress signaling devices;
- Paddles;
- Fresh water, desalinization equipment and water storage;
- Survival rations; and,
- First aid supplies;

Survival Equipment Storage

A life raft cannot be equipped with a giant storage locker, but some of them provide practical aids to stow equipment beyond the SEP, which generally is laid on the floor (or across the legs of survivors). Often, the SEP must be emptied partially to retrieve the desired equipment, and this risks losing equipment. If specific equipment is required quickly — for example, flares to signal a passing ship — the scramble to get the equipment invites loss. Having a means to organize and store equipment and supplies is a big advantage.

Service

A life raft and the auxiliary equipment require regular maintenance (see "Physical Fitness for Life Rafts and Life Vests," page 337). Some equipment has a limited shelf life and must be replaced at specific intervals. For example, in the United States, the Department of Transportation mandates inspection requirements for compressed-gas cylinders: five years for aluminum and steel, and three years for some composites. Flares, emergency food and other items also have time limits before they must be replaced, inspected or serviced, and usually are not produced by the life raft manufacturer, which stipulates the inspection and service intervals only for its life rafts. Until a few years ago, the service interval was uniformly set at one year. This has changed, and extended service intervals are more common.

While this is a convenience to operators, the reasonableness of some of the service intervals was examined. Manufacturers that have authorized service centers in many locations may provide additional convenience to operators. ■

The bottom line, in our opinion …

- **Studying an evaluation is a useful aid in understanding life rafts, but it should be the beginning — not the end — of the process to determine which life raft is best for your operation.**
- **Run from anyone who offers to sell you a life raft and tells you that training to use it isn't necessary.**
- **Good design makes the life raft functions and equipment obvious to survivors, but nothing will beat in-the-water training by an experienced instructor with the aircraft operator's life raft.**
- **The SEP provides essential equipment that varies in quantity and quality among manufacturers. Study it carefully and, if necessary, request appropriate changes.**

Notes

1. Hinz, Earl. "Heavy Weather Tactics Using Sea Anchors & Drogues." 2000. Paradise Cay Publications, Arcata, California, U.S. E-mail communication with Rozelle, Roger. Flight Safety Foundation. Alexandria, Virginia, U.S. June 13, 2003.
2. Prof. Dr. Ing. Fen-Dow, Chu, State University of New York Maritime College. Telephone communication with Rozelle, Roger. Flight Safety Foundation. Alexandria, Virginia, U.S. June 19, 2003.
3. Callahan, Steve, and Douglas S. Ritter. E-mail communication with Rozelle, Roger. Flight Safety Foundation. Alexandria, Virginia, U.S. April, 27, 2003.

Additional Notes

Ritter, Douglas S.; and Ritter, Sue. Interviews by Rozelle, Roger. Tempe, Arizona, U.S. Aug. 20–28, 2002.

Hoggle, Paul, engineering trainer and technician; Nelson, Douglas, manager; Saigler, Robert, operations manager; and Stegarl, Brian, chief inspector. Interviews by Rozelle, Roger. Goodrich. Phoenix, Arizona, U.S. Aug. 27, 2002.

Geits, Kate, director of administration; Graham, Bill, chief engineer; Hall, Tom, completion center manager; Mittelbach, Linda, director of human resources; Shoaff, Irene, vice president of production; Shoaff, Fred; and Williams, David, senior technical representative. Interviews by Rozelle, Roger. Winslow LifeRaft Co. Lake Suzy, Florida, U.S. Oct. 20–21, 2002.

Oroshnik, Miriam, president and CEO; Oroshnik, Sam, founder; Schwartz, Martin, chief engineer; and Wheeler, Matt, director of sales. Interviews by Rozelle, Roger. Eastern Aero Marine. Miami, Florida, U.S. Aug. 13, 2003.

Edrisinha, Thivi, engineer; Elliott, James, quality control supervisor; and Sosa, Alain, vice president of production. Interviews by Rozelle, Roger. Hoover Industries, Miami, Florida, U.S. Feb. 10, 2003.

Ableton, Beatrice, vice president; and Koniecpolski, Stella, president. Interviews by Rozelle, Roger. S.O.S. Food Lab, Miami, Florida, U.S. Feb. 11, 2003.

Miller, David, director of engineering; Rogers, Charles Jr., president; and Rogers, Donna, vice president of marketing. Interviews by Rozelle, Roger. Survival Products. Hollywood, Florida, U.S. Feb. 12, 2003.

Bant, Jay, sales, general aviation; Henry, Brian, program engineer; and Perdoni, Louis, vice president, Sales and Service. Air Cruisers. Interviews by Rozelle, Roger. Near Allaire Airport, New Jersey, U.S. March 14, 2003.

About the Author

Douglas S. Ritter founded in 1994 the Equipped to Survive Foundation <www.equipped.org> and is its executive director. The Internet site is a comprehensive online resource for independent reviews of survival equipment and outdoor gear, as well as survival and search-and-rescue information.

A licensed pilot, Ritter is a frequent contributor of articles to a wide variety of aviation and boating publications, but he has developed particular expertise in survival and survival equipment. Ritter has attended several survival-training programs, in addition to participating in field exercises with the U.S. military and several U.S. government agencies. He has published more than 250 articles related to survival and is a frequent speaker and consultant on the subject.

Writing about life rafts has earned him wide recognition and the top award from the 2000 Boating Writers International Writing Contest. As a full member of SAE International Aerospace Council, Aircraft Division, S-9 Cabin Safety Provisions Committee and the S-9A Subcommittee, Evacuation and Ditching Systems, Ritter participates in the development of standards, procedures and recommended practices on transport category aircraft.

Volunteers in the life raft are attempting to capsize it.

Life Raft Evaluation: Pooling the Resources

Unlike a car, you usually can't test drive a life raft. But our volunteers did, and learned plenty about what did — and didn't — make the work of surviving easier on models by seven leading manufacturers.

— DOUGLAS S. RITTER AND FSF EDITORIAL STAFF

The data in this evaluation are a compilation of the results of evaluations of aviation life rafts (and marine life rafts, which are not included here) in 1993, 1996, 2000 and 2002, all of which were conducted in Arizona, U.S., by Douglas S. Ritter, executive director of the Arizona-based Equipped to Survive Foundation <equippedtosurvive.org>.[1] The parameters of the 2002 evaluation (see "Life Raft Primer: Guidelines for Evaluation," page 233, for information that will enhance the understanding of "Pooling the Resources"), which was conducted with Flight Safety Foundation <www.flightsafety.org> Aug. 23 to Aug. 25, reflect similar parameters under which the previous evaluations were conducted.

This evaluation is only one of several articles in this publication that will help educate aircraft operators, flight crews and cabin crews about aviation life rafts, and provide them with practical information to consider in selecting a life raft to meet their particular operating requirements and budget limitations. Prospective buyers must gather current information from the manufacturers; ask questions about their respective products; evaluate differences in features and determine whether or not they are important for a particular operation; and ask for a product demonstration. Most important, get training to use the selected life raft.

As this article goes to press, some of the life rafts may not be in production (although they are likely to continue to be in use by aviation operators for many years); current features and auxiliary equipment may be different than those evaluated; and products were evaluated without regard to manufacturers' rankings of top-of-the-line vs. the most basic offerings, where such differences exist.

All the aviation life rafts in the 2002 evaluation have been approved by the U.S. Federal Aviation Administration (FAA) and therefore are required to meet the minimum standards of Technical Standard Order (TSO)-C70a (and some of the life rafts also have been approved by other national civil aviation authorities). Deficiencies, in our opinion, were based on the comments, observations and experiences of the volunteers (see "Life Rafts: Ask the Person Who's Tried One," page 293); Ritter; and during the 2002 evaluation, FSF editorial staff.

All the manufacturers provided helpful information in the development of this article. Moreover, some of the manufacturers loaned equipment to the FSF editorial staff: Air Cruisers provided a survival equipment pack (SEP); Eastern Aero Marine provided life vests; and Winslow LifeRaft Co. provided a life raft and an SEP.

Today's consumers have a wide array of independent forums that test, review and evaluate products ranging from peanut butter to automobiles to aircraft. Such forums have educated consumers and generated product improvements through competition. Ritter's previous evaluations of life rafts, which have been published in a variety of consumer-advocate publications, have helped to educate aircraft operators and have helped foster a more competitive market that continues to boast ongoing product improvements.

In 1993, only five U.S. companies manufactured general aviation life rafts: Goodrich (then BFGoodrich), Eastern Aero Marine (EAM), Hoover Industries, Survival Products and Winslow LifeRaft Co.; the latter two did not produce life rafts to meet requirements of TSO-C70a (see "FAA Technical Standard Order (TSO)-C70a, Life Rafts *(Reversible and Nonreversible*," page 396). Elliot Life Rafts had ceased production of aviation life rafts, and Switlik Parachute Co. was no longer selling to the general aviation market. No European manufacturer had a presence in the U.S. market that year.

In 1992, RFD, based in Northern Ireland, entered the U.S. market via Revere Aerospace, which marketed their approved life rafts as RFD/Revere. Winslow received its first TSO approval in 1994. In 1999, Air Cruisers entered the market with an entirely new approved design, and Survival Products began selling its first approved life raft.

ZODIAC

AIR CRUISERS

Air Cruisers was manufacturing life vests and life rafts for the military at least 60 years ago in New Jersey, U.S., said Louis Perdoni, vice president of sales and service.[2] Later, the company produced slide rafts for early jet transport aircraft and the first helicopter floats for Igor Sikorski. In 1987, the company was acquired by the France-based Groupe Zodiac and introduced its first general aviation life raft in 1999. Air Cruisers life rafts were constructed of single-coated polyurethane over single-ply nylon fabric with the coated side on the interior of air-holding chambers. The Premier Series included life rafts with four-person, 10-person, 12-person and 13-person rated capacities. The four-person Premier was hexagonal (six sided), and the larger Premier life rafts were round. The Excel Series was identical to the Premier, with less-sophisticated boarding aids that reduced weight and volume. In 2002, the PaxAir Series was introduced with a life raft with a rated capacity of 10 persons. The 10-person PaxAir was octagonal (eight sides) and had inflatable boarding aids, but appeared to be substantially similar to the Premier Series.

Air Cruisers provided a Premier Series life raft with a four-person rated capacity and a Premier Series life raft with a 13-person rated capacity for the 2000 evaluation.

The 13-person Premier Series life raft was the only life raft evaluated that did not meet the 3.6 square feet (0.334 square meter) per person standard of TSO-C70a (paragraph 4.1); it provided 3.36 square feet (0.312 square meter) per person. The measurements were checked and rechecked, but Air Cruisers said that the life raft did meet the standard. Air Cruisers also said that the life raft meets the requirements via the alternative compliance methods of the TSO (paragraph 4.1.1, which says, "The rated capacity … may be determined by the number of occupant seating spaces which can be accommodated within the occupiable area exclusive of the perimeter structure [such as buoyancy tubes] without overlapping of the occupant seating spaces and with the occupant seating spaces located to provide each occupant with a back support of not less than eight inches [20.3 centimeters] high"). Less than 3.6 square feet per person was a deficiency, in our opinion.

Valise

The yellow valise used nylon lacing to pack the life raft; no Velcro fastener was used, so an opportunity was removed for a survivor to attempt to inappropriately deploy the life raft by pulling apart the seams secured by Velcro. (Volunteers — people who participated in these evaluations — attempted to do this several times.) The 13-person life raft was vacuum packed, a US$300 option that reduced pack volume; this is a practical choice for space-limited applications, and provides added protection from the environment (e.g., spills).

Most essential information was printed in black on a white placard on the face of the yellow valise. The largest text on the placard was used for the operating instructions and the life raft's size. All the text was readily legible, a desirable feature.

Stenciled in red directly on the valise in larger — but narrower — text, were the instructions, "INFLATE THIS SIDE UP." Air Cruisers said that complying with the directions ensures that the life raft will inflate upright. In dim light, these instructions did not contrast well against the yellow valise, compared with the black-on-white inflation instructions.

A handle of wide white nylon webbing was attached to each end of the four-person life raft valise, and two such handles were attached to each end of the 13-person life raft valise as well as on each long side.

Mooring/Inflation Line

At one end of each valise was an orange flap (photo 1) with a single snap that retained the mooring/inflation line, but there was no immediate-inflation handle that would allow a survivor to quickly inflate the raft with a single short pull of the handle, rather than having to pull out the entire mooring/inflation line. The large snap clip on the end of the

1

mooring/inflation line hung loose and the mooring/inflation line was gathered under the flap and hung from each side of the flap. More-secure retention and protection of the mooring/inflation line and clip would help prevent inadvertent inflation. Under the flap was an excellent large aluminum handle that normally would be expected to be used for immediate inflation. Instead, the handle was secured to the far end of the mooring/inflation line, so that a survivor would have to pull out all the line to inflate the life raft. Instructions on the flap were in English and Spanish.

Of the TSO-approved life rafts, the Air Cruisers life raft had the best grip. The large T-shaped aluminum handle was four inches (10 centimeters) wide and was gripped easily even with gloved hands or with cold, wet, numbed hands. Nevertheless, the absence of an immediate-inflation handle was a deficiency, in our opinion.

The mooring/inflation line was 3/16-inch (0.5-centimeter) flat braid. A robust and easily operated stainless steel carabiner clip (an oblong metal ring with a spring clip) was affixed to the end of the line.

Inflation

The four-person Premier Series life raft inflated satisfactorily in 13 seconds. The volunteer attempting to inflate the 13-person life raft pulled the mooring/inflation line with a pull that normally would result in inflation, but inflation did not occur. The volunteer tried again, pulling harder; then again, pulling even harder. The life raft deployed on the fourth attempt as the volunteer pulled so hard that the life raft was almost as high out of the water as the 4.0 feet (1.2 meters) to the pool deck before inflation began.

Based on viewing videotapes of the inflation attempts, the vacuum packing appeared to interfere with the inflation mechanism and was a deficiency, in our opinion. This vacuum-packed life raft did not appear to meet, in our opinion, the TSO-C70a requirement (paragraph 5.2) that "the tension required to withdraw the static mooring line and to actuate the gas release mechanism(s) must be between 20 [pounds] and 30 pounds [9.0 kilograms and 13.6 kilograms]." The majority of the evaluated marine life rafts were vacuum packed, including five with similar vacuum-packing designs that were manufactured by Air Cruisers' parent, Zodiac. All inflated without excessive effort.

Righting

Air Cruisers used two different righting systems. On the four-person life raft, a single blue 1.0-inch-wide (2.5-centimeter-wide) nylon-webbing righting line was attached across the exterior bottom diameter of the life raft. Loops were sewn into the line at intervals to allow easy grasping of the line when righting the life raft. Stenciled instructions on the exterior bottom of a capsized life raft were satisfactory, except that these instructions were not visible to volunteers in the water.

On the 13-person life raft, a triangular righting ladder (photo 2, page 261) was constructed of red one-inch-wide nylon webbing. A correctly implemented righting ladder was an excellent asset in righting larger life rafts, compared with a line or a line with grab handles. The righting location was to the left of the inflation cylinder (when the capsized life raft was viewed from the water). The instructions/arrows

2

on the exterior bottom of the life raft described how to use the righting ladder to position the life raft upright.

The righting location was not identified, and no righting instructions were printed on the side of the life raft — these were deficiencies, in our opinion, that would affect survivors not trained to right a life raft. Moreover, despite the satisfactory instructions on the exterior bottom of the life raft, survivors who require instructions may not see them.

Boarding Aids

An inflatable boarding ramp was used for the primary boarding location on the life rafts we evaluated, and a boarding ladder was used at the alternate entry.

On the four-person life raft, the boarding ramp (photo 3) was located between the two buoyancy tubes, and on the 13-person life raft, which has two larger buoyancy tubes, the ramp was located below the midpoint of the lower buoyancy tube. While there were minor differences in construction, they did not seem to influence the effectiveness of the boarding ramp.

3

The inflatable tube support for the boarding ramp was splayed — that is, the tubes were spread apart in a U-shape on the four-person life raft, and in a truncated V-shape, in which a straight tube replaced the apex, on the 13-person life raft; both boarding ramps were about the same size. Buoyancy-tube fabric was attached across the bottom of each boarding ramp's buoyancy tubes to create a floor between them. The floor fabric was not stretched tightly, but had little slack.

When wet, the floor became slick and contributed to the difficulty some volunteers had in boarding the life rafts. Some volunteers reported that the slickness and the slight slackness contributed to the boarding ramps collapsing into the water (photo 4) while they attempted to board the life rafts. This, in turn, led to the failure of two volunteers to board the 13-person life raft, which already was more difficult to board because of its larger buoyancy tubes and the resulting higher freeboard (distance between the water surface and the highest point on the buoyancy tubes, see Table 1).

4

Table 1
Freeboard Comparison of Life Rafts in Evaluation

Raft	Freeboard (in/cm)	Freeboard With Tube Deflated (in/cm)	Freeboard Overload (in/cm)	Freeboard Overload With Tube Deflated (in/cm)
Air Cruisers — 13 person	19.88/50.50	11.25/28.58	16.75/42.55	9.75/24.77
EAM VIP — 10 person	18.75/47.62	9.85/25.02	16.03/40.72	9.63/24.46
Goodrich — 10 person	12.00/30.48	5.00/12.70	9.38/28.83	4.69/11.91
Hoover ReadyRescue — 6 person	15.75/40.01	8.19/20.80	12.25/31.12	6.31/16.03
Survival Products Type I — 6 person	15.25/38.74	7.69/19.53	12.31/31.27	6.25/15.88
Winslow FA-AV-UL Ultralight — 10 person	17.15/43.56	9.45/24.00	14.50/36.83	8.88/22.56
Winslow FA-AV Ultima — 12 person	21.00/53.34	12.25/31.12	18.50/46.99	10.25/26.04
Winslow FA-AV Ultima Light — 10 person	20.15/51.18	11.19/28.42	17.75/45.09	9.25/23.50

in/cm = inches/centimeters
*Freeboard measurements were not conducted at the time of the evaluation for RFD/Revere life rafts.
Source: Douglas S. Ritter

Air Cruisers later said that the boarding ramp of the 13-person configuration had been improved to prevent deflection under load, with an angle to make it easier to get inside the life raft.

On top of the upper buoyancy tube of both life rafts was a blue one-inch grab handle (four-person life raft) or a red one-inch grab handle (13-person life raft) constructed of nylon webbing. (Each grab handle was twisted so that it did not lie flat on the tube; this allowed easier grasping.) A similar grab handle was attached to each boarding ramp's floor, about one-third of each boarding ramp's length to its attachment point on the life raft. The four-person life raft also had a grab handle on top of the boarding-ramp tube at the center of the U-shape; the 13-person life raft had a grab handle at about the midpoint on both sides (interior and exterior) of the upper buoyancy tube.

The alternate entry on both life rafts incorporated a three-rung ladder of white 1.75-inch-wide (4.44-centimeter-wide) nylon webbing with sewn-in flat semi-flexible rungs (photo 5). The ladder extended well below the bottom of the life raft, making it easy to climb, although its presence was not immediately apparent to some volunteers. Within reach of the ladder, a grab handle was midway on the exterior side of the upper buoyancy tube and another grab handle was on top of the upper buoyancy tube.

5

On both life rafts, the entry flap was rolled down from the top and rested on the upper buoyancy tube across the entry. On both life rafts, some volunteers grabbed the rolled-up fabric to pull themselves aboard; a volunteer who was having difficulty boarding grabbed the edge of the canopy at the entry and ripped it apart at the zipper seam. Air Cruisers has reinforced this area on current life rafts.

A means was provided to assist pulling oneself into the life raft. On the four-person life raft, one end of blue one-inch-wide nylon webbing was attached to the midpoint interior side of the upper buoyancy tube and the opposite end was attached to a plastic snap buckle, which was then attached to an anchor point in the middle of the floor. Two staggered handhold loops were sewn onto each side of the webbing. The webbing was useful to pull oneself into the life raft (photo 6) but the effectiveness of the handhold loops was diminished because they were not easily grasped. The loops were constructed of flat webbing, and they tended to lie flat together, rather than in an easy-to-grasp open loop. Grasping a handhold loop would require first spreading the webbing apart, but that could be difficult with cold, wet, numbed hands. This was a deficiency, in our opinion.

6

The 13-person life raft had a pair of V-shaped interior ladders constructed of red one-inch nylon webbing. The narrower V-end of each ladder was attached with a plastic snap buckle to an anchor point in the center of the floor; plastic snap buckles at the wider end of the ladder were attached to an anchor point on the interior side of the upper buoyancy tube. Each ladder had three rungs, with the widest rung closest to the buoyancy tubes. Survivors could remove the interior ladders after boarding was completed. These ladders proved very effective for volunteers with long arms and those who had sufficient strength to reach over the upper buoyancy tubes, grasp the first rung and pull themselves aboard. Short and bottom-heavy volunteers, however, had difficulty in boarding the raft.

Two volunteers were unable to board the 13-person life raft from either the primary entry or the alternate entry. Moreover, the boarding-ramp inflatable-support tubes on the four-person life raft and the 13-person life raft had no check valves; if a boarding-ramp tube were punctured, the lower buoyancy tube would deflate. This was a deficiency, in our opinion. This design did not appear to meet the requirements of TSO-C70a (paragraph 4.6) that "puncturing of inflatable boarding aids must not affect the buoyancy of the raft buoyancy chambers."

Canopy

An inflatable single-arch canopy support was on the four-person life raft and 13-person life raft. It was not a stay-erect design: If the upper buoyancy tube were deflated, the canopy would deflate, too; if the canopy support deflated, the upper buoyancy tube would deflate. In either event, the canopy fabric and the canopy support would collapse on the survivors in the life raft, which then would have lower freeboard. In rough sea conditions — wind, waves and spray that wet the survivors and equipment, while moving the life raft very uncomfortably — water would be more likely to enter the life raft. The canopy — but not the canopy support — could be removed to allow survivors more freedom to repair the life raft, provided they were familiar with the life raft construction and assembly and had the presence of mind to do so. A better solution would be to install a check valve to prevent the loss of air from the undamaged tube. Absence of a check valve in this application was a deficiency, in our opinion.

The four-person life raft used a 6.0-inch-diameter (15.2-centimeter-diameter) canopy-support tube, and the 13-person life raft used a 7.5-inch-diameter (19.0-centimeter-diameter) canopy-support tube. Both canopy supports were squared, but had inward sloping legs. The canopy fabric was lightweight translucent-orange rip-stop nylon with retroreflective strips affixed. (Retroreflective materials are engineered to reflect light in the direction of its source and are most effective when the ambient light is low.)

The bottom edge of the canopy was secured with an elastic hem, which stretched over the upper buoyancy tube, and plastic quick-release buckles (photo 7) were used to attach the canopy to anchor points on the four-person life raft; nylon ties were used to tie the canopy to anchor points on the 13-person life raft. This type of design allowed relatively easy removal of the canopy.

7

Headroom was 41 inches (104 centimeters) at the center for the four-person life raft, 18.0 inches (45.7 centimeters) at the sides and 20.0 inches to 24.0 inches (50.8 centimeters to 61.0 centimeters) elsewhere; for the 13-person life raft, headroom was 46.0 inches (117.0 centimeters) at the center, 36.0 inches (91.4 centimeters) at the sides and 30.0 inches to 33.0 inches (76.2 centimeters to 83.8 centimeters) elsewhere. The 13-person life raft provided significantly more headroom than any of the other single-arch canopies.

The large buoyancy tubes on the 13-person life raft and the high canopy support reduced the inherent disadvantages of single-arch canopy designs that could force survivors to bend in an uncomfortable position that would be difficult to maintain for hours or in rough weather. The entries were arch shaped, and the closure flaps were rolled down and secured to the upper buoyancy tube. The zipper closure was of very lightweight construction. Cloth pulls were attached to the single-action zippers. Both zippers on the 13-person life raft failed. One zipper was ripped from the canopy (photo 8) and the other zipper was pulled out from one side when volunteers were closing the canopy (photo 9). The lightweight closure flap was jammed so firmly that it could not be loosened from a zipper on the four-person life raft. These failures would reduce dramatically the canopies' effectiveness to protect survivors from the wind, rain, waves and sun; these were deficiencies, in our opinion.

8

9

Air Cruisers said that a heavier fabric and more robust zippers were being used for closure flaps in current life rafts.

Rain Simulation

Because of the canopy problems, the life rafts were deficient in the rain simulation (photo 10). The rainwater collector appeared to function adequately. The canopy was equipped with a V-shaped diverter (photo 11) of semi-rigid fabric design that channeled water into a reservoir at the rainwater-collector tube (photo 12, page 264). This was necessary when the canopy slope was so steep that water would not naturally pool to the tube.

10

11

Lifelines and Grasp Lines

One-inch nylon webbing was used for lifelines and grasp lines: blue on the four-person life raft and red on the 13-person life raft. The lifeline was attached high on the lower buoyancy tube with adequate slack to be reached by survivors in the water, regardless of the life raft's orientation: upright or capsized.

12

The grasp line was strung along the interior side of the lower buoyancy tube. The grasp line was difficult for some volunteers to use because the line was too low. Storage bags were attached to the grasp line (photo 13), which compromised its usefulness because survivors would have to compete with the storage bags for space on the line.

13

Stability

The water-ballast bags were unusual in both shape and construction. The bags were a truncated V-shape with rounded bottoms, and each bag (photo 14) held approximately 63 pounds (29 kilograms) of fresh water. A small 3/8-inch (0.95-centimeter) drain hole was in each end of the bag. A spring wire was fitted inside the rim at either end, helping to maintain the bag's shape. This had been expected to

14

assist in quickly deploying each bag when the life raft was inflated, but did not seem to make any difference. The water-ballast bags dropped down and filled at about the same rate as conventional unweighted bags. The four-person life raft had three water-ballast bags, and the 13-person life raft had four water-ballast bags. Both life rafts were relatively easy to capsize during the evaluation because the water ballast was insufficient. This was a deficiency, in our opinion. The disadvantage of the high canopy was that it provided more surface area to be blown by the wind, which could contribute further to a capsizing.

The water-ballast bags were constructed of lightweight canopy fabric with buoyancy-tube fabric used only on the ends. The half-round inflow holes at the top had reinforcing trim sewn onto the rounded lower portion of the hole. We found tears in the fabric of the water-ballast bags of the 13-person raft during our evaluation (photo 15). The tears originated in the infill holes at the top of the bags, where some essentially square corners in the cutouts would invite propagation of tears.

Air Cruisers used a relatively large conical sea anchor of lightweight parachute fabric. It had a 24-inch-diameter (61-centimeter-diameter), unreinforced

15

opening at the entry end and a 3.0-inch-diameter (7.6-centimeter-diameter) opening at the bottom, with a drawcord to close the bottom if desired. The sea anchor was 44 inches (111 centimeters) long and was fitted to a 14.5-foot (4.4-meter) line of 3/16-inch (0.48 centimeter) braided nylon line. This was considerably less than the minimum 25.0 feet (7.6 meters) required by TSO-C70a (paragraph 5.3) and likely would prove unsatisfactory in a rough sea. On these two life rafts, the sea anchors would be deployed manually by survivors; the sea anchors on all the other aviation life rafts in the evaluation would be deployed automatically.

Despite the short line, the sea anchor performed satisfactorily in the sea-anchor evaluation, but longer lines would improve performance. There was no swivel in the sea anchor line to prevent line twisting. This was a deficiency, in our opinion.

Floor

A thin closed-cell foam was used for insulation. This feature eliminated the necessity of manually inflating a floor. The foam was glued to the interior of the life raft floor and had a very lightweight fabric covering; Air Cruisers said that the foam provided an insulation value equivalent to a 1.0-inch (2.5-centimeter) air space.

The foam proved to be vulnerable to damage (photo 16, page 265) during the evaluation. Sections of the insulation were

16

separated from the floor, and the surface of the floor was abraded. This was a deficiency, in our opinion. Air Cruisers said that it had added a layer of fabric that will withstand better the rigors of life raft use.

Life Raft Equipment

Pump

The manual inflation pump (also called a topping pump) was stored inside the survival equipment pack (SEP), making it unavailable immediately after deployment of the life raft. No tether was fitted to the pump, so it could be lost overboard. That was a deficiency, in our opinion.

Volunteers had difficulty using the manual inflation pump on the four-person life raft because the cap interfered with positioning the pump (photo 17), even when the cap lay flat, by preventing insertion of the pump into the valve.

17

On the 13-person life raft, a six-inch (15-centimeter) adapter hose was attached to the manual inflation pump with a beaded chain. Our initial impression was that this solved some of the tight-fit problems we had with the pump on the four-person life raft. Our enthusiasm evaporated quickly, however, when the bayonet fitting attached to the adapter hose did not match the fitting of the topping valves (inflation valves used to "top off" [add to] the air in the life raft).

It appeared from the U.S. military-specification (mil-spec) labeling that this combination of manual inflation pump and adapter was meant for a military life raft, not for this civilian life raft. Thus, the pump became useless. This was a deficiency, in our opinion.

Moreover, the beaded chain was attached to the hose with a cable tie that was trimmed incorrectly and had a very sharp tail that cut one of the volunteers. This was a deficiency, in our opinion. The injury was easily treated during the evaluation, but could have been much more serious in a survival situation.

Bailer and Sponge

The bailer was a flat 11.0-inch by 12.0-inch (27.9-centimeter by 30.5-centimeter) pouch, which was constructed of buoyancy-tube fabric. The seams were ultrasonically welded, so the pouch did not leak, an excellent attribute. The top 2.5 inches (6.4 centimeters) of the opening were folded over and welded to create a slightly stiff opening lip around the pouch. A 3.0-inch (7.6 centimeter) oval cut at the top on one side served as a handle. Being a flat pouch, it could not stand upright, nor could the open end easily be held open, which could be a disadvantage for some possible uses, such as to retain bodily waste or to collect rainwater.

Volunteers had difficulty using the bailer to empty water from the life raft because they were not able to capture much water in it, despite its capacity of 10.0 quarts (9.5 liters). A tether could be attached to the handle, but none was provided. The pouch was not identified as a bailer, so it could have been overlooked by someone who expected a more traditional bucket-shaped bailer. Its functionality was noted by volunteers as being unsatisfactory. This was a deficiency, in our opinion.

A single small, compressed sponge was included.

Heaving Line

A heaving/trailing line (also called a "rescue line") of mil-spec parachute cord was attached to a traditional round-ring rubber quoit. This was secured inside the life raft with a fabric clasp wrapped around an interior grasp line (photo 18) and secured with a metal snap. This location could interfere with the primary use for the grasp line. We were unable to throw the quoit without the line tangling. This was a deficiency, in our opinion. Moreover, the parachute cord was nylon, was not inherently buoyant and apparently did not comply with the TSO-C70a (paragraph 5.4) requirement for a "floating heaving/trailing line."

18

Raft Knife

A tethered raft knife (photo 19, page 266), intended to be used to cut the mooring/inflation line, was retained inside a yellow sheath attached to a silver piece of fabric glued to the upper buoyancy tube. The contrast between the yellow and silver helped to make the sheath more noticeable. A long Velcro-secured flap, upon which was stenciled "KNIFE" in black, retained the knife. A hook-shaped guard

19

(photo 20) helped to prevent contact with the knife blade. On the four-person life raft, the sheath was on top of the buoyancy tube to the left of the entry (while boarding), tucked under the canopy, where it was less visible and subject to being overlooked.

20

The raft knife on the 13-person life raft was located opposite the primary entry, on the interior side of the buoyancy tube, and was therefore more noticeable, as long as someone did not cover it while sitting in front of it. Because the normal survivor action upon boarding a life raft is to move as far from the entry as possible, the likelihood is high that the raft knife would be obscured from view. Moreover, volunteers discovered that the tether on the raft knife was four feet too short to reach the mooring/inflation line. This was a deficiency, in our opinion. Air Cruisers has extended the tether.

Lighting

TSO-approved survivor-locator lights (see "FAA Technical Standard Order [TSO]-C85a, Survivor-locator Lights," page 462), powered by separate water-activated batteries, were used for the exterior and the interior; the lights were secured with a metal snap. For the exterior light, that should have been satisfactory because the canopy fitted over the light and would help hold it down and in proper orientation. For the interior light, which was located off center on the canopy-support arch tube, however, the location allowed the fixture to hang down and direct its light to one side, somewhat reducing its effectiveness. Nevertheless, that also made the light easy to unsnap and to direct where needed, within the limited range of movement provided by the wire keepers. If the keeper were cut carefully, freeing the wire, or Air Cruisers provided more free-wire length, then this light could have been even more useful. Using the interior light would reduce the need to consume energy from the batteries in the flashlight.

ELT

Air Cruisers offered a DME Corp. 121.5-megahertz (MHz) auto-deploying emergency locator transmitter (ELT) as an option. The ELT was attached to the upper interior face of the lower buoyancy tube. The short whip antenna was attached to the upper tube near the primary entry. On both life rafts, the antenna was bent, which could compromise the ELT's transmission, said DME. The wires that connected the ELT to the remote antenna and to the water sensor were exposed for the most part on the interior and were subject to being snagged and damaged, which could render the ELT useless. Volunteers reported that the ELT was uncomfortable if they had to sit against it.

Air Cruisers offered a 406-MHz ELT option.

Survival Equipment Packs

On the 13-person life raft, the instructions "SURVIVAL EQUIPMENT PULL IN IMMEDIATELY" were stenciled on top of the upper buoyancy tube with an arrow pointing to where the SEP was tethered to the life raft. The canopy covered most of the text so that the text could not be seen readily or read. On the four-person life raft, "SURVIVAL KIT" was stenciled with an arrow on the interior side of the upper buoyancy tube. The imperative instructions were more appropriate, in our opinion, even if the text had to be smaller to fit.

The long box-shaped SEP was made of life raft buoyancy-tube fabric with heavy metal snaps to keep the top closed. An inner clear plastic bag, sealed closed with mil-spec tape, held all the contents, but water entered the plastic bag during its brief time in the water. Some water-resistant items were loose inside this larger bag, along with the shrink-wrapped Katadyn Survivor-06 hand-operated water maker (also known as a manual reverse-osmosis desalinator), but there were also two other "modules" vacuum packed in heavy clear plastic. Despite finger holes that allowed a good grip and a slit in the plastic, opening proved difficult when we tested one of these vacuum-packed modules on the 13-person life raft.

Two stowage bags were provided on the four-person life raft, and three larger bags were provided on the 13-person life raft. They were stenciled with "KIT STOWAGE" on the four-person life raft; a stencil on the buoyancy tube, "SURVIVAL KIT STORAGE," identified the stowage bags on the 13-person life raft. The stowage bags were constructed of buoyancy-tube fabric in an envelope-like manner, 12.0 inches by 11.0 inches (30.5 centimeters by 27.9 centimeters) on the four-person life raft and 23.0 inches by 11.5 inches (58.4 centimeters by 29.2 centimeters) on the 13-person life raft. The flap was secured with two metal snaps (photo 21, page 267) or four metal snaps, respectively. The flap was folded over the interior grasp line and then snapped closed, which attached the bag to the interior grasp lines. This attachment was viewed as unsatisfactory by volunteers because the bags got in the way of grasping the lines, and unsnapping

21

the flap meant that the bag was no longer secured to the life raft. This was a deficiency, in our opinion.

Survival Equipment

Repair

Two three-inch mil-spec repair clamps were included. Air Cruisers, in a departure from normal aviation life raft industry practice, recommended in their life raft manual (LRM) plugging the pressure-relief valves (PRVs) immediately after inflation. This would eliminate the need to top up the buoyancy tubes each evening, as is usually required with PRVs that are allowed to vent. Nevertheless, the PRVs are designed to vent excess pressure that is most likely present at warmer temperatures. If they are plugged immediately, higher-than-desired pressure may be retained.

The Air Cruisers plugs looked nothing like conventional plugs; rather, they were pins that secured the valve in the closed position. The pins were equipped with a float in case they were dropped into the water, but a tether would have been much better security. Clear instructions to use the pins were in the LRM.

Nevertheless, we question whether plugging the PRVs is of such high priority that it should be the fourth item on the immediate-action instructions in the LRM. Survivors would have much higher priorities at that time, such as ensuring that all survivors are aboard and recovering the SEP from the water.

Utility Knife

A good-quality Camillus Cutlery Co. Dura-Tool all-stainless-steel pocketknife, with a nonlocking 2 5/16-inch (5.8-centimeter) clip-point blade and bottle opener/screwdriver with an attached nylon cord tether, was provided.

Flashlight

Two waterproof Rayovac Roughneck flashlights were supplied, each with a krypton bulb and zoom lens, and powered by two AA-cell lithium batteries. A tether was attached to the lanyard ring. Two independent flashlights would eliminate the immediate need to change batteries and/or bulbs. The lithium batteries are light, perform well at cold temperatures and have a storage life of up to 10 years.

This flashlight had a push-on/push-off style switch on the top of the body. This model flashlight had been packed in other SEPs, and we discovered that the switch had been turned on during storage. Despite a plastic guard being added to prevent such occurrences, the guard failed — breaking in half — under packing pressure. The flashlights in the Air Cruisers SEPs functioned satisfactorily, but the importance of having a functioning flashlight is significant, and this flashlight's vulnerability was a deficiency, in our opinion.

Signaling Devices

Two Skyblazer XLT aerial meteor flares and a 2.0-inch by 3.0-inch (5.1-centimeter by 7.6-centimeter) Skyblazer acrylic signal mirror, which was equipped with a nonfunctional aiming aid and a lanyard. Volunteers previously rated the mirror as unsatisfactory. Also included were a small package of Skyblazer sea dye marker and a high-quality International Convention for the Safety of Life at Sea (SOLAS)-specification survival whistle with a lanyard.

Paddles

Air Cruisers provided a pair of two-piece plastic paddles. The handle had to be slipped into the paddle where it was retained solely by friction, not the most secure design. The paddles were not equipped with lanyards. Nevertheless, these were the most effective and comfortable paddles among the aviation life rafts compared and could be readily used with two hands. The wide plastic surface made a good, but not flat, cutting board.

Fishing Kit

A well-equipped and compact mil-spec fishing kit was provided. Lines on plastic winders, leaders, swivels, lures and an assortment of fishhooks were included with some other useful items such as a single-edge razor blade (which, however, will rust promptly if not already rusted), safety pins and aluminum foil. All were tightly packed inside a fragile hard plastic case, which was cracked in the 13-person SEP. The instructions were satisfactory and waterproof.

First Aid

Air Cruisers assembled its own first aid kit of individually packaged items, including an assortment of compress bandages, triangle bandages, adhesive bandages and medications. They were vacuum packed, but once opened, no storage was available for these items to keep them dry.

Water

A Survivor-06 hand-operated water maker was an option, and the life rafts were so equipped. There was no packaged ready-to-drink water. This was a deficiency, in our opinion.

Moreover, no dedicated means to store water was provided. This was a deficiency, in our opinion. Given that a moderately effective water collector was on the canopy — in addition to the optional Survivor-06 hand-operated water maker — a means to store water would be useful. A bottle of Portable Aqua tablets to purify fresh water was included, too.

Food

Food rations are required under some regulations. For short-term survival situations likely with aviation life rafts, food may not be necessary. Even the most easily digested dry foods require water to digest and few SEPs include adequate supplies of water, so the inclusion of food in these SEPs may not be necessary. Moreover, with insufficient water, eating food could hasten dehydration. The September 2000 revision of the recommendations contained in the SAE International Aerospace Recommended Practice ARP1282, Revision A, *Survival Kit – Life Rafts and Slide/Rafts* (aimed at transport category aircraft) deleted all requirements for food. If food is included, it should be appropriate for life raft survival: easily digested with minimal water, without provoking thirst.

Air Cruisers included mil-spec survival rations containing 1,447 kilocalories. The contents of each sealed pouch (photo 22) included a pair of vacuum-packed granola bars, a corn-flake bar, a shortbread bar and a chocolate-chip dessert bar, along with a roll of Life Savers (a hard candy) and a packet each of sugar, instant lemon tea and chicken-flavored soup with a gravy base. The instructions on the package cautioned that the soup base should not be used if the user is exposed to, or has swallowed, salt water. Moreover, while the tea and soup packets could be consumed without any water, their directions required reconstitution with 14 ounces of water. This was not appropriate for a life raft, in our opinion. Volunteers said that the food bars were extremely dry and thirst provoking; again, not a desirable attribute for a life raft ration.

22

Air Cruisers said that it had changed the food rations.

Providing one ration package per person, the supplied food did not meet the Part 135 specification of "a two-day supply of emergency food rations supplying at least 1,000 calories per day for each person." Our calculation determined that the supplied food was about 27 percent less than the specification.

After the SEPs were unpacked, several of the food packages were found ruptured or damaged and the food was spoiled. Another food package that appeared to be undamaged externally was discovered later to have been spoiled by water intrusion, probably during inflation of the life raft. Sugar and Life Savers turned the interior of the package into a gooey mess.

Survival Manual/Life Raft Manual

The Air Cruisers "Life Raft Manual — Immediate Action for Survival" was stored inside the SEP, which was not inside the life raft upon inflation. The waterproof manual was printed on one side only and held together with a brass grommet in one corner. The bold and large black text on white paper was easy to read and the brief instructions were easy to understand. Survivors in life rafts equipped with a Survivor-06 hand-operated water maker could be disappointed to discover that the listed water packets are absent. There was no mention of this water maker in the LRM.

Service

Air Cruisers made the life raft service interval a major marketing issue when it introduced its line of general aviation life rafts. Spending money on an annual service, in addition to the cost of a life raft (which most owners never expect to use), is viewed as an unnecessary aggravation and expense by some consumers. Air Cruisers claimed that these life rafts only require service every six years, compared with the then industry standard of annual service. This extended interval represented a significant reduction in aggravation and a benefit in financial savings. Nevertheless, consumers must understand some important details behind this claim.

Because the company uses a composite-wound inflation cylinder, this cylinder must be hydrostatically tested every three years, as opposed to every five years for an aluminum or steel inflation cylinder. Moreover, the composite cylinders have a maximum service life of 15 years, after which they must be replaced. Air Cruisers said that while the life raft valise must be opened and the cylinder must be removed for testing and then reinstalled, the life raft itself does not need servicing.

Currently available 121.5-MHz ELTs equipped with alkaline batteries have three-year service intervals. The ELT was attached to the buoyancy tube on the interior of the life raft, so to service the ELT and replace the battery, the life raft must be unpacked and unfolded.

Survival rations had a five-year service life before replacement from date of manufacture. Flares had a regulatory 42-month service life from date of manufacture.

To maintain compliance with the various replacement dates of different products produced by a variety of manufacturers, consumers may be required to remove the life raft from the aircraft and ship it for appropriate service at a service interval that will be less than six years and perhaps as often as every two years.

Aside from servicing components, the life raft manufacturer had determined that the life raft would not need to be serviced for six years. Nevertheless, humans construct and pack life rafts, and mistakes do occur. The deficiencies observed during this evaluation, such as the short tether on the raft knife and an incorrect manual inflation pump fitting, testify to that. Regular service tends to catch such errors.

EAM EASTERN AERO MARINE

Sam Oroshnik, the founder of his family-owned company, Eastern Aero Marine, worked on life rafts at Switlik Parachute Co. after his U.S. Army service as a meteorologist in Alaska, U.S.[3] Oroshnik then moved to Miami, Florida, U.S., where his company began refurbishing and reselling military surplus life rafts in 1952. By the 1960s, his company was focused on repairing life rafts and in 1968 began manufacturing them. In 1980, the company introduced its first TSO-approved Type II life raft, and later expanded to include TSO-approved Type I life rafts with rated capacities up to 46-person. Further expansion included the manufacturing of TSO-approved life vests, and servicing of aircraft evacuation slides. Today, Miriam Oroshnik has succeeded her father as president and CEO, but he continues a daily routine at the company.

EAM TSO-approved life rafts include the Classic and VIP series. All are constructed of double-coated neoprene over two-ply bias-cut nylon fabric.

The Classic Type I and Type II life rafts are the traditional line and use manually assembled and erected canopies that EAM has produced since the founding of the company (see "Life Raft Primer: Guideline for Evaluation," page 233). The VIP line was introduced in 2000 as the "Alpha Series" of Type I and Type II life rafts. The Type I was renamed the VIP Series in 2002 coincidental with the introduction of the VIP Deluxe Series version of the Type I life raft with added features. The VIP life rafts incorporated self-erecting canopies and other contemporary survival features.

The Classic Type I life rafts were available in six-person (hexagonal) and 12-person (octagonal) rated capacities. The Classic Type II life rafts were available in two-person, four-person (hexagonal), six-person and nine-person (octagonal) rated capacities. The VIP Type I life rafts were available in four-person, seven-person, 10-person and 15-person rated capacities. The VIP life rafts were octagonal.

EAM provided a Classic Type II four-person life raft for the first evaluation and thereafter declined to participate in evaluations. In subsequent evaluations, Classic life rafts were obtained from EAM dealers and service centers. The Classic Type I 12-person life raft, Classic Type II four-person life raft and Classic Type II six-person life raft were evaluated previously. In 2002, EAM again declined to participate in the evaluation. A new 10-person VIP life raft (then referred to as the Alpha Series) was purchased from EAM by an associate who provided it for the 2002 evaluation.

EAM's Type II life rafts incorporated a design feature, common to all other Type II life rafts in this evaluation, that seemed to conflict with TSO-C70a requirement (paragraph 4.2.2) that "the life raft will be capable of supporting the rated number of occupants out of fresh water in the event one chamber is deflated." The Type II (single-buoyancy-tube) life rafts, which we evaluated, did not appear to comply with the requirements of the TSO.

In these life rafts, the single buoyancy tube was divided in half by vertical bulkheads within the tube. When one chamber of the life raft was deflated, survivors were in a half circle of tube open to the water across the diameter of the life raft; the deflated half floated in the water and was incapable of supporting any significant weight. It was impossible for the survivors in the life raft at its rated capacity to either fit in the one-half life raft remaining afloat, or even if they somehow managed to fit, for them to fold the deflated portion of the life raft across the remaining buoyant chamber and remain "out of fresh water" as specified in TSO-C70a (paragraph 4.2.2). The remaining inflated portion of the tube provided buoyancy and a base from which repairs could be made, but repairs would be difficult at best.

Alternatives to this common design exist that can meet the TSO requirements. There are marine life rafts of these designs, and at least one aviation life raft was produced in very limited quantities using one of these concepts (but it has been dropped from the manufacturer's line). Such a life raft was evaluated previously and it functioned as advertised, maintaining adequate freeboard and keeping the survivors dry and "out of fresh water" after the deflation of one chamber. The disadvantage of such designs is that they cost more to manufacture, become heavier and require additional volume, though not nearly as much as a typical Type I life raft.

Valise

Classic life raft valises incorporated a separate valise for the SEP enclosed inside the primary valise and attached to the life raft with a nylon tether. The valise and SEP closures on the smaller Classic life rafts utilized metal snaps (photo 1, page 270) on three sides to close a top flap of the box-shaped valise. Based on the evaluations, this was not as secure as the slip-loop lacing used on EAM's larger life raft valises, and we found smaller Classic life rafts with one or more of these snaps unfastened.

1

A single white nylon-webbing handle was attached to one side on smaller valises (photo 2); two or four white nylon-webbing handles (photo 3) were provided on the side and one on each end of the larger valises.

2

3

Black instructions were stenciled on the yellow valise fabric. While easy to read when new, these instructions are susceptible to wear over time, and we have seen life rafts in service with instructions barely legible.

For the smaller Classic life rafts, the instructions were on the top face of the life raft valise with a large arrow pointing to the side where the mooring/inflation line was located. Some volunteers failed to readily find the instructions because they were in smaller print than the manufacturer's name and general information about the life raft. Despite what seemed to be reasonably clear instructions, most volunteers began the inflation by trying to unsnap the metal snaps of the valises.

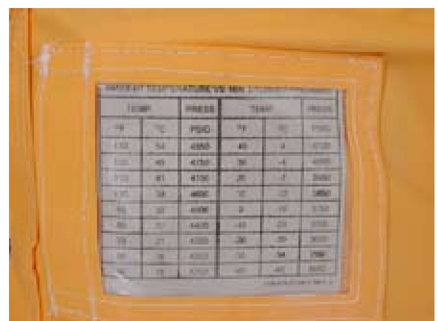
The larger Classic life raft and VIP life raft had no text instructions on the face of the valise; rather, they had a two-frame pictogram showing a woman deploying the life raft. There was no arrow indicating the position of the mooring/inflation line.

The VIP life raft had inflation instructions printed in small text on the end of the valise next to the mooring/inflation line. The text was partially covered by flaps and folds in the valise fabric (photo 4) and the mooring/inflation line.

4

The VIP life raft also incorporated a clear round plastic window (photo 5) to view a pressure gauge for the inflation cylinder. By checking this gauge, the cylinder pressure could be confirmed without conventional methods, such as weighing the life raft. The valise had a placard (photo 6) next to the gauge window that provided an "AMBIENT TEMPERATURE VS. MIN. CYLINDER PRESSURE" chart to determine if the pressure read on the gauge was satisfactory. While this is an innovative concept, there is a disadvantage: A pressure gauge can fail and cause a gas leak. The relatively fragile connection on the pressurized cylinder would be subject to damage if the life raft were mishandled. The gauge itself could be damaged in a ditching. Thus, this seems an unnecessary weak link in an otherwise robust inflation system. For example, the gauge was not aligned correctly in the life raft in the evaluation. Only by pulling the tight valise fabric aside did a portion of the gauge become visible.

5



6

Mooring/Inflation Line

The mooring/inflation line was located on the end of the life raft valise, protected under an orange flap with a pair of snaps to secure it in place on the Classic life rafts; a piece of Velcro and a snap secured this line on the VIP life raft. On the VIP life raft, and on some Classic life rafts, the immediate-inflation handle also was retained under this flap.

On the Classic Type I 12-person life raft, there were difficult-to-read small black text instructions for inflation stenciled on the orange flap. The smaller Classic life rafts were placarded boldly with the words "LANYARD PULL HANDLE" in black on yellow fabric and affixed to the orange flap. The VIP life rafts had no information on the flap, but the mooring/inflation line was imprinted with small black indistinct lettering (photo 7) directly on the thin 0.5-inch (1.3-centimeter-wide) white nylon webbing, "RETAINING LINE," and the end loop affixed around the flap so it was visible.


7

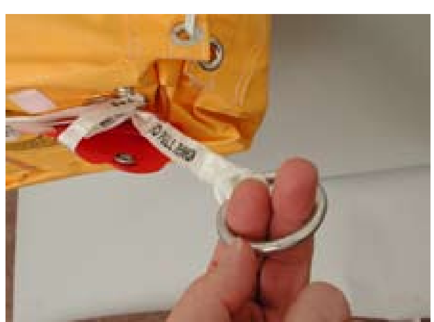
The 0.5-inch-wide nylon-webbing mooring/inflation line (photo 8) on all EAM rafts was terminated by a loop sewn back onto the webbing, creating a 4.0-inch (10.2-centimeter) handhold (photo 9). The only means to secure the life raft to the aircraft would be to use the webbing; this method requires a person to tie a knot that won't fail. This appears to be inconsistent with TSO-C70a (paragraph 5.2): "The ripcord grip or the attached static mooring line must be provided with means for attachment to the aircraft." This was a deficiency, in our opinion. A snap clip would offer a readily usable means to secure the mooring/inflation line to the aircraft.

On the life rafts so equipped, the immediate-inflation handle was a 2.0-inch-diameter plated-steel ring, providing a narrower grip area than the ripcord grip required in TSO-C70a (paragraph 5.2). A survivor would be able to grip the ring (photo 10, photo 11) with only two fingers or three fingers (average male or female, respectively). This was a deficiency, in our opinion. The 12-person Type I life raft was not equipped with the aforementioned ring or any other similar device to serve as the "primary inflation control" required in TSO-C70a (paragraph 5.2), which was a deficiency, in our opinion.


8


9


10


11

The lengths of the mooring/inflation lines ranged from 67.0 feet (20.4 meters) to 72.0 feet (21.9 meters) on the VIP life raft, collectively the longest such lines of all the life rafts we evaluated. This far exceeded the minimum 20.0 feet (6.1 meters) required by TSO-C70a (paragraph 5.1). On the Classic life rafts, the mooring/inflation line was not secured to the life raft at or next to the primary boarding aids, but to the inflation cylinder, which was on the opposite side of the life raft. On the VIP life rafts, the mooring/inflation line was attached to the inflation cylinder located near the primary boarding aid; thus, the line led survivors to this important location.

Inflation

The four-person Classic life raft provided by EAM for our first evaluation could not be inflated in the conventional manner, despite 10 attempts, including pulling hard enough to lift the valise entirely from the water and almost back onto the pool deck. A volunteer finally inflated this life raft by getting in the water, bracing both feet on the life raft valise on either side of the line's exit location, and pulling on the mooring/inflation line with considerable force. This was far in excess of the 20 pounds to 30 pounds (nine kilograms to 14 kilograms) actuation tension required by TSO-C70a (paragraph 5.2) and an effort that might preclude timely inflation in an emergency. This was a deficiency, in our opinion. A similar problem occurred previously with an EAM Classic life raft, which had been packed by an authorized service facility. We also experienced difficulty with the 10-person VIP life raft during our second inflation after the life raft was repacked and recertified by EAM. It, too, required a number of tries and was lifted nearly onto the pool deck before it finally inflated. The other EAM life rafts were inflated without difficulty.

The inflation times until PRVs actuated on the Classic life rafts, without a canopy, were all in the range of 15 seconds to 17 seconds. The VIP life raft achieved full inflation in 14.6 seconds. This rapid inflation of the VIP life raft was the result of using nitrogen as the primary inflation gas with a small amount of carbon dioxide, as opposed to carbon dioxide being the primary inflation gas with a small amount of nitrogen, the conventional standard in the industry. The nitrogen inflation provides another benefit: the inflation time is not significantly affected by cold temperatures, whereas inflation systems with carbon dioxide often barely meet the TSO-C70a requirement (paragraph 6.2.5) of one minute until the life raft is rounded out (i.e., attains its design shape and approximate dimensions) at whatever minimum temperature is specified by the manufacturer, typically –30 degrees Fahrenheit (F; –34 degrees Celsius [C]).

The VIP life raft used a composite-wound cylinder that would have to be hydrostatically tested every three years, as opposed to every five years for a traditional aluminum or steel cylinder. The composite cylinders also had a maximum service life of 15 years, after which they would have to be replaced.

Righting

The righting aid on EAM Classic Type II life rafts was a single nylon-webbing grab handle affixed to the bottom of the life raft with the text "RIGHTING HANDLE" stenciled adjacent to it. Persons of short stature might have difficulty reaching this grab handle. It was effective on the smaller life rafts we evaluated, but we had concerns about its effectiveness on larger life rafts based on experience with other life rafts and boarding aids.

The VIP life raft was equipped with a black one-inch-wide nylon-webbing righting line that crossed the bottom of the life raft off-center (photo 12), and a single black nylon-webbing grab handle adjacent to the line at the righting point. The righting aids functioned satisfactorily, but a good grip on the narrow righting line was necessary, which might be difficult in cold conditions.

12

The EAM life rafts had no indication on the side of the life raft of the righting-aid location or any instructions for righting the life raft. This was a deficiency, in our opinion.

Boarding Aids

The EAM Classic Type II life rafts had a single boarding location (photo 13) with a single long loop of one-inch-wide white nylon webbing hanging down at the boarding position to be used as a foothold, which volunteers often overlooked. Three white nylon-webbing grab handles (photo 14) were provided, one on top of the buoyancy tube, one midway down on the interior side of the buoyancy tube and one on the floor, as well as the interior grasp line. The foothold was not much help, even for volunteers who recognized it and used it; the foothold would swing under or away from the life raft after any weight was placed upon it, rendering it nearly useless. The grab handles were more useful. Volunteers had considerable difficulty boarding the life rafts despite the single buoyancy tube and low freeboard. The ineffective foothold seemed to be the primary culprit. Volunteers with superior upper-body strength and minimal lower body bulk had less difficulty in boarding.

13

14

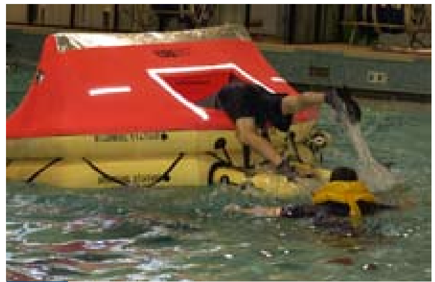
The Classic Type I life rafts were equipped with a two-rung boarding ladder made of white two-inch-wide (five-centimeter-wide) nylon webbing hanging down at the entry. The ladder was equipped with semi-rigid flat rungs; a hard, but flexible, material was sewn between two pieces of webbing to make the rungs. The lower rung hung well below the bottom exterior of the life raft (photo 15). There were two white nylon-webbing grab handles, one on top of the buoyancy tube and one midway down the interior side of the buoyancy tube. A lifeline passed behind the ladder's midsection. While difficult for those heavier and shorter than average, most volunteers managed to board the life raft with minimal problems.

15

The VIP life raft (seven-person and larger) was equipped with an inflatable boarding platform (photo 16) and an interior boarding ladder of black two-inch-wide nylon webbing at the primary entry. The boarding platform had a fabric bottom with five drainage holes (photo 17). There were black two-inch-wide nylon-webbing grab handles on the top of the platform's inflatable buoyancy tube at the center and along both legs that extended from that center. (On a four-person VIP Deluxe life raft exhibited at a National Business Aviation Association (NBAA) convention, these three grab handles were replaced by a single black one-inch-wide nylon-webbing grab handle on the end of the platform.) The lifeline provided a handhold at the buoyancy tubes. A webbing brace extended from the upper buoyancy tube to the end of each leg of the platform to provide support to help prevent the platform from collapsing under load (photo 18). This functioned for the most part, though it was possible to bend the platform down with the right combination of weight and force, as some heavier volunteers discovered. The platform proved an easily used and effective boarding aid for all volunteers.

16

17



18

The secondary entry on the larger life rafts was equipped with a boarding ladder with rigid telescoping beams, a pair of semi-rigid flat rungs and an interior boarding ladder, both of black two-inch-wide nylon webbing. The interior boarding ladder was attached to the exterior of the lower buoyancy tube, and two rungs were available as handholds on the exterior of the life raft, in addition to the four rungs inside. A nylon-webbing grab handle was on top of the upper buoyancy tube, and the lifeline crossed the boarding point to provide an additional handhold.

The two-inch-wide black nylon-webbing beams of the boarding ladder (photo 19) encased a two-part telescoping, spring-loaded tube that was compressed for packing and which was supposed to extend automatically upon inflation of the life raft. The two rungs were attached to the lower section of the beams, both rungs hanging below the lower buoyancy tube. The ladder beams were attached to and hung from the upper portion of the lower buoyancy tube. The telescoping upper section of the rigid beams was forced against the exterior side of the lower buoyancy tube when weight was applied to the ladder, thus preventing the ladder from swinging under the life raft, as occurs with webbing-only ladders.

19

The result was a secondary boarding aid that all volunteers found to be effective, even though on the evaluation life raft, the left-hand beam failed to extend (photo 20), so only one beam was working as designed. This was a deficiency, in our opinion. Had both beams failed to extend, the failure would have been more noticeable and would have more adversely affected the ease of entry, though it likely would have remained a functional boarding aid, just not as effective. Given that no changes have been indicated and that the telescoping rails were made of aluminum tubing and a nonstainless-steel spring and are subject to both normal corrosion and galvanic corrosion in storage under adverse environmental conditions, we remain concerned about the reliability of this otherwise excellent design concept.

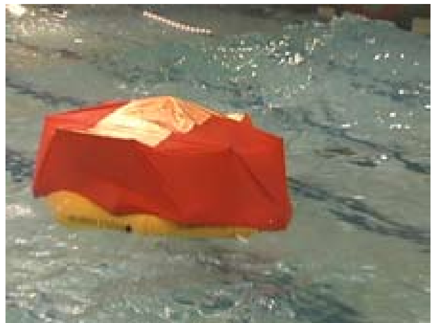
20

The four-person VIP life raft (not evaluated) was available with either the inflatable boarding platform or the telescoping rigid boarding ladder as the primary entry. The four-person VIP Deluxe life raft included as standard equipment the inflatable boarding platform. For boarding aids at the other required entry on this smaller raft, EAM said, "The inflation cylinder is positioned at the rear of the EAM-T4AS along with handles to be used as a boarding aid." With no means provided for a survivor to get a foothold below water level or on the bottom of the life raft and only a single nylon-webbing grab handle on top of the buoyancy tube to assist, in our opinion, these aids are not functional for a significant portion of potential users and do not appear to satisfy the requirements of TSO-C70a (paragraph 4.6) that "for Type I life rafts, boarding aids must be provided at two opposing positions on the raft. Boarding aids must permit unassisted entry from the water into the unoccupied raft." With a possibility of a failure of the primary boarding aid, the ineffective alternative boarding aids on this four-person raft were a deficiency, in our opinion.

Canopy

The EAM Classic life raft canopy was a manually erected stick-built design using lightweight translucent orange rip-stop nylon fabric (photo 21). The canopy option provided a section of metalized polyester fabric (photo 22), which is radar reflective but too small to be effective. Moreover, is not retroreflective, so it is

21


22

ineffective in reflecting light, nor will it reflect radar signals effectively. (The U.S. Coast Guard has suspended the SOLAS requirement that *marine* life rafts in the United States be equipped with a radar reflector until one is proven effective for this application.)

A water-collection tube was sewn into the canopy top surface (photo 23), approximately at the midpoint between the center mast and the periphery. Water pooling on the top surface naturally flows to the tube.


23

On smaller life rafts, EAM used telescoping tubular-aluminum canopy-support rods to hold up the periphery and the center of the canopy. On larger life rafts, the outer canopy-support rods were of fixed length; only the mast (the central canopy-support rod) telescoped. There was a peripheral canopy-support rod at each corner of the hexagon or octagon (the configuration depended on the life raft). This ensured that the canopy sides were supported outside the inside circumference of the buoyancy tube.

The telescoping canopy-support rods often were the source of considerable frustration for volunteers (photo 24). Problems manifested themselves during the installation of the canopy, and demonstrated that previous training would be required to erect this canopy.


24

The telescoping canopy-support rods had a spring-loaded mechanism to lock them into the extended position. Nevertheless, there was nothing to prevent the two independent sections from being separated, although they remained connected by an internal nylon string. An arrow was printed in black ink on each of the sections of rod — one slightly larger than the other — that must be aligned so that the ball on one rod can be aligned with the socket on the other rod. All volunteers who expanded the canopy-support rods initially separated the two sections (sometimes two times or three times before they determined how the rods were joined), which then had to be rejoined. The nylon string, which connected the sections, complicated rejoining the rods because the string first had be pushed back into the larger section (photo 25, page 275). If several volunteers were involved in assembling the canopy, then more time and coordination were required for them to develop sufficient synchronization to assemble the canopy in a reasonable amount of time.

Assembly was not made easier by the spring-loaded locking buttons, which sometimes required soaking in water for several minutes before the locking buttons functioned correctly; otherwise

25

in these situations, the buttons did not operate or were "sticky." No information or cautions were provided about these problems, which was a deficiency, in our opinion.

The male snaps at the ends of the canopy-support rods (photo 26), which connected to the canopy and life raft, were screwed into wooden plugs that were then press-fitted into the ends of the tubing. Many of these wooden plugs fell out easily or were pulled out by the volunteers while assembling the canopy; then the small plugs had to be found — which would be difficult to accomplish in a crowded raft or if lost overboard — and reinserted in the rod. Only by soaking them in water for about 10 minutes to 15 minutes would these wooden plugs expand and remain in place. No information was provided about this problem, which was a deficiency, in our opinion.

Despite instructions stenciled on the interior side of the buoyancy tube, the volunteers improperly installed the periphery canopy-support-rod base in three of four evaluations (photo 27).

26

27

The canopy-support rod had to pass through a loop of nylon webbing and then be snapped onto a small retainer tab equipped with a female snap (photo 28). Volunteers consistently failed to insert the canopy-support rod through the loop.

28

Initially, this was believed to result from difficulty in recognizing the instructions that were obstructed by other volunteers in the crowded life raft. Therefore, experiments were conducted with volunteers who were handed a canopy-support rod and directed to read the instructions before installing the canopy-support rod on the buoyancy tube. Despite the effort to ensure that volunteers read the instructions, more than half of them failed to install correctly the canopy-support rod. This led to the conclusion that the instructions were inadequate, a deficiency, in our opinion.

On the Classic Type II life rafts, either the three-section tubular canopy-support rod or one of the paddles could be used for the canopy mast. One group of volunteers tried using a paddle for the canopy mast. When they placed the paddle into position, they discovered that a snap was broken and the assembly could not be completed. Instructions were on the floor of the life raft, but they were easily overlooked, especially when they were under foot. Moreover, volunteers said that the instructions were not clear.

The Classic Type I life raft had a manually inflatable "donut" (photo 29) surrounding the center mast (or a pillow under the mast on the six-person life raft). This provided added support for the center of the life raft floor, preventing the center mast from depressing the floor too far into the water.

29

Snaps were used to attach the canopy to the top of the canopy-support rods. The bottom skirt was elastic and was forced down around the outside of the buoyancy tube to hold it in place. During one evaluation, despite many hands to assist, the elastic bottom was impossible to put into place because it was too small to fit over the buoyancy tube. On another occasion when the volunteers gave up, the canopy already was coming apart at a seam where it snapped onto a canopy-support rod.

The Classic Type I life rafts had a pair of openings on opposite sides of the canopy; the Classic Type II life rafts had a single opening. These were equipped with closure flaps that could be secured with cloth ties along the two sides, but there were gaps between the ties; the closure flap was not weathertight. The closure flap could be rolled up and secured in the open position with cloth ties (photo 30, page 276).

30

On two occasions, the volunteers overlooked the instructions stenciled on the canopy or they failed to comprehend that the canopy opening was supposed to be aligned with the boarding aids; therefore, the canopy was installed with the opening in an incorrect position.

The average time to (incorrectly) erect the canopy was 28 minutes. After trying to erect a canopy for 33 minutes, one group of volunteers gave up. Another group correctly erected the canopy in 14 minutes. These evaluations were conducted in optimum daylight conditions with no wind, rain, high waves or cold.

Even after they were erected properly, none of these stick-built canopies survived capsizing and subsequent righting without damage to the canopy and degradation of the protection it provided. Most often, the canopy came loose from the snaps holding it to the canopy-support tubes. In every capsizing, the canopy fabric ripped at some of the snap-attachment locations. In some capsizings, one or more canopy-support rods were bent to the point of no longer being useable, while others were bent slightly, but enough that the canopy no longer fit properly.

While submerged under the life raft after a capsizing, survivors could become entangled in the fabric and their escape to the surface could be hindered. The ends of the canopy-support rods caused minor scratches and bruises to some of the volunteers despite precautions. A serious injury — such as poking an eye — would be possible. On the Classic Type I reversible life raft, retrieving the canopy and the canopy-support rods from underneath the life raft so that they could be reinstalled again would present a problem. This type of canopy system was deficient, in our opinion.

The VIP life raft had a single square-arch self-erecting canopy (photo 31) with a 5.0-inch-diameter (12.7-centimeter)-diameter inflatable canopy-support tube. The lightweight translucent rip-stop nylon fabric was orange, with much greater conspicuity than the traditional lightweight orange canopy fabric. The ridge of the canopy was covered with a metallic-coated (or metalized) fabric. Effective radar reflectivity was no more likely than with any other nonreflective radar reflector. Because this fabric covered only a small portion of the upper surface of the canopy, there was little likelihood that ELT signals would be affected.

31

The PRV for the upper buoyancy tube was located on the exterior of one leg of the canopy-support tube, and there was a matching hole in the canopy. The canopy (reinforced at this location) was secured to the support tube with Velcro placed around the PRV.

The canopy was attached to the buoyancy tube with a two-inch-wide Velcro strip. After the second inflation of this raft, it was thoroughly rinsed and left overnight indoors to dry. The next morning, we discovered that the Velcro strips used to secure the canopy to the upper tube had come unglued along one section of the raft (photo 32). The Velcro also was coming unglued on two other sections. The tension of the tightly stretched canopy was pulling up the Velcro. Temperature was approximately 95 degrees F (35 degrees C). In addition, the Velcro attachment of the canopy to the tube was not even and, in some places, only 0.5-inch (1.3 centimeters) of the 2.0-inch (five-centimeter) Velcro was attached.

32

During the in-water evaluation, the glue on the canopy-support tube failed where the tube was folded to create an arch. There was no reinforcement of this section of the tube (photo 33). When the glue failed, the tube was retained by the canopy. The canopy became elongated and created a dip in the center of the arch (photo 34, page 277), which resulted in the canopy collapsing during the rain simulation. The black fabric-reinforcing donut, where the canopy support tube was attached to the buoyancy tube, also experienced a partial glue failure (photo 35, page 277).

33

Ritter said that after the 2002 evaluation was completed, his proxy contacted EAM

34

35

during a period of several weeks by telephone and e-mail several times to discuss the glue failure, before EAM requested that the life raft be returned for inspection; it was returned to the proxy several weeks later.

After the life raft had been returned to the proxy, FSF staff told EAM that the life raft had been used in an evaluation and that Ritter had asked to confirm that the repair had been completed correctly. EAM agreed to have Ritter check the life raft and agreed to repack and certify the life raft after that in-the-water check at EAM's expense. A brief summary of the check and of EAM's responses is cited below:

> As to the Velcro failures, EAM said that the Velcro had been removed from the tube sections of the life raft to determine if it had been applied correctly. EAM reported that "adhesion application was found to be uneven in the few, small areas (approximately 18.0 linear inches [45.7 linear centimeters]) where you saw the Velcro lifting. However, in the remaining areas (approximately 320 linear inches [810 linear centimeters]), peel and shear adhesion were excellent. … The remaining bonded areas would have stayed in place and not allowed attachment of the canopy to fail. As the photos in your report show, after two tests in chlorinated pool water, the canopy of the raft remained attached." Nevertheless, the Velcro was not subject to any abuse in the second inflation, as might occur in a real survival situation.
>
> As a result of the evaluation, however, tape reinforcement of the canopy arch tube was incorporated into the life raft design.
>
> The sea anchor and sea anchor line were found inside the raft, although the sea anchor is supposed to be deployed automatically. The sea anchor line was routed incorrectly and was captured by the Velcro that secured the canopy to the side of the upper buoyancy tube. The coiled sea anchor line also was secured incorrectly with a plastic cable tie, which was determined to have been done before the life raft was packaged for return to EAM. EAM acknowledged the possibility that, during the repair to the canopy, their inspectors and mechanics had failed to notice the plastic cable tie and that the sea anchor was placed improperly during the repair of the canopy. EAM said that it reviewed these oversights with its repair station personnel.
>
> The locator light did not activate upon the second deployment. EAM did not replace the water-activated battery, and said that the life raft had been returned with a work request that did not indicate that the life raft had been deployed in water. The battery checks were passed and the original light was reinstalled.
>
> Both boarding-ladder beams extended fully, but the ladder became hung on the exterior lifeline (photo 36). (The primary boarding aid deployed correctly.) Upon entering the water, we made what we believed would be the natural reaction of a survivor by pulling on the ladder, which only worsened the situation. Only by lifting the ladder legs up and clear of the lifeline (photo 37) was it possible to deploy the ladder. This proved awkward to accomplish from the water. This was a deficiency, in our opinion.

36

37

> EAM said that this had occurred a few times during deployment tests, and had been remedied by test subjects lifting the ladder from the lifeline.
>
> EAM said that "any discrepancies found did not affect the air-holding or lifesaving ability of the life raft" and "that they were isolated and specific to the life raft tested."

EAM was not the only manufacturer that experienced failures from human error, but this example was well documented and allowed closer examination than others. If anything, this underscores that aircraft operators, flight crews and cabin crews should recognize the importance of redundancy and training to use the equipment that is carried on their aircraft. Ideally, the equipment will function correctly. If it does not, a trained survivor is more capable of correcting the problem or discovering a satisfactory alternative.

For example, a survivor without life raft training may not have realized the importance of the sea anchor deployment; with training, the survivor likely would have determined quickly how to resolve rerouting of the line, cut the plastic tie and deployed the sea anchor. As for the nonfunctional light, if *trained* survivors correctly deployed the life raft, they would know to use the mooring/inflation line to lead them to the life raft, even in total darkness.

In addition to the glue and the locator light, there were other anomalies involving the canopy.

There were two openings, one at each boarding aid, that were closed via a flap that was rolled down to the tube upon inflation and secured with a pair of one-inch-wide Velcro straps. Closure was made by strips of two-inch-wide Velcro surrounding the openings. These did not align very well and gaps were apparent when the flaps were closed. After our in-water evaluation, tears were found in the canopy at the corners of the openings (photo 38), and a number of sewn seams were beginning to pull apart. Strips of two-inch-wide retroreflective tape were affixed around the canopy openings and on some shorter strips on the sides, making them very visible at night when light is shone on them. These strips were backed by the Velcro and helped stop further ripping of the canopy at the openings' corners.

Rain Simulation

Both Classic Type I and Type II life rafts leaked significantly in the same areas. The flap entries were impossible to seal completely and allowed considerable water to enter through the gaps. Some flaps blew open, despite the cloth ties; others held. Tying technique apparently had a lot to do with their effectiveness. These gaps also would allow the entry of cold air and spray in windy conditions.

38

All the canopies allowed large quantities of water into the interior of the life raft, because the elastic skirt was pushed over the buoyancy tube by the water spray, creating a gap between the bottom edge of the canopy and the buoyancy tube. The sewn seams of the canopy fabric showed some stress and signs of parting at some stress points on some of the canopies, even after our brief evaluation. This was a deficiency, in our opinion.

The canopies leaked significantly where the water-collection tube was sewn into the canopies' top surface. Some leakage occurred at all sewn seams. Aside from the leaks, the water-collection tube functioned reasonably well, although the only way to close it was to tie a knot in it.

The VIP life raft canopy collapsed during the rain simulation (photo 39). It appeared that this was related to the earlier canopy-support-tube failure. We were not able to re-evaluate this during the second inflation after it was upgraded. This was a deficiency, in our opinion. The Velcro closure of the canopy entry

39

flaps held, but large quantities of water leaked through the Velcro around the entry flaps.

Lifelines and Grasp Lines

The lifeline and the grasp line on the Classic Type II life rafts were 0.75-inch-wide (1.9-centimeter-wide) thin white nylon tape, which would be difficult to grip with cold, wet, numbed hands. The Classic Type I life raft was equipped with heavier nylon webbing that was easier to grip. The white webbing did not provide a high contrast against the yellow fabric of the life raft.

The Classic Type II life rafts had only a single lifeline that was located on the upper section of the interior of the buoyancy tube (photo 40). The lifeline could not be seen easily by a survivor floating in the water. It could be difficult or uncomfortable to grasp in the water by survivors, particularly those with shorter arms, who would have to reach over the tube. In our opinion, this lifeline did not meet the requirement of TSO-C70a (paragraph 4.8) that it "must encircle the life raft on the

40

outside periphery so that it can be easily grasped by persons in the water." The lifeline was not visible or functional while the life raft was overturned. This was a deficiency, in our opinion.

The Classic Type I life raft had both a lifeline and an interior grasp line. The lifeline was attached to the lower buoyancy tube without much slack, and this could be difficult for some survivors to reach on the larger life rafts. The grasp line did not cross the two entry points; this was a deficiency, in our opinion.

The VIP life raft had a lifeline and an interior grasp line of black one-inch-wide nylon webbing. A loop of webbing was provided for each section of the octagon, inside and out, secured to the life raft by passing the webbing through the joint between the two buoyancy tubes where it was sewn in place (photo 41). We had some reservations about adding any stress to this joint because it is a common life raft failure point.

41

EAM said that this is preferable to the method used by all other manufacturers, as well as by EAM on their other life rafts, of gluing patches to the buoyancy tube to which the lines are secured, which they said can lead to a buoyancy-tube failure if a patch is pulled off. This is not in compliance with U.K. Civil Aviation Authority (CAA) requirements, for example, "that failure or tearing off of the attachment will not damage any inflated compartment." In other words, the glue shall fail before the integrity of the buoyancy tube fabric is compromised. The assembly method used on the VIP life raft did save weight and bulk.

There was sufficient slack in the lifeline to allow the line to hang within easy reach whether the life raft was upright or capsized.

Stability

The Classic life rafts had no provisions for ballast. This was a deficiency, in our opinion. EAM did fit a pair of sea anchors on short (36-inch [91-centimeter]) tethers (photo 42), which they said in their brochure "improves raft stability." Volunteers noticed no difference in raft stability with the anchors or without them. The conical anchors were 12.0 inches (30.5 centimeters) in diameter on the large end and 3.0 inches (7.6 centimeters) in diameter at the other end. They were constructed of rip-stop nylon canopy fabric with a nylon cinch line at the exit end, but it seemed to make no difference if they were open or closed.

The short sea anchors did not appear to comply with TSO-C70a (paragraph 5.3), which says, "The line must be at least 25 feet [7.6 meters] in length." It may be that the life rafts so fitted did meet the drift requirements of this paragraph (we had no means to evaluate this), but being so small and on such short tethers they could not have any anti-capsizing effect.

42

The Classic Type I reversible life raft had some theoretical inherent anti-capsizing potential because of the vacuum that could be created with the floor between the two buoyancy tubes as the life raft rises during a capsizing. This was mostly noticeable in calm waters. Waves or movement of the life raft tended to unseal the lower buoyancy tube, negating any vacuum effect.

The Classic life rafts that we evaluated were capsized easily, a deficiency, in our opinion.

The VIP life raft had five V-shaped water-ballast bags (photo 43) that had an approximate capacity of 63 pounds (29 kilograms) of fresh water. The bags had polyurethane-coated nylon-fabric attachments and were constructed of rip-stop canopy fabric. We experienced no damage to the bags as a result of our evaluation. Those water-ballast bags were weighted, so we expected them to drop immediately upon inflation and to fill rapidly; they required one minute and four seconds to drop, despite induced movement of the life raft. This could be a problem in some situations and was a deficiency, in our opinion.

43

A self-deploying sea anchor on a 24.0-foot (7.3-meter) length of 1/8-inch (0.32-centimeter) braided nylon line was fitted. There was no swivel, a deficiency, in our opinion. The sea anchor was the same type used on the Classic life rafts and had no noticeable anti-capsizing effect, although we expect that it would reduce drift and provide some influence on stability.

Floor

The Classic life rafts were not available with an insulated floor. The Type I life rafts offered some potential for improved thermal protection. Depending upon how heavily loaded the life raft was, all or some sections of the floor could be elevated above the water surface in calm water. If the life raft were in rough sea conditions, heavily loaded or the lower buoyancy tube were collapsed, then such insulation performance would be lost.

An option for the VIP life raft was a manually inflatable insulated floor that incorporated 18 reeds (these short fabric pieces were attached between the two floors — interior and exterior — to restrain the floor from ballooning when air was pumped into the chamber to provide an insulating barrier of air). The manual inflation pump was used to inflate the insulated floor. Other than the inflation valve in the floor and accompanying notation — either text or pictogram for the VIP life raft and VIP Deluxe life raft, respectively — there was no indication that an inflatable floor was available to survivors, who might not recognize this feature or its influence on their survival. This was a deficiency, in our opinion.

Life Raft Equipment

Pump

EAM's manual inflation pump was of the common bellows design. On all the Classic life rafts we evaluated, this pump provided about 75 percent of the capacity, "at least 32 cubic inches [524 cubic centimeters][of air] per full stroke," required by TSO-C70a (paragraph 5.5).

Volunteers observed several minor problems and some more serious problems with the EAM manual inflation pump in the first evaluation. These problems were resolved with the current pump supplied with EAM life rafts. Nevertheless, many of these older pumps remain in service with older life rafts.

The older manual inflation pump used a bayonet adapter, which was contained in a separate bag attached to the pump and had to be screwed onto the pump by the survivor. There was no tether attached, so the opportunity existed for the adapter to be lost overboard in the process of installing it on the pump. Without the adapter, the pump would be useless. This was a deficiency, in our opinion.

The older manual inflation pump had an aluminum male-bayonet fitting, and it came out of the valve almost as easily as it went in, despite an O-ring which was supposed to secure it, and that created problems for our volunteers. As soon as a volunteer reached the end of the expansion stroke (air being pulled into the pump), the pump was pulled easily out of the valve.

The instructions did not mention the need to hold the manual inflation pump into the valve; they simply said to "insert pump in valve and pump to inflate." Having to hold the pump with both hands was a disadvantage; it would be an advantage to be able to pump with only one hand. We asked a dozen volunteers to try using the pump, and all experienced the same difficulty.

Of more concern, one of the volunteers trying to use the manual inflation pump became frustrated with it slipping out of the valve; instead of pumping in and out exactly in line with the valve, he inadvertently applied force to the pump at an angle. The threaded pump fitting, to which the bayonet adapter was attached, failed and separated from the pump, making it useless.

This would not be an unusual application of force in normal survival circumstances, with the life raft's motion and a survivor attempting to cope with that motion. Immediately, several volunteers tried the same action with all the other life raft manufacturers' manual inflation pumps on hand (and we subsequently did so with all pumps we evaluated; there were no similar failures).

EAM said that the EAM-designed manual inflation pump does need to be held in place, especially as the inflation pressure approaches full inflation, and later said that perhaps the instructions could have been clearer.

EAM said, "We have had a problem," and that the fitting had been redesigned to improve the swedge where it is secured to the pump. We asked to receive a new pump with the redesigned fitting. It arrived quickly, but the new fitting and swedging looked no different than the fitting that failed. A quick evaluation resulted in exactly the same failure.

The failure of the manual-inflation-pump fitting was a deficiency, in our opinion.

As a result of the 1993 evaluation, EAM said that clearer instructions were issued for those pumps on hand and that the EAM pump was replaced quickly by one produced by Mirada Research and Manufacturing.

The VIP life raft arrived with a Mirada industry-standard manual inflation pump (model B-51224) that passed our out-of-alignment pumping evaluations. EAM said that this pump is now standard on all current-production life rafts. The green bayonet adapter was tethered to the pump, but was secured with a nylon line through the adapter (photo 44). While it was possible to assemble and use the adapter without detaching it from the tether, it was difficult to screw onto the

44

pump and difficult to force into the topping valve; the tether had to be cut (photo 45), which risked loss of the adapter. A 9.0-foot (2.7-meter) twisted nylon cord tether was attached to one of the pump's finger loops, but there was no attached instruction to secure the line to the life raft, potentially putting the pump at risk of loss — a deficiency, in our opinion.

45

Bailer and Sponge

The bailer in Classic life rafts was tethered to the life raft — inside on Type II rafts, over the side on Type I rafts. A stenciled placard on the buoyancy tube indicated the attachment point. The 9.0-quart (8.5-liter) capacity bailer was constructed of sewn buoyancy-tube fabric.

The VIP bailer was packed inside the SEP where it was inaccessible immediately upon boarding. The 8.0-quart (7.6-liter) capacity bailer was constructed of sewn polyurethane-coated life vest fabric. An 8.8-foot (2.7-meter) twisted nylon cord tether was attached to a metal grommet on the bailer, but no attached instruction directed the survivor to secure it to the life raft, a deficiency, in our opinion.

Neither bailer was fitted with a handle (photo 46), or had any reinforcement to the mouth that would keep it open, which makes a bailer more effective. The bailers leaked at the sewn seams. While not an issue for bailing, for other uses, such as holding fresh water or emptying collected waste, this was a deficiency, in our opinion.

46

No sponge was included with the Classic life raft in standard SEPs. A three-inch by four-inch inch compressed sponge was included with the VIP life raft SEP.

Heaving Line

For the required heaving/trailing line on its Classic life rafts, EAM used mil-spec parachute cord, which was not inherently buoyant and did not appear to be in compliance with the requirements of TSO-C70a (paragraph 5.4) for at least one "floating line" and a round-rubber buoyant quoit (photo 47). It was packed inside a small pouch; on the Type I life raft, it had to be retrieved from over the side.

47

The VIP heaving/trailing line was inherently buoyant 3/16-inch braided-polypropylene line with a special quoit. This was constructed of a 90-degree plastic barbed hose fitting with attached orange-plastic tubing that was kinked (photo 48) to return to the other side of the plastic fitting. The line was attached to the fitting, and the result was a

48

somewhat elliptical-shaped device with a very narrow-angle end grip, which was uncomfortable to grasp and might be difficult with a cold hand. The line was coiled, gathered with a pair of rubber bands, and then the line and quoit were suspended from a grasp line using a fabric clasp with two metal snaps. Volunteers were unable to throw the quoit successfully because the line tangled, a deficiency, in our opinion.

Raft Knife

The tethered raft knife was stored inside a sheath with a snap closure in the Classic life rafts; the sheath was attached to the buoyancy tube at the closed end. The raft knife was placarded with a stenciled "KNIFE" on the buoyancy tube below the sheath (photo 49) with an arrow pointing to the sheath. Stenciled instructions were partially obscured by the interior boarding ladder on the VIP life raft. On the VIP Deluxe life raft, printed placards added an instructional pictorial instruction (which illustrated a life raft mooring/inflation line being cut loose from a boat).

49

Lighting

The TSO-approved locator light on Classic life rafts was attached to the buoyancy tube adjacent to the entry (or adjacent to an entry if there were two entries, as on both sides of the Type I life raft). Another locator light was stored in a plastic bag (photo 50) and attached to the life raft lifeline. After the canopy was erected, an attachment was provided for the light on the canopy (photo 51). With the canopy erected, the light located on the buoyancy tube near an entry became the interior light, but it was not high enough to be very effective. On the first Classic life raft that volunteers evaluated, the locator light was ripped off the buoyancy tube during boarding by one of the volunteers. Being located adjacent to the entry made such a loss possible.

50


51

The VIP life raft was equipped with an exterior locator light affixed to one end of the canopy at the peak (photo 52). No interior light was fitted. The VIP Deluxe life raft was equipped with a manually switched lithium-battery-powered ACR HemiLight (photo 53), which was secured


52


53

to the center underside of the canopy-support tube. This was a superior source of illumination for the interior, compared with using the traditional survivor-locator light, which is not designed for general area illumination. Being able to switch the light off to conserve the battery for later use was another advantage.

ELT

None of the life rafts was equipped with the optional ELT. EAM offered DME and Artex 121.5-MHz ELTs in either auto-deploying or manually deploying versions.

Survival Equipment Packs

The SEPs on all Classic life rafts were packed externally to the life raft and were secured via a 5.0-foot (1.5-meter) tether. The SEP would have to be retrieved from the water by the survivors, who might not even realize the SEP exists. The location of the attachment point was stenciled in black on the buoyancy tube or floor, but it was easily overlooked because it generally would be behind a survivor or underfoot. If the survivors did not know that they should retrieve the SEP, they might not do so in a timely manner. The canopy and canopy-support rods also were contained in the SEP, so failure to retrieve the SEP also would delay erection of the canopy.

Because the SEP was not waterproof, the contents were exposed to the water and depended on their own packaging to remain dry. Unfortunately, several items were inadequately packaged to prevent them from being damaged by water.

On two occasions, the closures on the SEPs came loose after the life raft was deployed and before the SEPs were retrieved. Both life rafts lost important survival equipment before the SEPs were retrieved from the water. This was a deficiency, in our opinion.

The SEP on the VIP life raft was packed inside the life raft and attached to the life raft by a single tether. When the life raft deployed upside down, the SEP was ejected from the interior of the life raft through the primary entry and had to be retrieved from the water after the life raft was righted. There was no placard to indicate the SEP location or that retrieval might be required.

The SEP was a flat pouch constructed of yellow polyurethane-coated nylon life vest fabric, and "EQUIPMENT" was stenciled in large text on its face. A life vest oral-inflation tube was affixed to the face of the pouch. A vacuum was drawn via the oral-inflation tube (EAM also manufactured life vests which had to be evacuated via their oral-inflation tube before packaging), so that the SEP became a vacuum-sealed pouch; the contents remained completely dry while submerged and until the pouch was opened, which is a good concept, in our opinion.

A slit across the top face of the pouch near one end was sealed with adhesive and seam tape. A short tab was used to grasp the tape and pull it loose, which was easy to accomplish. While, for the most part, this was self-evident, instructions for opening should have been included. Once opened, the SEP could not be resealed or closed, except perhaps by the expedient means of using the tether to tie off the open end of the pouch. The contents inside the pouch were contained in a heavy plastic bag with the open top folded over, but not sealed.

Survival Equipment

Repair

A single three-inch mil-spec life raft-repair clamp was provided with all life rafts, regardless of size. No means was provided to plug the PRVs.

Utility Knife

A poor-quality (in our opinion) multifunction pocketknife with a nonlocking drop-point blade, can opener, screwdriver/bottle cap opener and a 14.5-inch (36.8-centimeter) twisted nylon cord tether was included in the Classic life raft SEPs. The knife became wet upon deployment, and where the knife blade and other parts were joined at the handle, rust began appearing almost immediately.

The VIP SEP included a good-quality Imperial (by Camillus Cutlery Co.) official Boy Scout pocketknife incorporating a nonlocking spear-point blade, screwdriver/bottle cap opener, can opener, leather punch and a 14.5-inch twisted-nylon-cord tether.

Flashlight

A water-resistant, two-D-cell flashlight with conventional bulb was provided in the Classic SEP, and a similar flashlight with krypton bulb, which provided much brighter illumination at the cost of reducing run time, was provided in the VIP SEP. Both had a spare bulb in the tailcap, which was very difficult to remove. No spare batteries were included. A 27.0-inch (68.6-centimeter) twisted-nylon-cord tether was attached to each of the flashlights.

The VIP Deluxe life raft also included a two-AA-cell aluminum water-resistant flashlight in a sheath on a leg of the canopy support tube for immediate access after boarding the life raft, a desirable feature, in our opinion.

Signaling Devices

A single mil-spec Mark13 MOD-0 Day/Night hand flare or an Orion 12-gauge flare pistol and four red 12-gauge aerial flares were included.

A flimsy metal mirror with no sighting aid was included in Classic SEPs. The VIP SEP included a good-quality two-inch by three-inch Ultimate Survival polycarbonate mil-spec mirror with a tether.

Also included was a single mil-spec sea dye marker packet and a superior-quality SOLAS-specification survival whistle with a lanyard.

Paddles

Paddles were constructed of hardened foam, life vest fabric, wire and aluminum tube (photo 54). The paddles were usable only after being immersed in water for a while to allow the ball-and-socket lock on the telescoping-tubular-aluminum handles to become functional. These paddles' longer handles provided enough reach that they could be used with two hands, making them easier to use and more effective. They were not useful for any other purpose (and they were not required to be) — as a cutting board, for example — because the fabric easily could be cut or punctured.

54

Fishing Kit

EAM's fishing kit provided an assortment of hooks and other fishing gear, as well as a pair of heavy cotton gloves, which would be worthwhile for handling the monofilament fishing line.

First Aid

EAM had a variety of first aid kits designed to meet the various requirements of the FARs and the European Joint Aviation Requirements.

Water

SEPs included a combination of water sources, depending upon the specific SEP and options selected. Older Classic life rafts in service provided mil-spec chemical desalting kits. Some current Classic SEPs include these desalting kits.

Sealed pouches that contain 0.025 pint/125 milliliters of water also might be included in an SEP. These have a five-year shelf life.

EAM included a Survivor-06 hand-operated water maker in some SEPs, such as the one that came with the Alpha Series (VIP) life raft that was evaluated.

No packaged ready-to-drink water was included. Having no water available immediately upon boarding is a deficiency, in our opinion.

An 8.0-inch by 24.0-inch (20.3-centimeter by 61.0-centimeter) plastic water-storage bag with a roll-and-tie-sealed spout and five cone-shaped paper drinking cups were provided.

Food

Appropriate quantities of U.S. Coast Guard-approved and vacuum-packed survival rations produced by S.O.S. Food Lab, with an EAM label and part number, are now included.[4]

Survival Manual/Life Raft Manual

A reprint of an outdated *U.S. Air Force Aircrew Survival Manual* in a plastic binder was provided. The pages did not turn easily and tore in use; they were not water resistant and likely would deteriorate quickly in a life raft environment. The absence of a waterproof survival manual in a life raft is a deficiency, in our opinion.

Log pages were provided for six days, but no writing instrument was provided, rendering the log pages useless unless survivors had a writing instrument. The ability to maintain a log of events, to write notes and to record important information that otherwise might be forgotten under the stress of survival, is an important element for improving survival chances.

An abbreviated LRM provided an appropriate list of immediate-action items and general life raft-maintenance information, including illustrations that showed how to use a life raft-repair clamp and signaling instructions. It was tethered to the floor of the Classic Type II life rafts, but it was stored inside the SEP of the Classic Type II and VIP life rafts where it would not be immediately available for reference to the immediate-action items. Even when this abbreviated LRM was immediately available, not one volunteer found the manual until after settling in the life raft and beginning to organize the life raft equipment with the other volunteers.

This abbreviated LRM was waterproof with bold, easy-to-read printing, with black text on white material. In the Alpha Series (VIP) life raft, the instructions for canopy setup and some other instructions were not relevant to the features of that life raft, a deficiency, in our opinion.

Service

The Classic life raft series had an annual service requirement. The VIP life raft had a three-year service interval.

GOODRICH

Goodrich — once known for its tires and now known for its aerospace and chemical businesses — entered the aviation life raft business when it purchased Sergeant Pico in 1985 and moved production from California, U.S., to a newly built plant in Phoenix, Arizona, U.S., in 1987. The Goodrich life rafts were constructed of neoprene-coated fabric and incorporated auto-erecting canopies and other features more commonly found at that time on marine life rafts. Goodrich provided a four-person Type II life raft and a seven-person Type I life raft for evaluation in 1993 and, despite some advanced features, the life rafts had, in our opinion, some deficiencies, including ineffective boarding aids and an absence of water ballast. The four-person Type II life raft was round; the seven-person Type I was rectangular with round ends (rectangular oval).

After publication of the 1993 evaluation results and the announcement at the 1995 NBAA convention of the then-upcoming 1996 life raft evaluation, in late 1995 and early 1996 Goodrich developed and delivered for the evaluation a 10-person Type I prototype for a new generation of Goodrich life rafts. With a few changes, these life rafts were put into production in early 1997, followed quickly by termination of production of the older-style life rafts. Goodrich ceased offering a Type II life raft. In 2000, Goodrich provided for evaluation production versions of four-person and 12-person Type I life rafts.

The manufacturing of Goodrich's new-generation life rafts was moved to the company's West Virginia, U.S., facility from Phoenix soon after FAA TSO approvals of the new designs were received in 1997. In 1999, manufacturing of the life rafts was moved to the company's facility in India. Production of life rafts ceased in India in 2001, and in 2002, Goodrich consolidated its entire slide, slide-raft and life raft production into expanded facilities in Phoenix, where Aircraft Interior Products is headquartered, said Douglas Nelson, manager, Aviation Life Rafts.[5]

Current Goodrich life rafts are rectangular with round ends (rectangular ovals) and are constructed of single-coated polyurethane over single-ply nylon fabric with the coated side on the interior of air-holding chambers. They are available in four-person, eight-person, 10-person and 12-person rated capacities.

A new Goodrich 10-person life raft was provided for the 2002 evaluation; the life raft was sold directly by Goodrich to a customer who planned to use it on a corporate aircraft, and it was delivered for customer pickup the day before the evaluation. The customer agreed to allow it to be used in the evaluation. The production date stamped on the life raft was January 2001, 19 months before delivery to the customer; the production date stamped on the valise was March 2001.

Valise

The standard yellow valise was of conventional box-style construction (photo 1, page 285). The valise was fastened with a Velcro seam along the middle of the top surface with yellow Velcro that matched the valise fabric. Use of a matching color would make the Velcro seam less visible

1

to a survivor and would make it less likely that survivors would attempt to open the valise at the seam. The valise had white nylon-webbing handles — two grab handles on the face of the smaller valises and two grab handles along each side of the larger valises — with one grab handle at the end opposite the inflation mechanisms.

Orange placards were used for essential information and for nonessential information (photo 2); thus, a survivor's attention could be misdirected at a critical time. The manufacturer-and-data placard was the largest placard, and black text was printed against the orange background. A smaller orange placard was printed with the instructions "EJECT THIS END FIRST" with an arrow pointing in the correct direction.

2

(At an NBAA convention, a model of this life raft was exhibited, and the orange placard with nonessential information had been replaced with a silver placard, allowing the user to distinguish it from essential information on the orange placards.)

The life raft could be packed in an optional white plastic hard case secured by two plastic bands. The case had two red nylon-webbing grab handles on each side.

At one end of the hard-case top was another orange placard with inflation instructions in small and readable text. There was no arrow indicating that the mooring/inflation line was on the side of the life raft adjoining this placard, although the mooring/inflation line and hardware were readily visible.

Goodrich used red one-inch-wide nylon webbing sewn into a triangular shape for an immediate-inflation handle, which was secured by Velcro to the valise on two legs of the triangle. With one side of the triangle unsecured, there was a possibility that the unsecured leg could be hooked inadvertently and the life raft could be inflated, a serious occurrence inside an aircraft cabin during flight or when trying to evacuate after a ditching.

No adjoining instructions/identification of the immediate-inflation handle were located on one end of the hard case or the valise, although such information was located on the top surfaces of both packages. Because the immediate-inflation handle was boldly visible (photo 3), it might be selected inadvertently for inflation, in lieu of the mooring/inflation line.

3

Mooring/Inflation Line

Next to the immediate-inflation handle was an orange fabric sleeve that contained the white mil-spec parachute-cord mooring/inflation line (referred to as a "firing" line on the placard), which was not inherently buoyant. Satisfactory instructions/identification to attach the snap to the aircraft were stenciled in black on the sleeve, but this information was obscured partially by the line and snap on the valise. On the hard case, the last line of the information was obscured because it was well under the curve of the sleeve.

Inflation

The small, lightweight snap (photo 4) was slipped over the open end of the fabric sleeve; it slid off several times when the packed life raft was moved during the evaluation and if unnoticed, could have snagged on something and deployed the life raft. The small snap was not satisfactory for attaching directly to any but the slimmest secure structure, but it was adequate for attaching to the mooring/inflation line that was looped around a secure structure.

The mooring/inflation line was 31.3 feet (9.5 meters) long and led to the boarding aids. The thin parachute cord exceeded the strength requirements of the TSO but might be difficult to grasp with cold, wet, numbed hands.

Volunteers had no difficulty understanding the inflation instructions, but they had to move much closer than might be

4

desirable to read the instructions, which were in small text.

The 10-person life raft inflated in 25 seconds; the hard case was designed so that both halves would be jettisoned upon inflation, which we prefer because they then could not interfere either with survivors or with the life raft.

Righting

Goodrich stenciled explicit righting instructions on one side of the life raft; they were designed to be read when the life raft is capsized: "PULL STRAP TO UPRIGHT" (photo 5). On the opposite side of the life raft was stenciled: "RIGHT FROM OTHER SIDE." The stenciled text was in red on the yellow fabric. (The life raft exhibited at the 2003 NBAA convention had text accompanied by pictorial righting instructions that provided very clear and unambiguous instructions. Placards and instructions were printed rather than stenciled, so readability was improved.)

5

A single red one-inch nylon webbing with two hand loops sewn into it was attached from one side of the life raft across to the other side in the middle of the life raft (photo 6). The hand loops laid flat and were not easily grasped, but they helped to counteract slipping on the exterior bottom of the life raft. (The life raft exhibited at the 2003 NBAA convention had a righting ladder constructed of one-inch nylon-webbing rails with five two-inch nylon-webbing rungs. This would appear to address concerns about

6

obtaining a good grasp with which to right the life raft.)

The inflatable canopy-support tubes were relatively narrow — four inches in diameter. When the life raft was capsized, the canopy-support tubes had insufficient buoyancy to lift the life raft off the surface of the water; the canopy support tubes were submerged and the life raft floated flat against the water on the upper buoyancy tube. When righting the 10-person life raft, the submerged canopy became a sea anchor that had to be overcome to turn it upright (photo 7); a small and lightweight person could have difficulty accomplishing the task. The canopy remained collapsed after the life

7

raft was righted (photo 8), a deficiency, in our opinion; the volunteers pushed it up after boarding.

The four-person life raft presented a similar problem. The small diameter of the single-arch canopy-support tube lacked sufficient buoyancy to prevent the life raft from settling upside down, rather than resting on its side on the surface of

8

the water. Moreover, the capsized life raft submerged enough to create a vacuum that made righting it more difficult without assistance from additional volunteers or without breaking the seal to the water first; this was problem solving that a survivor should not be expected to perform. This experience was not repeated with similar-capacity single-buoyancy-tube life rafts (without canopies), which had larger tubes and weighed less, because they tended to lie on the water — not to submerge in the water — when capsized.

Boarding Aids

In our opinion, the old-style Goodrich designs had the least-satisfactory boarding aids of the life rafts that were evaluated. Current Goodrich life rafts have a boarding platform, similar to one used on a line of European life rafts (Autoflug). A prototype in the 1996 evaluation was found to have deficiencies, but Goodrich made substantial changes before certification.

A pair of inflatable tubes projected from the life raft at the entries (photo 9, page 287). A pair of white one-inch nylon-webbing straps from the upper buoyancy tube attached to these tubes, near their outermost ends. They served as braces to prevent bending when weight was placed on the platform. A large section of fabric was hung between the projecting tubes and was lower; this platform satisfactorily supported the heaviest volunteers. Height to the top of the lower buoyancy tube was approximately 28.0

9

inches (71.1 centimeters), which was a comfortable distance for all but the shortest volunteers.

The platform was made of buoyancy-tube fabric with a triangle arrangement of six large round holes cut into the center of the platform and three large round holes next to the buoyancy tube to allow the platform to settle in the water. A double layer of fabric reinforced the area with the holes. The holes were large enough that a small foot could get caught in one, a deficiency, in our opinion.

Despite the holes, the fabric platform tended to float upward (photo 10), and this caused some hesitance on the part of some volunteers as they stopped to assess the situation and then pushed the fabric down into the water before proceeding with boarding. Volunteers boarded with minimal difficulty, although several reported that there was room for improvement. (The life raft exhibited at the 2003 NBAA convention had a more conventional boarding platform installed with a flat fabric floor and an inflatable crosspiece at the fore end. This crosspiece had a depressed section in the center, apparently to ease entry onto the platform. It was otherwise similar in construction to the original, but extended out further to provide a substantial base for boarding.)

10

There were several red, one-inch nylon-webbing grab handles. While not twisted, they were constructed so that they tended to rise up from the buoyancy tubes to which they were affixed; thus, they were easier to grab. There was one grab handle on the top forward section of each support tube, one centered below the entry above the midpoint of the lower buoyancy tube and one on each side of the midpoint of the entry above the midpoint of the upper buoyancy tube.

An interior three-rung boarding ladder of white, one-inch nylon webbing had one rung directly on top of the upper buoyancy tube, serving as a grab handle (photo 11). The ladder was attached permanently to the life raft floor at the bases of the beams, extended up and over the upper buoyancy tube and was attached to the boarding platform support tubes with quick-release buckles. These buckles had to be released to close the canopy door. The canopy door was rolled down to the tube, but it was secured tightly to the tube with the ladder rung lying on top of it; it was unlikely that it would be grabbed to assist in boarding.

The interior boarding ladder, located in the midst of the volunteers, proved an annoyance even when released. One volunteer suggested using the raft knife to cut the boarding ladder loose from the floor to eliminate the annoyance. The alternate solution, used effectively on life rafts by Air Cruisers, EAM and Winslow, would be quick-release buckles at the bases of the ladder rails inside the life raft.

One platform entry was installed at each end of the larger life rafts. A single platform entry was fitted to the four-

11

person life raft; at the second entry, a single one-inch nylon-webbing loop hung from the lower buoyancy tube approximately 12 inches and had grab handles near the top of the tube (photo 12). This entry was unsatisfactory for many volunteers, especially those who were shorter than average, had minimal upper-body strength or were mid-section heavy or bottom heavy. As with the EAM VIP four-person life raft, this type of boarding aid is deficient, in our opinion; it does not comply with the requirements of TSO-C70a (paragraph 4.6).

The support tubes for the boarding platform had no check valves; and, if punctured, the lower buoyancy tube would deflate, thus it did not meet the requirements of TSO-C70a (paragraph 4.6). (On the revised platform exhibited at the 2003 NBAA convention, it appeared that this

12

had been addressed and, if so, should have met the TSO-C70a [paragraph 4.6] requirement.)

The sea-anchor attachment point for the larger life rafts was centered on the end, bisecting one of the boarding platforms. This was the same entry to which the mooring/inflation line led, thus making it the de facto primary entry. The location of the sea anchor line interfered with boarding. A solution would be to direct survivors to the opposite entry as the primary boarding location.

Canopy

The four-person life raft was equipped with a four-inch-diameter auto-erecting stay-erect single-arch canopy-support tube located on the short (eight-inch) straight center section of the buoyancy tube (photo 13). The arch incorporated square corners for improved headroom. The canopy was constructed of lightweight translucent orange coated rip-stop nylon fabric. As with all the translucent fabric canopies, sun shining through it gave everything and everyone an unappealing orange tinge.

13

The canopy fabric was glued to the top of the canopy-support tube and glued where it was attached to the upper buoyancy tube. Upon inflation, the two flaps were rolled down on the upper buoyancy tube and secured with Velcro straps. Both sides of the life raft were fully exposed with the flaps open. A large plastic one-way zipper was used on each of the flaps. The single-truck zipper made it difficult to adjust the opening or to rig the flap for shade. (The life raft exhibited at the 2003 NBAA convention had double trucks to allow for more versatility.) There was satisfactory headroom in the center rectangular section of the life raft, 36.5 inches (92.7 centimeters), 40.5 inches (102.9 centimeters) to the top of the arch tube, and less headroom at the ends and sides, 29.0 inches (73.7 centimeters), where the canopy sloped down to the upper buoyancy tube.

The larger life rafts were equipped with an auto-erecting, stay-erect canopy. A pair of four-inch canopy-support tubes were fitted at the corners of the life raft (photo 14). A central tube connected the two arches across the center of the life raft, adding rigidity to the arches. The canopy fabric was glued to the top of the canopy-support tubes and to the central

14

connecting tube. The top of the canopy was approximately three feet wide and extended between the two arches. The sides and ends could be opened or closed, so the life raft could be well ventilated.

Upon inflation, all the flaps were rolled down on the tube and secured by Velcro straps. As on the smaller life raft, a large plastic zipper was used on each of the four opening flaps. The single-truck zipper made it more difficult to adjust the opening or to rig for shade.

There was good headroom in the center rectangular section of the larger life raft, 36.5 inches and 40.5 inches, and less headroom (29 inches) at the ends and sides, where the canopy sloped down to the tube.

There was no rainwater-collection mechanism.

Rain Simulation

Closing up the canopies was easy and quick to accomplish; the life rafts proved reasonably weathertight, though they leaked some water through the zippers because storm flaps were not effective (they were too small). (The life raft exhibited at the 2003 NBAA convention had larger storm flaps that might be more effective.)

The canopies on the larger life rafts sagged considerably after they became wet, significantly reducing headroom (photo 15). More of a concern was the fact that the larger life raft canopy

15

seemed to have a weak spot on top where the center support was joined. A partial collapse of that section was observed, particularly on the 12-person life raft, but a complete collapse did not occur; the canopy rebounded immediately after water pressure was removed.

Lifelines and Grasp Lines

The lifelines and grasp lines were red one-inch nylon webbing. Lifelines were attached along the sides of the life raft and extended to the boarding aids, where they were secured to the upper buoyancy tube with adequate slack to be easily reached by survivors in the water. Grasp lines, secured to the upper buoyancy tube, encircled the interior of the life raft.

Stability

The Goodrich life rafts had four small ballast bags constructed of buoyancy tube material containing approximately 56.1 pounds (25.4 kilograms) of fresh water each. A bag was attached at each corner of the rectangular life rafts (photo 16) and at equidistant intervals around the four-person life raft. Five one-inch holes were in the bottom of each bag, which allowed water to escape, albeit relatively slowly (photo 17). Nevertheless, drain holes should not be in the bottom of water-ballast bags, because the ultimate

16

17

performance of the water ballast would be diminished, compromising the stability of the life raft. (The life raft exhibited at the 2003 NBAA convention had ballast bags constructed of lightweight canopy fabric and did not have drain holes.)

The water ballast did not appear sufficient to compensate for the rectangular shape of the larger life raft, which was particularly vulnerable to capsizing if the sea anchor was lost or was deployed incorrectly. This was a deficiency, in our opinion. The yellow tab that held the sea anchor detached from one of our evaluation Goodrich life rafts (photo 18).

18

Goodrich used a flat, round, parachute-style sea anchor made of lightweight nylon parachute fabric, 36 inches in diameter (flat) with eight shrouds. The anchor was deployed automatically upon life raft inflation and was attached to the life raft opposite the primary entry on the four-person life raft and at the primary entry of the larger life rafts. No swivel was fitted to the 29.0-foot (8.8-meter) parachute cord that was the sea anchor line, so the likelihood of failure was increased, a deficiency, in our opinion.

The sea-anchor attachment point failed on the 12-person life raft we evaluated in 2000, tearing away from the life raft during boarding (photo 19). The failed assembly was returned to Goodrich, which said that analysis showed that the failure was the result of substandard bonding, an assembly error.

19

On the life raft (built in 2001) borrowed for the 2002 evaluation, the attachment point had been improved and was satisfactory (photo 20).

20

Stability of the four-person life raft was satisfactory. On the larger life rafts, the ballast was inadequate. The lack of a swivel in the sea anchor was a deficiency, in our opinion. This was particularly an issue on the four-person life raft and on the larger Goodyear life rafts, given the boat-shaped life rafts' dependence upon an effective sea anchor.

Floor

An inflatable floor was standard on all the Goodrich life rafts. These were equipped with long reeds that ran from one side of the life raft to the other, two in the smaller life rafts and three in the larger life rafts. This floor construction did not lend itself to being inflated "hard," it just ballooned up between the reeds; thus, its effectiveness was compromised (photo 21).

The inflation valve was located near the edge of the floor, rather than in its center

21

(photo 22). Survivors might not readily locate the inflation valve. Moreover, the valve was not comfortable to sit on, even though it was recessed; volunteers adjusted their position to avoid sitting on the valve.

22

The red-stenciled placard next to the inflation valve said "HAND PUMP FITTING" and had a small arrow pointing toward the valve. (The life raft exhibited at the 2003 NBAA convention had screen-printed text with two arrows that was easier to read. There were also a pictogram and further instructions to use the manual inflation pump, which was located near one of the buoyancy tube topping valves.)

Life Raft Equipment

Pump

A molded recessed receptacle held the topping valve. While volunteers attempted to insert the manual inflation pump into the topping valve, the attached rubber cap interfered with the pump body. The cap had to be positioned carefully and held out of the way to attach the pump. The recess did not allow the attached cap enough space to be flat, as it would be when the valve was fitted flush.

A recessed valve also made it more difficult to use the manual inflation pump with two hands for maximum-effort pumping (photo 23). On the larger life raft, the positioning of the topping valve on the lower buoyancy tube was too close to the upper buoyancy tube; the overhang of the upper buoyancy tube interfered with the

23

pump body and caused difficulty inserting or operating the pump. A red-stenciled "HAND PUMP FITTING" was adjacent to each valve. (The life raft exhibited at the 2003 NBAA convention had screen-printed text and an arrow that was easier to read. There were also a pictogram and instructions to use the manual inflation pump, which was located near the upper buoyancy tube topping valve.)

The manual inflation pump was a conventional bellows pump, but it had fewer bellows and very short strokes compared with other pumps. The TSO-C70a requirement (paragraph 5.5) is 32.0 cubic inches (524.4 cubic centimeters) per full stroke. The pump provided about 75 percent of the TSO-required capacity during our evaluation.

The manual inflation pump was stowed in a small pouch constructed of orange canopy fabric and stenciled with "HAND PUMP." It was secured in the pouch under a long flap tucked in beside the pump. The pump pouch was in the life raft, tethered to the floor. It was difficult to remove the pump from the tightly fitted pouch, and the flap was difficult to open. There was no tether or lanyard on the pump; thus, it could be lost overboard after being removed from the pouch, a deficiency, in our opinion.

Bailer and Sponge

The bailer was stored inside the SEP, where it was not immediately available after boarding. It was constructed of sewn plastic-coated fabric with a wire-reinforced rim. The rim maintained an open end and made the bailer easier to use. It had a capacity of 4.0 quarts (3.8 liters) and leaked at the seams. There was no tether and no place to attach one conveniently, a deficiency, in our opinion.

Goodrich included a single six-inch by 3.75-inch (9.53-centimeter) by one-inch compressed sponge that was very dense and difficult to squeeze. That was not a good attribute for a life raft sponge because ease of use and conservation of strength are a vital survival necessity.

Heaving Line

Goodrich used nylon parachute cord, which was not inherently buoyant, and a round-ring rubber quoit (photo 24). The line was retained on the upper buoyancy tube to the right (while boarding) of the primary entry with a yellow buoyancy tube fabric clasp. A single metal snap held it together. The clasp wrapped entirely around the line and quoit, squeezing the quoit into an oval shape. The clasp was stenciled in red with "RESCUE LINE," and the fabric tab for the metal snap was stenciled "LIFT." Neither was easily readable because of wrinkled fabric and inadequate stenciling. The quoit did not return to a round shape after it was released from the clasp, making the quoit more difficult to grasp from some angles (photo 25, page 291). (The four-person life raft exhibited at the 2003 NBAA convention had screen-printed text for "RESCUE LINE" that was easier to read; "LIFT" was stenciled in small text and was difficult to read. There was also a

24

25

pictogram showing how to throw the rescue line to retrieve survivors from the water.) Volunteers were unable to throw the quoit successfully because the line tangled, a deficiency, in our opinion.

While measuring the length of the heaving line (to check for the required 75 feet) on the four-person life raft, the end attachment to the quoit came loose. The knot securing the line to the quoit had come undone after minimal handling, a deficiency, in our opinion.

Raft Knife

The raft knife was located on the interior side of the canopy support-tube to the right (while boarding) of the entry. The raft knife was wrapped in its tether and held under a Velcro-secured flap in a sheath of yellow buoyancy-tube fabric. The yellow sheath was not readily visible against the identically colored life raft fabric. The sheath was stenciled inadequately in red: "KNIFE." On the four-person life raft, a loop of the tether was hanging out of the sheath, and it was easy to use that to pull out the knife. On the larger life rafts, there was no such loop, and it was not easy to pull the raft knife from the sheath. (The life raft exhibited at the 2003 NBAA convention had "KNIFE" screen-printed in large vertical text next to the raft knife sheath and a screen-printed pictorial instruction of the raft knife on the sheath; both contributed to making its location very noticeable. A pictorial instruction and text instructions to use the manual inflation pump were located near one of the buoyancy tube topping valves.)

Goodrich used a raft knife that was made by Hoover Industries. The finger hole retained the little nibs that remained after removal of the plug that was molded originally in the hole. These nibs were sharp and painful when the raft knife was pulled from the sheath or when the knife was used to cut anything (photo 26). Hoover trimmed these nibs on the knives used in their life rafts; Goodrich did not.

26

The mooring/inflation line and the sea-anchor line were in relatively close proximity to each other. A confused or panic-stricken survivor could cut the wrong line by mistake, a deficiency, in our opinion. On the floor of the life raft, stenciled text and a small arrow identified the lines, but the information was difficult to read or to see and might be overlooked or obscured by survivors (photo 27). (On the life raft exhibited at the 2003 NBAA convention, screen-printed text with a larger arrow made

27

the information more readable, but the information remained on the floor of the life raft where it could be overlooked or obscured by survivors.)

Lighting

Approved locator lights were used in the interior and on the exterior of the life rafts, except no interior light was used in the four-person life raft, a deficiency, in our opinion. On the larger life rafts, the exterior light was on top of one canopy-support tube, at the primary entry, and the interior light was on the underside of the opposite canopy-support tube. The interior light was at the end opposite where the immediate-action instructions were displayed.

This was likely an effort to meet the requirements of TSO-C70a (paragraph 4.12) that the locator light be "visible from any direction by persons in the water." Because the exterior light was not at the highest point on the canopy, the light was shaded from effective view for approximately 200 degrees around the life raft. The interior light located at the opposite end would appear to have provided a locator light for the shaded areas, at least upon inflation or when the canopy was open (except the sections blocked by the canopy support tubes). This does not meet the requirements of the TSO or the practical reasons for having the light in the first place: to serve as a life raft locator light for survivors in the water and for searchers. Successful rescues have occurred because of these dim lights, whose effectiveness is multiplied when searchers use night-vision equipment.

(On the life raft exhibited at the 2003 NBAA convention, there was also a locator light on the underside of the life raft, which was an improvement, in our opinion. Nevertheless, it was located opposite the righting location, which was somewhat counterintuitive because in that position it would attract survivors to the wrong side of the life raft.)

ELT

The life rafts were equipped with an auto-deploying DME Corp. 121.5-MHz ELT. The ELT was installed in a pocket on the exterior of the life raft: on the lower buoyancy tube on the larger life rafts and on the upper buoyancy tube on the four-person life raft. Located on the exterior of the life raft, opportunities for discomfort caused by sitting against the ELT were eliminated. The whip antenna was located in the interior on top of the upper buoyancy tube beside a canopy-support tube. No 406-MHz ELT option was offered. (On the life raft exhibited at the 2003 NBAA convention, the beacon location was on the interior, attached to the leg of the canopy-support tube.)

Survival Equipment Packs

Goodrich secured one pouch or two pouches inside the life rafts on short tethers (photo 28). Pouches were constructed of orange canopy fabric; several strips of yellow Velcro were used to close each pouch into a compact bundle.

28

Inside the pouches were four 4-mil zipper lock plastic bags containing survival equipment modules for signaling, life raft maintenance, first aid and food. A shrink-wrapped Survivor-06 hand-operated water maker, vacuum-packed Land/Shark Emergency Survival Bag and paddles also were included.

Goodrich provided two 9.0-inch by 14.0-inch (22.9-centimeter by 35.6-centimeter) envelope-construction bags of lightweight

29

canopy fabric (photo 29). There was a short strip of one-inch Velcro on the flap closure, but there was a large gap at each end that allowed the contents to escape. Simply extending the Velcro all the way across the flap would improve the closure. (On the life raft exhibited at the 2003 NBAA convention, there were four stowage pouches, and the Velcro extended across the flap, a notable improvement.)

Survival Equipment

Repair

One three-inch mil-spec repair clamp and one five-inch mil-spec repair clamp were included. (On the life raft exhibited at the 2003 NBAA convention, there was a screen-printed placard on the upper buoyancy tube illustrating how to install a repair clamp.)

Utility Knife

A poor-quality stockman's pocketknife was fitted with a non-locking three-inch spear-point blade, an awl, a pair of combination bottle/cap openers and large/small screwdrivers. This knife began to rust almost immediately after immersion.

Flashlight

Goodrich used two Rayovac Roughneck flashlights powered by two AA-cell lithium-batteries. As noted in the Air Cruisers evaluation, the switch on the Roughneck flashlight was subject to inadvertent activation, a deficiency, in our opinion.

Signaling Devices

Two Skyblazer XLT aerial meteor flares and a mil-spec sea-dye marker packet were provided. The two flares in the SEP from the 2002 evaluation life raft were manufactured in February 2000 and had an expiration date of August 2003.

A two-inch by two-inch BCB International signal mirror had an effective aiming aid, but offered inadequate reflectivity. A superior-quality SOLAS-specification WindStorm Safety Whistle with a lanyard was included.

Paddles

Goodrich used the mil-spec blue plywood paddles with a retroreflective tape applied to one side. These were not comfortable to use because the handles were difficult to grip and the paddles were too short to be very effective or to be used with two hands. Wrist lanyards of nylon tape were fitted to the handles.

Fishing Kit

A mil-spec fishing kit was included.

First Aid

A useful assortment of first aid supplies was assembled into plastic zipper-lock bags. A plastic bottle of SPF (sun protection factor) 30 sunscreen was included. The inclusion of the sunscreen was excellent because sunburn can cause great discomfort and accelerate dehydration. The bottle had leaked sunscreen into its heavy plastic zipper-lock bag in one of the three SEPs examined, however.

The antibiotic ointment packets in the 2002 evaluation life raft were labeled by the manufacturer with expiration dates of August 2002 (seven packets) and January 2003 (three packets). Affixed to the packets was a paper label "EXPIRATION

Continued on page 298

Life Rafts: Ask the Person Who's Tried One

Jan Rishbim, aircraft certification service, U.S. Federal Aviation Administration, who has responsibility for many TSOs (technical standard orders), including those for life rafts, said that he had never been in a life raft before the evaluation.

> *It was a great opportunity to come out here and get a good hands-on feel for what these life rafts are like … how they perform … and what some of the important features are.*
>
> *The life rafts were a lot more cramped than I expected … that was the biggest thing for me. And if you can't get in them, they don't do you any good.*
>
> *I was very impressed … how organized it was … a well-done event.*

Edie Redfern, 30, is a civilian intern training to be a survival instructor for the U.S. Air Force at Sheppard Air Force Base, Wichita Falls, Texas. Redfern, a former high school teacher with a master's degree in education, recently changed careers and is in her first year as an intern, training to train.

> *I just took on this job at Sheppard and part of what I do is teaching individuals about life rafts. I've not [been trained in or] taught those blocks yet. It's brand new and I totally have no clue where to start.*
>
> *I was a little nervous [about deploying the life raft] … the arrow pointed to a certain area … I pulled a line and that's not exactly what [the instructions] wanted me to do … I had done the wrong thing, but it was easy enough to see what the right thing was.*
>
> *Getting in [the life raft] was a little bit difficult. I actually had to reach down and loop the ladder over my foot and I don't have a lot of upper-body strength, so that was a little challenge. But I made it in.*
>
> *To survive, yeah, I could spend time in a life raft. You know, five days would be pushing your luck. I'm thinking three would be pushing your luck and hopefully the rescue would be a lot sooner than that. It was pretty cramped in there. So, you have to like the people you're in the life raft with. Our legs were like, entwined with each other. If you were injured you'd be hard up. I don't know if an injured person could have gotten in the life raft. It would have taken people in the [life] raft to get them in. … Alone, I don't know if [an injured person] could have gotten in or not. Honestly, that was a challenge even for … a testing environment. I thought about that as I was climbing in, what if I was injured?*
>
> *When I go back to [work as a survival instructor] I have the knowledge and terminology about how the life raft functions because [at Sheppard] we don't have [in-water training for life rafts] … it's in a classroom, so having this background will definitely be a plus.*

Julia Ripps, 43, from Scottsdale, Arizona, recently retired from her picture-framing business of 20 years, and is planning to go cruising with Ron, her husband, aboard their sailboat.

> *We wanted to experiment with life rafts since we need to purchase one and find out what a really good life raft should be.*
>
> *I was in … this particular life raft that had …only two openings and when we had to tip the [life] raft over, and swim out from underneath it, that was a pretty interesting experience with all the people in there.*
>
> *Never having done that before and then realizing that there was enough air once the [10-person] life raft was turned over, that you didn't have to rush to get out. You didn't have to panic.*
>
> *There's plenty of room in this life raft, especially for four to six people. You know 10 people could just fit in there, and 11 was getting snug, and then we had 15 people [overload capacity] in there. It held up pretty well. But it was really packed.*

Ron Ripps, 59, retired entrepreneur, Scottsdale, Arizona:

> *I think [the evaluation] ought to be required … for people going off shore … because there's a lot of surprises when you open up these [life rafts] such as how they're boarded. What the different accessories are. And really, which [life] rafts are good [life] rafts to be in. [As a result of this experience], I know pretty much which [life raft] I'm going to get, which company I'm going to use and to some degree a lot of the equipment I may want on it.*

Ron Ripps

Jonathan Redfern

Tech. Sgt. Jonathan Redfern, 33, aircrew life support instructor, U.S. Air Force, Sheppard Air Force Base, Wichita Falls, Texas:

> *[The evaluation is an] opportunity to see, maybe the best and not so best of the aviation and marine life raft products that are available today. Also to see what is already out there compared to what we have in the military.*
>
> *I participated two years ago in [a similar] test and it's just incredible to see that some of the manufacturers really heeded some of the [previous volunteers'] safety concerns … and corrected them, and some of their innovations are really neat with what they came up with. On the downside it's kind of sad that there are still some of the manufacturers … that have done nothing and … are still selling 'dogs.'*

Nancy Miller, 47, from Concord, California, is a biology instructor at a community junior college. She is an instrument-rated 600-hour private pilot who flies her single-engine Piper Archer for pleasure with her husband Patrick, a student pilot.

> *I participated in [a previous life raft evaluation by Doug Ritter] and I think he does it very well. Anyone who is in boating or in aviation … ought to volunteer… because it is a wonderful experience …because … you buy a life raft, what do you know about it?*
>
> *We fly over San Francisco Bay fairly regularly. When I'm shooting approaches into Monterey I carry life vests, which most people think I'm really silly to do, but that's an overwater approach … I would rather have a life vest on board than not.*

Patrick Miller, 45, is a principal engineer for a software company.

> *The [evaluation] is well organized and I feel safe because there's a number of people making sure that the people who are in the [life] raft when we do [a capsizing], to make sure you make it out. There's life guards … and underwater divers.*
>
> *Staying in the [life] raft in rough seas I think would be [likely] but getting into the raft injured [and] by yourself, I don't believe is possible. I think it would be very difficult to do any kind of first aid … other than lying across everyone [else in the loaded life raft] and … I'm not sure that you can get more than one or two lying down simultaneously.*
>
> *It looked like the seams were coming already coming apart on a brand new [life] raft.*

Mike Shaw, 35, an environmental consultant from Charlotte, North Carolina, is a sailboat owner who plans to sail offshore. He said that he had never been in a life raft until the evaluation.

> *I think one thing that was confirmed was how cramped the life rafts are. It's really surprising when you put eight people in an eight-man life raft how little space you have.*
>
> *This [evaluation] … brought it to life. Oh, if you're out there on the water [in a life raft] you are going to be incredibly uncomfortable. You're going to have to be getting along with these people for who knows how long and [that] just makes the situation that much worse. You would lose all humility… .*
>
> *Here, I've [boarded] eight [life] rafts … and can really compare the pros and cons of all of them. They all have something I like, they all have something I don't like. Getting the practice of getting in and out of a [life] raft has been incredible.*
>
> *I think I'm learning as much watching [the life raft activity from poolside] as being in the water."*

Alan Shaw (no relation to Mike Shaw), 49, from Lummi Island, Washington, is a consultant working with regulatory issues for manufacturers of lifesaving equipment.

> *The marine side of life raft specifications has been revamped more recently than the aviation life raft specifications… that go back to the 1970s and essentially nothing's changed … there's been a lot of advances in life raft products in that time.*
>
> *A ditching will happen … do you want to have a life raft on board or do you want to be swimming? It's that simple. The odds are small, but because there are odds, it does happen and will happen.*

Nancy Miller

This [evaluation] is exciting because you've got products represented by many manufacturers and you've also got people that are not familiar with life rafts, using them. And that's the key. Because a life raft has to be used by someone who's never seen one before and it has to be reasonably easy … to use. And if it's not, the manufacturer has failed.

This [evaluation] has been well planned. To have a pool with a ramped entrance and a wave generator … it's great.

You can see why the manufacturers dislike this process. With life rafts, the difficulty is nobody ever sees the product, it's always in a container. So this is a rare chance to see what's inside those containers and for ordinary people … to compare the products arbitrarily, with no bias, and come up with an opinion. Very valuable, and the manufacturers should listen up. The manufacturers that listen up will certainly benefit.

Master Chief Butch Flythe, U.S. Coast Guard rescue swimmer program manager, Washington, D.C., is considering retirement.

We thought it would be a good idea to come out here and see the industry's latest … 'cause sooner or later we're going to start looking for replacements [for life rafts in Coast Guard airplanes and helicopters].

Instead of just looking in the [government's] stock system, [I am] trying to find something better … in the commercial world, if I can. If you can justify it by salient features or price or quality … they'll let you go outside the system and get something commercial.

"This facility is really nice as far as being able to generate at least some kind of wave action … . There's a few of us here that are trained, but for the most part, its people off the street, the kind of people you want to know: Are they going to be able to use that life raft?

Things are set up safely. I think [Ritter] is being very meticulous in his filming [of the life rafts] and tracking all the comments [of the volunteers]. I'm very impressed with the set-up. It's a very good test. In the military, I wish we did more things like this.

It's really interesting to see the different designs and how they're marked, the different equipment and type of equipment that a manufacturer chooses to put in a life raft and other manufacturers don't.

If I was going to give somebody advice … you need to pay attention to what kind of equipment. Does that equipment meet my needs? Don't just say, 'Well, here's a life raft and I'll just buy this one.' You really need to take some time and effort and research it.

I think life rafts in airplanes are a must. If you're flying over water and don't have one, you're stupid. Anybody that is going to fly over

Continued on page 297

Hal Jensen is an aerospace engineer in the Aircraft Engineering Division at the Federal Aviation Administration (FAA) in Washington, D.C. Jensen and a colleague from the FAA participated in the 2002 life raft evaluation, in Phoenix, Arizona. During the evaluation he shared some of his personal opinions and observations.

Basically, at headquarters, we have responsibility for some of the TSO [technical service order] standards that apply to … aviation life rafts. My interest [in attending the evaluation] was in getting a hands-on experience at what makes the life raft a good design and really to get some fundamental, in-the-water experience.

This type of event is more valuable than a lot of the things that I would typically do. I get more information from trying to board the life rafts, get out of the life rafts, roll over in life rafts than six months of sitting behind a desk or going to an SAE meeting. It's extremely valuable.

Hal Jensen

[Until this evaluation] I have never had any experience in climbing in or out of a life raft. For me, it was going from looking at standards that talk about what type of boarding aid [an aviation life raft] should have and what type of design features we would like as a minimum performance standard, to actually looking at some of those life rafts that meet the standard and seeing the difference between the ones that far exceeded that standard and the ones that may [have] met the minimum standard. So the actual use of the boarding aids, erecting the canopies, all of that was unique for me and extremely valuable.

With this experience now, I'll look at something [on a life *raft] and be able to [better understand it] based on my experience. One thing I thought was very enlightening was the length of the ladders … [and the number] of rungs that were necessary to get in the life raft. Some that were very short may have passed the TSO but they were not nearly as easy to use as one of the longer ladders. It was [very] tough to get into some of them and … the longer the ladder, the easier it was.*

So that is … the type of thing I would push for in the next TSO revision. Maybe we should consider a minimum length for that ladder.

The key word is 'minimum': minimum performance specifications or standards. For some people, it's going to be more difficult to get in [a life raft]. I did see that everyone here was able to get in. I'll admit that I thought …some [life] rafts would be [easier] to get into — the ones with the [boarding ramps] certainly were much easier, but even I had some trouble, initially, [getting in the life raft].

A couple of times the [ladder] rungs were [too short]. That was a difficulty, particularly with the tall two-chambered life rafts. But it goes back to the minimum performance standards. And while it's going to be difficult for some folks, if we can ensure a certain level — it's not going to cover every single person — but the vast majority should be covered by that minimum standard. That's the kind of approach we take not only with these standards, but the certification of aircraft in general.

From what I've seen, most of these life rafts surpass the TSO minimums [but] there were a couple in my mind that might be a little suspect.

This [evaluation of life rafts] gives me so much more confidence in the evaluation of the TSO … but when there are [requests for deviations] — someone says they want to show a different way of meeting one of the criteria — that has to come to headquarters for our approval. Seeing something here gives me so much more experience upon which to base approvals or rejections of those requests.

[This evaluation] is interesting, because it's not a certification test, it's like an evaluation … from a consumer-advocate group. I liked it. It's my first experience in something like this.

This facility was … very adequate, particularly … because you had the waves coming at different angles. I think that probably demonstrated what you might have with light seas. And it certainly gave you an idea that if you had trouble in any of the [life] rafts in these 'seas', … in a little bit heavier seas … the problem will probably [increase] exponentially.

In my opinion — not FAA's — some people are willing to take more risks than others. We need to ensure that not only the operator of the aircraft is safe, but the people who are relying on him, that get in that aircraft with him and are more naïve about the environment … that is the reason that we want to ensure that specific aircraft have a specific-size life raft and meet a specific standard. It's really to protect not only the operator … but the people who might be flying with him.

The other thing I saw here was … some people already have some of these life rafts and it's obvious they didn't know how to use them … in these [very] benign conditions. We have plenty of light and there was a little stress level trying to get the [life rafts] deployed, but nothing like what you might find if it's a dark night in storm conditions. So … people that might buy these off the trade-room floor probably need to take that extra step and get training, even if … it's a video that would come with the life raft. Training is the key with these types of survival equipment.

I was very impressed with Doug Ritter and the degree of organization … and effort that he and his wife [Sue] put into it. I think it accomplished his mission of being safe.

I thought Doug had just the right level of obvious participation, particularly with the life raft deployments. He only stepped in when he thought that there might be a potential safety issue, someone trying to inflate the [life] raft on the deck, for [example]. Other than that, he allowed people to deal with the situation the way they would have to on their own. I've known Doug for about four years [through mutual involvement with SAE International] and I've been very impressed with what he does … and [that he] is open to different ideas.

I filled out all the evaluation forms for every [life] raft that I was in. I put as much detail as I could … and of course you focus on the things where a life raft seems weak compared to the way it performs adequately. ■

— FSF Editorial Staff

water for any length of time is … at risk by not having some type of [life raft] other than a PFD [personal flotation device]. The quicker you can get out of the water and into that [life] raft, you're buying yourself a lot of time.

Jim Kir, 54, prison counselor, Gilbert, Arizona, is a member of his local U.S. Coast Guard Auxiliary (there are large lakes in Arizona).

This is a great opportunity … to learn a little bit about what it's like to deploy a life raft.

You really have to be pretty agile [to get in the life raft]. And you have to work as a team. If one person is having a problem getting in, you've got to grab the person and pull 'em in.

To spend two days or three days on a [life] raft would be pretty difficult. I think legs would go to sleep … and it would be pretty chilly.

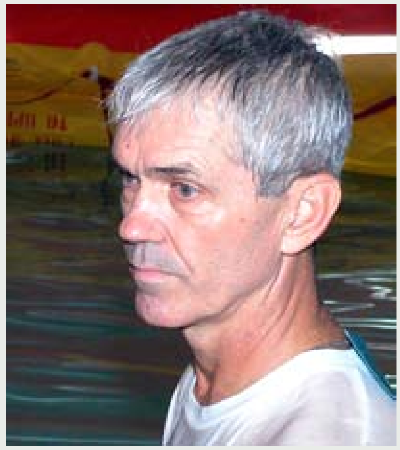
You'd have to go [urinate] over the side. You'd have to untangle your legs and let everybody know what you're doing … I think out in open water it might be difficult.

Ed Blanchard, 57, is bio-medical engineer from Gilbert, Arizona.

I'm retired from the [U.S.] Marine Corps so I've done stuff like this before. I'm really impressed with the way the [life] rafts are put together and all the accessories that are placed in them to help you in a survival situation. I can't think of any of the [life] rafts I've been in today that I wouldn't want to be in a real survival situation.

Carol Curt, 46, is a human factors specialist from Chicago, Illinois.

I was interested in coming out here … to see how they did this kind of product testing. And they know what they're doing. They've got a real good program here. All the videotaping … getting people who don't know what they're doing to do the [evaluation]. That's exactly the way it should be tested, at least from my training and my work in usability.



Ed Blanchard

Bob Moretti is a psychologist from Chicago, Illinois.

As a sailor, I always have had an interest in survival stuff. And all the products are marketed at very high prices … but you never really get a chance to 'try before you buy' and I wanted to see what these products would be like to use. Just to have the experience of getting in a life raft. Hopefully, I never have to do it for real.

I deployed one of the … life rafts. I was the guy who couldn't get it open. I was in the water for three or four minutes searching for the line. I own [the same kind of life raft]. I just bought it, and despite that I had looked at the [life] raft … and thought I knew exactly how to deploy it, I had forgotten all … I had read … and now, under the gun to deploy this thing I couldn't do it.

The instructions [on the life raft] were not clearly marked. You can see how a small change could be made that would be so important. All [the instructions] had to say was 'lift this flap' not 'lift the Velcro flap'; there were two Velcro flaps. You could see how something like that could save somebody's life. It's kind of neat to think that you participate in something that might have an impact on somebody else."

Rick Bogden, 50, a chiropractor from Mesa, Arizona, is interested in cruising a sailboat after his retirement.

I thought it would be a lot easier getting in and out of the [life] rafts and things like that and it's very difficult. You have to have some athletic abilities to get into these things. You've got to use your upper-body strength to pull yourself in. The first time was an effort, then it got easier as the days progressed.

A couple of these [life] rafts had … a nauseating odor when you opened them. I couldn't stay in [those life rafts] for more than [a few] minutes. A few of them … I felt like I was trapped. [In] other ones I felt more comfortable and felt safe ... but none of them were real comfortable.

Bill Bogden (Rick's brother), 55, a registered nurse, wants to sail with his wife to foreign ports during retirement.

It would be very difficult for people to get in these [life] rafts who don't have any kind of training or any kind of [appropriate knowledge]. On top of all that, the factors of fear and 'What's going to happen next'… it would be real difficult.

We were on the [life] raft just a couple of minutes and [another volunteer] was already claustrophobic. Some of these [life] rafts are a lot darker [inside] than others … and I hadn't thought about the air circulation [when the canopy is closed] but that is a real concern. Some of the [life] rafts had windows, some of them didn't … but having that little bit of light … you get the feeling you're not trapped. ■

— FSF Editorial Staff

Note: Interviews with volunteers during life raft evaluation with Rozelle, Roger. Tempe, Arizona, Aug. 23–25, 2002.

DATE 1/03" that had been added. Seven of the ointment packets had expired before the customer purchased the life raft; the other three would expire before the first service date. Despite the amended expiration date, all would expire before the next service date, a deficiency, in our opinion.

Water

A Survivor-06 hand-operated water maker was included, but there was no packaged ready-to-drink water, a deficiency, in our opinion. A mil-spec 5.0-pint (2.4-liter) water bag was provided.

Food

Vacuum-packed S.O.S. Food Lab survival rations were provided.

Miscellaneous

An emergency ("space") blanket (typically made of laminated layers of polyester film, such as Mylar, with a reflective coating that can be used either to retain body heat or to protect from sunlight) was provided — not as a thermal protective aid, but as a radar reflector. A small fresnel lens magnifier, helpful for reading small print, was included. (Such a lens has a surface consisting of a concentric series of lens sections so that a thin lens and large diameter are possible.)

Survival Manual/Life Raft Manual

An immediate-action list/LRM was hung from the canopy support arch and was readily visible (photo 30). It was printed on waterproof paper and stored in a zipper-lock plastic bag. The back of this "Management Guide — Liferaft" was easy-to-read bold print.

While the LRM was relatively easy to read, it was not well written. Moreover, one passage said that "assistance may be expected within a few hours to not more than 24 hours." Inclement weather or a ditching well offshore could slow a rescue operation, and survival manuals never should set deadlines or promote high expectations. A positive mental attitude, confidence in a successful outcome and realistic expectations should be encouraged.

30

Service

The life raft required initial service after two years, then had a one-year service interval.

HOOVER INDUSTRIES

Hoover Industries, has been involved in manufacturing a variety of products since 1955, beginning with interiors for trains and buses, aircraft furniture and medical gowns and masks, said Alain Sosa, general facilities manager.[6] About 1985, the company entered the life raft market when it acquired the product line of the then-defunct American Safety Co. Today, the company manufactures various models of TSO-approved Type I and Type II life rafts up to 46-person capacity and life vests, and continues to install aircraft interiors.

Hoover's unique reversible life raft, the patented ReadyRescue, was made available for the 2002 evaluation. This life raft was different from Hoover's previous life rafts, which were similar to those produced by EAM (the same engineer developed both companies' early designs). For purposes of clarity in this evaluation, Hoover's earlier designs, with manually erectable canopies, will be referred to as "conventional"; this was not a distinction made by Hoover.

Hoover provided a four-person conventional Type II life raft for the first evaluation, did not participate in the second evaluation, provided a newly developed six-person conventional Type I life raft for the third evaluation and provided a six-person Type I ReadyRescue prototype (photo 1) for the 2002 evaluation.

1

The life rafts were constructed of double-coated neoprene over two-ply bias-cut nylon fabric. The conventional life rafts were octagonal. The Type I reversible life raft was available in four-person and six-person rated capacities; the conventional Type II life raft was available in two-person, four-person, six-person and eight-person rated capacities. The ReadyRescue Type I reversible was a rectangular octagon with a pair of long sides creating a "boat-shaped" life raft. It was available only in a six-person rated capacity, but greater-capacity life rafts were planned.

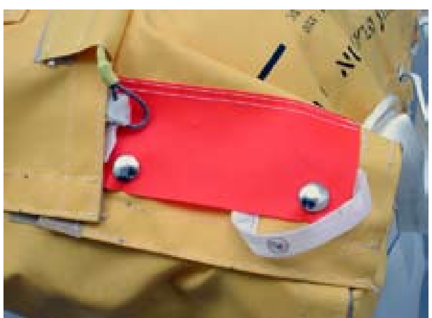
Valise

The valises for the conventional life rafts and for the ReadyRescue life raft were nearly identical to EAM valises.

The six-person conventional Type I valise and the ReadyRescue valise were rectangular with nylon lacing holding the valises together (photo 2). One-inch-wide Velcro was used at the end to hold the valise flaps. The SEP was inside the valise, in its own separate pack, constructed with snaps to close it. A pair of nylon-webbing grab handles was provided on each side, but none were at the ends.

2

Instructions for inflation were stenciled in black in very small, indistinct text on the yellow valise fabric. The instructions would be difficult to read in dim light. There were no pictorial instructions. The end of the mooring/inflation line was protected under an orange — unlabeled — flap with snaps to hold it in place (photo 3).



3

Mooring/Inflation Line

Like EAM, Hoover used 0.5-inch-wide white nylon tape for a mooring/inflation line, with a 3.75-inch hand loop on the end (photo 4). The absence of a handle was a deficiency, in our opinion. The line was 18.0 feet (5.5 meters) for the conventional Type II life raft, 20.75 feet

4

(6.33 meters) for the conventional Type I life raft and 19.5 feet (5.9 meters) for the ReadyRescue life raft. TSO-C70a (paragraph 5.1) requires 20.0 feet (6.1 meters), so only the conventional Type I life raft met the requirement, a deficiency, in our opinion.

Inflation

All the life rafts deployed easily.

The ReadyRescue life raft fully deployed in 30 seconds. The PRV was located on the canopy-support tube and vented inside the canopy. SOLAS marine specifications do not allow interior venting of PRVs. Interior-venting PRVs are an inadequate design, in our opinion, and the carbon-dioxide gas vented in a closed or even partially closed canopy could have ill effects on survivors, who might experience dizziness, headache, nausea or rapid breathing, symptoms that would be resolved with fresh air flow.

Righting

Hoover's righting aid on the conventional Type II life rafts was essentially the same as on EAM's life rafts, a deficiency, in our opinion. Type I reversible life rafts require no righting aids.

Boarding Aids

On the conventional life rafts, a ladder with two semi-rigid flat rungs made of two-inch wide white nylon webbing hung at the entries (photo 5). The flat

5

rungs were weighted — a good feature — but the ladder was too short and barely hung below the exterior bottom of the life raft, a deficiency, in our opinion. Getting a foothold, while still maintaining a grip on the grab handle(s), was very difficult for some volunteers and was impossible for a few. After our 1996 evaluation, Hoover added another rung to the larger transport category life rafts, but this improvement had not been incorporated in all the aviation life rafts.

The Type II life raft had grab handles on top of the buoyancy tube and on the interior side of the buoyancy tube, and an interior grasp line. On the conventional Type I life raft, the grasp line did not extend across the entry, but another grab handle was added to the midpoint interior side and exterior side of the buoyancy tube (photo 6).

On the conventional Type I life raft, the entry was flanked on both sides by the blue insulated wire from the battery to the locator light attached to the top of each buoyancy tube (photo 7, page 300). The locator light inadvertently was pulled

6

7

from its location during the evaluation. The light was attached with a snap, so it could be reattached. Nevertheless, the locator light and/or the inadequately located wiring could be damaged by survivors boarding the life raft, a deficiency, in our opinion.

The ReadyRescue life raft featured a unique reversible boarding aid — part boarding ladder, part rigid boarding platform (photo 8). The rigid 20.0-inch by 16.0-inch (50.8-centimeter by 40.6-centimeter) platform was covered with fabric; hanging at its end was a single semi-rigid flat-rung nylon-webbing ladder. The platform hung from two-inch-wide nylon webbing, and the base was located at the bottom of the lower buoyancy tube, creating a slope up from the tube to the open boarding end of the platform. No matter which side was up, the boarding aid flipped to function correctly. After volunteers boarded the platform, typically on their knees, the slope helped prevent them from slipping off the platform. One-inch-wide nylon-webbing grab handles were located at the midpoint on the exterior and interior on the upper buoyancy tube and on the top of the upper buoyancy tube. Some volunteers had difficulty boarding, but all succeeded. Volunteers suggested adding another rung to the ladder and/or stiffening the ladder, as well as adding more handholds.

8

Canopy

The canopy on the conventional life raft was a manually erected stick-built design (photo 9) similar to EAM's. It used telescoping-aluminum canopy-support rods to hold up the edges and center of the translucent orange-coated rip-stop-nylon canopy (photo 10). There were four outer masts on smaller life rafts and eight outer masts on the six-person and larger life rafts, all spaced equidistantly around the inside periphery of the life raft.

9

10

Volunteers had the same problems with the Hoover canopies (photo 11) that they did with the EAM canopies with one notable exception: Hoover's telescoping canopy-support rods had

11

stops to prevent them from separating, a simple improvement that substantially improved usability. Hoover also did not include the dual-purpose paddles/canopy supports used in the EAM life rafts.

The Hoover canopy had two entries — which the company called "ventilation windows" — on opposite sides that were closed with metal snaps, but did not seal tightly (photo 12). They could be rolled up and secured with fabric ties. In a seating position, approximately 24 inches to 29.0 inches (73.7 centimeters)

12

of headroom were available, depending on whether measurements were taken at the rods or between the rods, with 39.0 inches (99.1 centimeters) of headroom in the center of the single-buoyancy-tube life raft.

On the conventional Type I life raft, 33 inches to 38.0 inches (96.5 centimeters) of headroom were available around the periphery and about 68.0 inches (172.7 centimeters) in the center. This resulted in a life raft floor that was sloped steeply down to the center, making sitting in the life raft difficult because volunteers kept sliding toward the center of the life raft (photo 13). The center rod also was difficult to erect fully. If left only partly erected, the floor was "loose" and the canopy sagged. The end of the center canopy-support rod cut a hole in the floor, not a good thing for a life raft (photo 14, photo 15). When the life raft was capsized, the canopy tore in several places and some of the rods were bent, making re-erection of the canopy more difficult, a deficiency, in our opinion.

Attached to the top surface of the Type I life raft's canopy was a metallic surface reinforced with a backing material, which served as a radar reflector, albeit one that might be lost in high winds because it was secured only on the corners.

A fabric water-collection tube was fitted to the canopy; no retroreflective tape was fitted to the canopy.

For the ReadyRescue life raft, Hoover went back to the drawing board and

13

14

15

developed its first canopy with an inflatable support tube, a single square-arch stay-erect design with the arch bisecting the rectangular oval life raft. A canopy and its support arch were installed on both sides of the reversible life raft.

During inflation, the canopy-support tube inflated, but the canopy did not erect. The inflated support tube and the attached canopy were secured to the upper buoyancy tube by a tab secured with a pinned loop. Instructions — "PULL PIN TO RELEASE CANOPY"— were stenciled on the buoyancy tube below the pin at the boarding location, centered on the entry (photo 16). The same

16

instructions were inside the life raft, on the floor, with an arrow pointing to the exterior location of the pin. Attached to the pin with a stainless steel cable was a red one-inch-wide nylon-webbing pull tab six inches long with "PULL" stenciled in black and a piece of retroreflective tape affixed to the end.

On the canopy-support tube was the exterior locator light, attached to the top of the canopy. Its lens, facing sideways with the canopy still pinned down, would be excessively bright for anyone looking directly at it (photo 17); however, most likely, the pin would be

17

pulled while survivors were in the water with their eyes below the light, so in most circumstances, it would be less of an issue. In rough weather conditions, it could become more of a factor as the life raft moved.

Thread secured the pin to prevent inadvertent release of the canopy. Pulling the pin released the canopy-support tube, which immediately erected the canopy. This worked satisfactorily on one side of the reversible life raft. On the opposite side, when the pin was pulled, the thread did not break; rather than pulling the pin, the entire pinned loop was pulled off the canopy from where it was sewn on, resulting in a small tear in the canopy (photo 18, page 302). The tear occurred in a section where no adverse effect was created, either structurally or functionally. Hoover later said that it had reinforced this attachment point to prevent a similar failure.

18

The ReadyRescue life raft canopy was constructed of the same lightweight rip-stop-nylon fabric as the conventional canopies. On the side where the canopy release was located, the flap closure was rolled up and tied. One-inch-wide Velcro was used to close the flap along both sides and at the buoyancy tube. The narrow Velcro and tight canopy fabric made sealing the flap difficult, and the fabric was torn on the lower corners of the canopy opening and the flap (photo 19).

The other side of the canopy was equipped with a zipper that extended nearly from one canopy support tube to the other. This left a short piece of fabric attached to the upper buoyancy tube, and the remainder was attached to the canopy-support tube. No means was provided to restrain either flap; so upon canopy inflation, the upper flap hung in the middle of the life raft. There was a water-collection tube fitted

19

to the upper portion of the canopy that was only marginally effective because of the steep slope; the tube could be closed only by tying a knot in it.

If the life raft were capsized and the canopy zipper were open, the arch would lay over in the same manner as when the life raft was originally deployed. If the zipper were closed, the canopy would not lay over but would remain as erected. After a capsizing, the canopy on the opposite — upright — side could be released, and the survivors would be able to reboard a life raft with a canopy (photo 20).

20

Large tears in the canopy fabric appeared on one side and were believed to have occurred during the capsizing evaluation (photo 21). Hoover said that it had reinforced these areas to prevent tears in production life rafts.

21

The canopy zipper on the undamaged side failed during the evaluation. The canopy was stretched so tightly that closing the zipper was very difficult, a deficiency, in our opinion. During examination after the in-water evaluation, the cloth pull on the zipper tore off as the zipper was closed. When the zipper was closed, the zipper tended to part behind the zipper truck (photo 22). Hoover said that it had upgraded the zipper from the size no. 5 YKK zipper that failed on the prototype to the industry-standard heavy duty no. 10 YKK zipper for production life rafts. The company also said that the canopy was given adequate slack in the fabric to prevent this from occurring again.

22

The canopies were fitted with retroreflective tape in an approximation of the U.K. CAA standard pattern, with a cross of tape over the top centered on a segmented circle (photo 23), a good location for this conspicuity aid. However, there was little retroreflective tape visible from either end of the life raft, nor was much of this retroreflective tape visible when the canopy was down.

23

Rain Simulation

The rain simulation results for the conventional Hoover life rafts mirrored the results of EAM's Classic life rafts.

The ReadyRescue life raft's Velcro-secured flap-entry closure failed; it was

24

insufficiently secure to withstand the spray (photo 24). The long zipper on the other side, with no storm flap or protection, "leaked like a sieve," one volunteer reported. Overall, Hoover's canopies were deficient, in our opinion. Hoover instituted improvements to the life raft after receiving the damaged prototype from the evaluation.

Lifelines and Grasp Lines

The conventional Type II life raft had its lifeline strung along the midpoint of the exterior side of the buoyancy tube.

The Type I life raft had a more substantial one-inch-wide white nylon-webbing lifeline strung along one of the tubes approximately midway between the centerpoint of the upper buoyancy tube and the joint between the two tubes. The lifeline did not extend to the entry, stopping short in the adjoining segment.

The lifeline on the ReadyRescue life raft was attached only on the three end sections and did not extend along the sides, leaving a large gap. On the end where the inflation cylinder was located, the lifeline was stretched tightly over the cylinder and was difficult to grasp. The lifeline was attached to one buoyancy tube near the joint and had little slack, so it could be difficult to reach for some survivors in the water. The lifelines also were obscured underneath the water-ballast bags that were attached to and draped over the canopy, so survivors in the water might grab onto that fabric, rather than the lifelines.

Stability

Four water-ballast bags ("water ballast pockets," Hoover calls them) were suspended from the bottom of the periphery of the conventional Type II single-buoyancy-tube life rafts (photo 25). The water-ballast bags were constructed from canopy fabric and were cylindrical in shape; each held approximately 52.7 pounds (23.9 kilograms) of fresh water. The conventional reversible Type I life raft had three of the same size ballast bags on each of its two upright sides. A small weight in the bottom of each ballast bag caused the bag to drop down for immediate filling.

25

Water-ballast bags made the conventional Type II life raft only slightly more difficult to capsize than its EAM counterpart. On the conventional reversible Type I life raft with a higher center of gravity, the water ballast was ineffective, a deficiency, in our opinion.

The ReadyRescue life raft had four large water-ballast bags on each side, constructed of canopy fabric and attached to the canopy where the canopy joined the buoyancy tube (photo 26). These hung at the outer perimeter of the life raft. They were irregularly shaped, and determining their capacity was difficult: Each held approximately 175.5 pounds (79.6 kilograms) of fresh water. They were heavily weighted and required only 42 seconds to drop down and fill after the life raft inflated.

The sea anchor was the same on all the Hoover life rafts: a 13-inch-long

26

(33-centimeter-long) cone-shape construction of canopy fabric with a 12-inch wire-reinforced opening (photo 27). The 5/32-inch (0.4-centimeter) white-nylon flat-braid line was 14.0 feet (4.3 meters) long with a 10.0-inch (25.4-centimeter) bridle secured to brass grommets, considerably shorter than the TSO-C70a (paragraph 5.3) requirement of 25 feet. No swivel was fitted, a deficiency, in our opinion.

27

On the ReadyRescue life raft, the sea anchor was attached to the life raft off-center on one end. Given the boat-shaped life raft's dependence upon an effective sea anchor, this was a deficiency, in our opinion.

Floor

No insulated floor was available. The conventional reversible Type I life raft with the floor between the two tubes offered some insulation protection in calm seas and with less than a full-capacity load, but not at full capacity or overload capacity or in rough weather conditions.

Raft Equipment

Pump

A conventional bellows manual inflation pump was used; it was similar in design to all the others but provided the highest capacity of any we evaluated.

Hoover was the only remaining manufacturer of TSO-approved life rafts to continue to use a threaded connector (photo 28) and a manually operated rotary topping valve with no check valve, instead of a bayonet connector with an integral check valve.

28

To operate the manual inflation pump, the user would screw the pump into the threaded valve and open the plated-metal valve by rotating it clockwise. When pumping was completed, the valve would be turned counterclockwise to close the valve and the pump would be removed. "OPEN" and "CLOSED" text and arrows at the valve indicated clearly the required movement of the valve. Instructions stenciled on the floor of the life raft showed users the proper procedure and order of action, and included the instruction, "OPEN VALVE ONE TURN."

These instructions were not always immediately adjacent to the manual topping valve(s) and could be obscured from view under the bottoms and feet of survivors. If the valve was opened too far, as it was when some volunteers overlooked the instructions (photo 29), the valve jammed open and was difficult to close. There was no caution

29

about over-tightening the valve upon closure. A natural tendency to tighten the valve more than necessary could lead to over-tightening the manual topping valve. On several occasions, volunteers tightened the valve so firmly that it could not be opened again using finger strength alone.

Thus, with this valve design, a tool, such as pliers, should be included with the life raft. Pliers have been included in the past by other manufacturers that used this type of valve. Hoover, however, did not include pliers or any other suitable tool to open/close the valve. If the valve could not be opened, the pump would be unusable. This was a deficiency, in our opinion.

On the ReadyRescue life raft, several problems were experienced with the manual inflation pump. The pump was attached via a tether to the exterior of the life raft and was stored inside the bailer. The tether was too short to allow the pump to reach three of the four manual topping valves. (Hoover later said that it had lengthened the tether.) Volunteers also were unable to attach the pump to the topping valve on the lower buoyancy tube. The valve was inset into the floor, and there was insufficient room for the pump (photo 30). (Hoover said that it had included a six-inch hose extension for the pump and that the extension was tethered to the pump for security.)

Bailer and Sponge

The eight-quart bailer was constructed of sewn buoyancy-tube fabric, which leaked

30

at the seams (photo 31). The bailer had no handle, so it was difficult to use, a deficiency, in our opinion.

31

The bailer was tethered to the life raft; a large placard was stenciled on the buoyancy tube with a brief list of what was attached and with an arrow indicating the exterior location of the "SURVIVAL EQUIPMENT." The placard was obscured by seated volunteers (photo 32), and they did not locate the equipment until they were coached about where to look for it. The manual inflation pump and the immediate-action instructions were stored inside the bailer (photo 33, page 305).

32


33

The bailer's tether was too short, and it would have had to be untied or cut to allow the bailer to be used, a deficiency, in our opinion. Without a secured tether, the bailer could be lost overboard.

Heaving Line

On the conventional Type II life rafts, the 50.5-foot (15.4-meter) 3/16-inch braided-polyethylene (which floats) heaving line and traditional round-rubber quoit were secured inside the life raft and attached to the floor in a small pouch, which would not be readily identifiable by survivors in the life raft.

On the conventional Type I and ReadyRescue life rafts, the 42.3-foot (12.9-meter) heaving line and quoit were attached to the exterior lifeline with a fabric flap folded over the lifeline and secured with two snaps, and tethered to the life raft at the same point as the bailer and the SEP (photo 34). The "HEAVING LINE" was listed in smaller text under the larger "SURVIVAL EQUIPMENT" placard. The heaving line failed to meet the TSO-C70a requirement (paragraph 5.4)

34

of 75 feet for Type I life rafts, a deficiency, in our opinion.

Raft Knife

The tethered raft knife was stored inside a sheath of yellow buoyancy-tube fabric with a snap closure (photo 35). "KNIFE" was stenciled indistinctly in black on the sheath, but the sheath was not very noticeable, being the same color as the life raft.


35

On the conventional Type I and ReadyRescue life rafts, the raft knife was in the sheath on the top of one buoyancy tube next to the mooring/inflation line attachment. Because the sheath was attached only at the closed end, it could be "bent" upward for access and raft knife removal. A small placard was stenciled with "MOORING LINE KNIFE" and an arrow on the interior of the upper buoyancy tube. The text was small, indistinct and easily overlooked (photo 36). This was a deficiency, in our opinion, because survivors might have an urgent requirement to sever the line attaching the life raft to a sinking aircraft.

Given the low cost, weight and volume of a raft knife, there seems little reason not to attach a raft knife on both upright sides of the life raft, with appropriate placards.

36

On previously evaluated traditional Hoover life rafts, the sharp molding nibs in the life raft knife's finger hole had been removed, but the ReadyRescue life raft's knife had many nibs in place and was uncomfortable.

Lighting

In our opinion, the exterior locator light on the ReadyRescue life raft did not appear to meet the requirement of TSO-C70a (paragraph 4.12), because when the canopy was pinned down to the buoyancy tube upon inflation of the life raft, the locator light was not "visible from any direction by persons in the water" (photo 37). After the canopy was erected, the light still did not meet this requirement because it was blocked by the canopy. The light was not visible to volunteers in the water when they were located on the side of the life raft opposite the light.

In a lightly loaded life raft in calm conditions, the water-activated battery for the locator light might not function. The battery, located on the midpoint of the exterior side of the lower buoyancy tube


37

(there were two lights in mirrored installations, one for each side of the reversible life raft), might be above the water (photo 38), a deficiency, in our opinion. The life raft had no interior light, which was a deficiency, in our opinion.

38

ELT

"Dummy" ELTs provided by life raft manufacturers usually were delivered in a normal ELT case with an antenna — with no electronic components — but weighted correctly. The ReadyRescue life raft was equipped with a dummy 121.5-MHz ELT, which initially confused everyone, because it was a long, heavy piece of white-capped plastic pipe tethered to the life raft. Finally, it was recognized as a dummy for the type of survival-type ELT used only on transport category aircraft, an ACR Electronics ELT-201. This ELT was oversized and overweight, and not appropriate, in our opinion.

The ACR ELT was normally activated upon immersion and floated with the top of the ELT and its whip antenna above the water. When the ReadyRescue life raft was deployed in the evaluation, the dummy ELT was trapped by its tether under the life raft. The thin polypropylene line, attaching the ELT to the life raft at the same attachment point as other survival equipment, was not noticed when the SEP and other equipment were retrieved. The dummy ELT was discovered during the capsizing evaluation. Trapped under the life raft in a survival situation, an ELT would have been useless. No placards to identify the ELT's location, coupled with an unsatisfactory attachment/inflation, combined to make this a deficiency, in our opinion.

Survival Equipment Packs

The SEPs on the conventional Type II life rafts were tethered in a similar manner as the EAM SEPs, with the same deficiencies, in our opinion.

On the Type I life rafts, including the ReadyRescue life raft, the SEP was attached to the life raft (as noted earlier) and was contained in a heavy plastic bag (photo 39), which had been tied closed with a knotted line; the bag's presence was not obvious. The knotted line was difficult to untie, and untying the bag would have been much more difficult with cold, wet, numbed hands. Moreover, water had leaked into the bag and had soaked the equipment.

A tether loop was in the center of the life raft floor with a placard stenciled:

39

"KEEP ACCESSORIES TIED TO RAFT TO AVOID LOSS IN CASE OF CAPSIZING." To do so, the tether would have had to be cut and then relocated to the tether loop; the bag would have had to be retied after every access. This unwieldy process, which would tend to increase the likelihood that it would not be adhered to, would put the survival equipment at risk for loss. There was no other storage for survival equipment. These were deficiencies, in our opinion.

Survival Equipment

Repair

A single three-inch mil-spec repair clamp was included. No PRV plugs were included. These were deficiencies, in our opinion.

Utility Knife

The Type II life rafts, including the ReadyRescue life raft, had a Part 135 SEP, including a high-quality utility knife: a standard U.S. military-issue stainless steel pocketknife with can opener, bottle opener, screwdriver, awl and a non-locking 2.5-inch (6.4-centimeter) spear-point knife blade.

No utility knife was included in SEPs of the conventional Type I life rafts, a deficiency, in our opinion.

Flashlight

A single water-resistant aluminum flashlight with two AA-cell batteries and a krypton bulb was included.

Signaling Devices

A Pains Wessex Mark 14 Day/Night hand flare was included; it resembled a traditional Mark 13 flare, with a plastic body, screw-on caps and better ergonomics. Nevertheless, it was just as ineffective because it only provided 18 seconds of smoke for day use and 20 seconds of flare for night use. There were also a mil-spec sea dye marker packet and a mil-spec survival whistle with a lanyard.

The conventional Type I life raft did not include a signal mirror, a deficiency, in our opinion. The conventional Type II life rafts had a two-inch by three-inch Survival polycarbonate mil-spec mirror.

The ReadyRescue life raft included a 2.5-inch square-acrylic signal mirror with a rudimentary aiming aid. Four V-grooved lines milled into the back (removing reflective material) met at the 5/16-inch (0.8-centimeter) center hole and created an aiming spot on the edge of the center hole. It had a very limited effective angle of incidence to the sun and proved not to be as accurate as conventional aiming aids. A removable paper cover protected the face of the mirror until the mirror was used (photo 40,). All the signal mirrors were equipped with an 18-inch tether.

40

Paddles

Mil-spec blue plywood paddles were provided with retroreflective tape on one side and with wrist lanyards.

Fishing Kit

The Hoover fishing kit (photo 41) included only some line wrapped around a piece of cardboard, which disintegrated when wet (and it was wet), a pair of leaders

41

and a pair of lures. This was a deficiency, in our opinion.

First Aid

A satisfactory assortment of packaged first aid supplies and a bandage scissors in two lightweight zipper-lock bags were provided. The bags were not waterproof; the supplies were soaked when they were unpacked.

Water

A combination of water packets — a good feature — and a chemical desalting kit were provided for drinking water. No separate water container was provided, a deficiency, in our opinion. A Survivor-06 hand-operated water maker is offered as an option.

Food

Hoover provided S.O.S. Food Lab survival rations.

Miscellaneous

Seventy-five feet of 1/2-inch wide nylon tape and a space blanket were included.

Survival Manual/Life Raft Manual

The conventional life rafts included the *U.S. Air Force Aircrew Survival Manual* which, though abbreviated compared with the more comprehensive version, was water resistant and was designed for use in a wet environment. Neither version had specific information on life raft care and use. Some water-survival information was included, but it was spread throughout the manual. In the ReadyRescue life raft SEP, we received the more comprehensive version, which was not waterproof, a deficiency, in our opinion.

An LRM was packed inside the bailer (not immediately available upon boarding because it must be retrieved from the bailer) and was printed on waterproof material with bold, easy-to-read black text on a white background. A reasonable list was included of immediate-action items and general life raft maintenance information, as well as some basic-water survival instructions and signaling instructions.

Service

Hoover life rafts required annual service.

In 1992, RFD Co. (now RFD Beaufort) of Dunmurry, Northern Ireland, and Revere Supply Co. of West Caldwell, New Jersey, U.S., entered a joint marketing agreement to manufacture and distribute RFD/Revere life rafts in the marine and aviation markets. RFD Co. was founded by Reginald Foster Dagnall in 1920 and claims to have invented the first inflatable life raft in 1932. Revere Supply Co., founded in 1936, initially distributed flotation equipment and signaling devices manufactured by its subsidiaries, and distributed life rafts manufactured by other companies. In 1967, Revere established its own life raft manufacturing facility.

RFD/Revere offered two lines of TSO-approved life rafts. For the 1996 evaluation, the company provided a seven-person version of its R (reversible) Series life raft, designed for offshore helicopter use in the North Sea oil fields (and known as the Heliraft in other markets) and also marketed for use by U.S. corporate aircraft operators.[7] The company also produced a more conventional non-reversible life raft, the Aerolite Series, which was promoted for corporate aviation use but not provided for the evaluation. The company did not provide life rafts for evaluations in 2000 and 2002.

RFD/Revere life rafts were constructed of single-coated polyurethane over single-ply nylon fabric with the coated side on the exterior of air-holding chambers. The R Series life rafts were octagonal and available in seven-person, 10-person, 12-person and 14-person rated capacities. The hexagonal Aerolite life rafts were available in four-person, six-person and 11-person rated capacities.

Valise

When the R Series life raft was evaluated, the company said that it had 167 different custom valise configurations. The life raft that was evaluated apparently had a standard generic valise, similar to the one shown in a promotional and training video provided by RFD/Revere. The round, duffel-shaped valise of heavyweight polyurethane-coated yellow fabric was laced across the top and down both ends. The lacing was very thin, almost thread-like in appearance, but very strong; the volunteers were unable to pull it apart. No Velcro was used for closure.

A pair of long handles was attached to the sides of the valise (photo 1); the handles could be grabbed at the top, or one handle each could be used by two people to carry the life raft between them. The handles were white two-inch-wide

1

nylon webbing, folded and sewn to create a one-inch grab handle that was easy to grasp. The webbing wrapped completely under the valise from one side to the other. The handles did not stay in place on top, but flopped at the sides, making it difficult to grab one with a single hand. Having grabbed one handle, it was impossible to also grab the other with the same hand. If placed on top to be within reach, it immediately flopped back down to the side. Volunteers found the floppy handles annoying because two hands were required to grasp the life raft. This could slow inflation because there was no way to just grab and lift the life raft with one hand. This was a deficiency, in our opinion. A break-away tie or Velcro would be useful to hold the loose handles together and to make them easier to grasp as a single handle.

At each end of the valise was a parallel pair of small grab handles, one on either side of the seam, constructed of one-inch-wide nylon webbing. This was satisfactory to pull or carry the life raft from the end(s), if necessary.

Information was stenciled in black on the valise fabric and was worn and not particularly dark on the well-traveled demonstration sample. All the information on the top/sides of the valise was manufacturer's data with the exception of the word "PULL" near one end, with an arrow pointing to the end of the valise. This information was not readily recognizable, a deficiency, in our opinion.

On one end of the valise, two flaps were located on either side of the seam at the bottom (with the main seam topmost), one orange with black trim, the other yellow with gray trim, each secured with button snaps. Instructions were stenciled on the flaps in black and were not easily read because of the small size and indistinct stenciling (photo 2). In addition, because of the slightly bulbous shape of the end of the valise, neither flap could be read without standing the valise on end, a deficiency, in our

2

opinion. Hanging from the yellow flap on the seam side of the flap was the mooring/inflation line with a heavy clip. This clip was not secured to prevent inadvertent snagging, which could result in an accidental inflation, a deficiency, in our opinion.

Under the orange flap, labeled "SHORT MOORING LINE," was a steel ring attached to the immediate-inflation line. Anyone who pulled this line might be surprised to discover that it was the immediate-inflation line. The volunteers did not readily locate the inflation instructions or the mooring/inflation line, deficiencies, in our opinion.

Mooring/Inflation Line

A small steel ring was used as a hand grip for immediate inflation. This ring was too small to easily grip. A survivor would have to hold onto the ring to keep the life raft near the ditched aircraft (for a dry boarding, for example): this would require considerable strength, and a couple of fingers worth of grip might be insufficient, a deficiency, in our opinion.

The mooring/inflation line was equipped with a robust heavy-duty spring clip (photo 3, page 309). The spring clip was so stiff that some volunteers were unable to use it easily; it was difficult for most of them to clip it back onto the mooring/inflation line. Sturdy fittings are benefits generally, but when an average person cannot easily operate a spring clip, it is too sturdy. This clip was a deficiency, in our opinion.

3

Inflation

The life raft deployed in 22 seconds.

Righting

No righting aids were included with the R Series life raft because it was a reversible life raft. Nevertheless, in a videotape supplied with the life raft, the possibility was discussed of the life raft capsizing and being righted by a conventional method. This could be accomplished if it overturned with the erected canopy, while survivors were inside the life raft. The videotape demonstrated a "survivor" using the inside grasp line as a righting aid. This method of righting the life raft was not attempted by the volunteers, but this method could be successful. Considering the lack of effectiveness of the life raft's vacuum ballast, capsizing is a possibility.

Boarding Aids

The Aerolite Series life rafts and R Series life rafts were fitted with a semi-rigid inflatable boarding ramp (photo 4). This entry comprised a splayed U-shaped inflated tube that protruded from the life raft. The base of the U was hinged with heavy rubber at the attachment point. Between the splayed side tubes was white open-mesh nylon netting that provided a slip-resistant surface. A one-inch-wide white nylon-tape grab handle was attached in the center of the mesh platform about two-thirds up the ramp. The white grab handle on the white mesh resulted in little contrast, so the white grab handle was not recognized readily. Two other grab handles were fitted, one at the hinge point and one on the top of the upper buoyancy tube.

4

In general, weak or injured survivors probably could pull themselves onto the ramp and into the life raft (photo 5). For a heavy survivor, however, the ramp's buoyancy could be difficult to overcome, leaving the survivor with little or no leverage against which to push, making boarding very difficult. Moreover, volunteers of average weight and height who tried to kneel or stand on the bottom half of the ramp found that the ramp collapsed under them. Boarding became easier as volunteers followed others who had already boarded the life raft, thus lowering the freeboard and creating a lower ramp angle.

5

Although it was a two-buoyancy-tube Type I design, with the floor placed between the tubes there was much less initial buoyancy than with a conventional non-reversible life raft, resulting in the reversible life raft floating lower in the water when it was loaded. Experience and reports from other venues indicated that this same boarding ramp on the higher-freeboard Aerolite Series life rafts would be more difficult for some survivors to use successfully.

The seven-person R Series life raft was equipped with a white one-inch-wide nylon-webbing three-rung boarding ladder at the alternate entry (photo 6). A single grab handle was provided at the top of the ladder where it attached to the top of the upper buoyancy tube. This boarding aid's performance was deficient, in our opinion. Larger versions of this life raft had dual boarding ramps, one attached to either tube. This would appear to provide a satisfactory alternate entry, though the steeper incline might make it more difficult to use compared with the primary entry, in our opinion.

6

Canopy

The canopy was spacious and weatherproof (photo 7). Although it was an auto-inflating stay-erect design, it did not erect automatically. RFD/Revere said that this

7

would allow survivors an unobstructed 360-degree view to search for other survivors in the water and would allow entry into the life raft from anywhere on its periphery.

When the two parallel six-inch-diameter canopy-support arches were inflated, each laid down horizontally around the outside of the main buoyancy tube. They were held in place by a sewn and Velcro-secured cover and served as a bumper protecting the main buoyancy tubes. The cover had a layer of black fabric on the outermost part for increased abrasion protection and puncture protection.

RFD/Revere said that these two canopy-support arches were intended to be two of the four buoyancy chambers required by the Helicopter Liferaft Amendment to U.K. CAA Specification No. 2, paragraph 2.2: "The life raft shall incorporate a minimum of four independent primary buoyancy chambers." As the life raft was inflated, secured at the sides, the canopy-support arches served that purpose, albeit with considerably less buoyancy than the main buoyancy tubes. After they were erected, they ceased being "primary buoyancy chambers." Nevertheless, considering TSO-C70a (paragraph 4.2.1 and paragraph 4.2.2), this was not an issue because only two primary buoyancy chambers are required. Each arch was fitted with a manual topping valve.

If the canopy-support tube were damaged while acting as a bumper, despite the protective cover, the canopy could not be erected until the tube was repaired and reinflated. This might be preferable to having a main buoyancy tube damaged, but the reason for having two independent buoyancy tubes is to provide redundancy. Delay in erecting the canopy support could have serious consequences for survivors.

The procedure for erecting the canopy was not obvious or intuitive. Moreover, although the instructions included both drawings and text on a very readable black-on-white placard, they were insufficient, a deficiency, in our opinion. Only half of the volunteers understood the instructions and successfully erected the canopy. In addition, being on the interior side of the upper buoyancy tube, the instructions could be obscured by survivors, who might overlook them, particularly in darkness or in adverse weather conditions.

The first group of volunteers was unaware that a canopy was on the life raft and made no attempt to find it and erect it, although canopies were on all the other life rafts, some of which required manual erection. These volunteers had to be told to read the instructions (photo 8) so that they could erect the canopy. When all who might have to use the life raft have been trained to accomplish the task, this would not be a problem. Unfortunately, that is an ideal that should not be taken for granted.

8

To erect the canopy, a survivor would have to release the protective cover over each canopy arch by pulling on a fabric tab placarded "PULL FOR CANOPY RELEASE" (photo 9) The placard was on the

9

interior side of the buoyancy tube for each canopy arch; the volunteers overlooked the placards. The tabs were secured with Velcro to the buoyancy tube. When pulled, the tabs ripped open the top seam on the canopy cover. There was a seam on both "top" and "bottom"; thus, a seam would be accessible regardless of which side of the reversible life raft was used. On this life raft, one of each canopy cover's two seams was stitched (photo 10); the other was restrained with Velcro.

10

The canopy was yellow polyurethane-coated fabric that was somewhat translucent. The yellow interior was cause for negative comments by some volunteers; as with all the translucent fabric canopies, sun shining through it gave everything and everyone an unappealing yellow tinge. The canopy fabric was attached permanently to the arches and to the exterior of the life raft from the point outward of the canopy-arch attachment points (photo 11). The canopy arches were attached to opposite sides of the life raft, leaving two opposing segments clear for entry.

11

Volunteers could not assess the difficulty of ripping open the sewn seam because we were requested not to do so by RFD/Revere. Ripping open the Velcro-secured side required some effort but was not beyond the capability of most people. Volunteers wondered aloud how difficult it would be to pull the tab with cold, wet, numbed hands, because the grip area was not large or easy to grasp; a loop, instead of a plain tab, might have been easier to grab. The Velcro pull strip consisted of two pieces of hook Velcro sewn back-to-back to create a double-sided hook strip with the canopy cover and the buoyancy tube having the loop Velcro. RFD/Revere said that it planned to replace the sewn side with Velcro.

Having uncovered the canopy (photo 12), volunteers next had to pull one two-inch wide nylon-webbing strap from one canopy arch to the other and attach it with a plastic quick-connect buckle (photo 13). Pulling the loose end of the strap was supposed to raise the canopy. Volunteers discovered that raising the canopy-support arch by hand was easier than pulling on the strap to raise it. This expedient solution would not be possible for a survivor working alone. Volunteers had to pull very hard to raise

12

13

the canopy supports using the strap; the working leverage was initially not very effective because the canopy supports were being pulled sideways, not up at an angle. Lifting up at least one arch several inches by hand made pulling the strap much easier (photo 14). Once semi-erect, another 11 quick-connect buckles had to be connected to fully erect and secure the canopy. The final buckles required significant strength to connect.

14

The volunteers questioned whether a lone and injured survivor with a single usable hand could erect the canopy and seal it from the weather, and they believed that even some uninjured survivors without sufficient upper-body strength and grip strength would have difficulty erecting the canopy. Quick exit after capsizing also could be hampered by the canopy design. Survivors could right the life raft by crawling "up" the interior of the canopy until their weight caused the life raft to right. That action would require prior training or considerable presence of mind, because no such instructions were provided on the life raft, a deficiency, in our opinion.

The buckles were attached to the canopy fabric, not to the canopy-support tubes. The tubes were erected to their final position by pulling together the canopy to a point where the tubes were at an angle of about 50 degrees from horizontal, and then the canopy was stretched between them; this also held the canopy-support arch tubes upright. The connecting point was off center, with the bulk of the canopy top deploying from one side and only a few inches deploying from the other side. Once connected, there was about a six-inch to eight-inch gap between the two pieces of the canopy top.

Two flaps of canopy fabric (photo 15), one inside and one outside, completed the seal to make the canopy weathertight. The inside flap was tucked up between the canopy tube and the canopy top with Velcro, but it provided a weathertight seal even without the Velcro. The outside flap normally would have been sealed first, but it would have been more difficult to reach. Volunteers did not even notice it; hence, our confirmation that the single flap provided a weathertight seal. The flap went over the canopy and connected to the canopy-support tube with Velcro. When both flaps were sealed, the canopy was weathertight and sturdy, with 32.0 inches (81.3 centimeters) of headroom at the center of the life raft and 22.0 inches (55.9 centimeters) at the entries and sides.

The process of erecting the canopy proved to be confusing, even when instructions and hints were provided to the volunteers. Admittedly, erecting this canopy was not nearly as confusing as the manually erected canopies on the EAM Classic life rafts and on the Hoover conventional life rafts, but the process was not easy either.

15

For providing ventilation, the canopy was not as versatile as others (photo 16, page 312). Although the canopy could provide nearly full shade, not considering the translucence of the canopy fabric,

16

very little ventilation would be provided by the small gap in the canopy top. The gap could be widened by releasing some of the lower buckles, but this provided only minimal ventilation because there was only one cloth tie at each entry to tie back the flap; this provided only marginally increased ventilation. Additional ventilation, not normally a concern in the North Sea, would be most welcome in more moderate conditions or tropical conditions. An improvement would be to provide a means to retain the interior flap and exterior flap so they would remain out of the flow of air when ventilation was desired. The interior flap, especially, was annoying because it hung down when the entry was open and impeded what little ventilation was provided by leaving the narrow gap open.

If the canopy were put down after erection (photo 17), it would fill with water and would be very difficult to erect again — especially by a lone and injured survivor — and would be almost impossible to erect again without soaking the interior of the life raft. Nevertheless, the problem could be avoided by ensuring that the canopy fabric was gathered on the top of the buoyancy tube rather than just lowering the canopy support, which would tend to immerse the canopy in the water. Nevertheless, no means to keep the canopy in place was provided, so the survivor would have to improvise. This problem was not discussed in any instructions, but it should have been noted in the LRM.

17

Rain Simulation

A single small reversible water-collection tube was installed off center in the flat top of the canopy. It had a reversible rubber plug and worked very well, although minor water leaks occurred on the seam where it was sewn to the canopy (the only leaks in the otherwise weathertight canopy). A large cross of retroreflective tape was affixed to the flat top of the canopy (photo 18); retroreflective strips also were located on the perimeter of the life raft's buoyancy tubes, providing satisfactory all-around retroreflective performance.

18

Lifelines and Grasp Lines

The life raft was equipped with white one-inch nylon tape for the lifeline, attached tautly to the center of the covering over the canopy-support tubes. After the canopy-support tubes were raised, there was no lifeline, a deficiency, in our opinion. This could be a problem because the canopy might not be raisable until almost all survivors were in the life raft, because they would lose any place to easily hold onto the life raft while in the water. It also could be a problem in an overcrowded life raft when it might be desirable or necessary for some survivors to remain in the water, where they would have nothing to grab.

The interior grasp line was attached to the floor — not to a buoyancy tube — in an octagon approximately midway between the tube and the center (photo 19). Volunteers evaluated all lines and attachment points on all the life rafts as best they could, by pulling hard against them, first with arm strength, then using their legs where appropriate. The R Series life raft was the only other life raft that experienced a failure, aside from the sea anchor failure on the Goodrich life raft. The grasp line was ripped from its attachment point using only a single arm's strength, obviously less than the TSO-C70a (paragraph 4.9) requirement for 500 pounds (227 kilograms) minimum strength. This was a deficiency, in our opinion. (This was a demonstration life raft and no doubt had been subjected to abuse prior to the evaluation, which may have contributed to the failure.) The thin nylon webbing also was not as comfortable to hold as wider or more substantial webbing.

19

The floor-mounted interior grasp line was more comfortable to hold onto, compared with buoyancy-tube-mounted grasp lines.

A survivor could brace against the buoyancy tube and reach down to hold the floor-mounted grasp line in a natural position. If a life raft were crowded, survivors would have to reach behind themselves to hold a buoyancy-tube-mounted grasp line, an awkward and tiring position. In an uncrowded life raft, the buoyancy-tube-mounted line would have the advantage because survivors could pull themselves against the buoyancy tube to maintain a position in rough sea conditions. It also would be possible to tie oneself or another survivor to the buoyancy-tube-mounted grasp line to assist in remaining in place.

Stability

The life raft did not have traditional water-ballast bags but depended upon "vacuum" for stability. The concept is that the lower buoyancy tube and the raised floor create an air space, which develops a vacuum when any attempt is made to lift the buoyancy tube from the surface. When the life raft is well loaded, the concept is reasonably effective; the weight of the survivors helps keep the lower tube in contact with the water so that vacuum can be maintained.

Nevertheless, vacuum might not be satisfactory in rough sea conditions or in a lightly loaded life raft. With only one person aboard, the vacuum was broken easily in the wave pool during the evaluation; the life raft was easy to capsize and offered minimal resistance to capsizing. Even at normal capacity, the life raft was capsized with relative ease.

(This life raft was evaluated before the inclusion of sea-anchor evaluations.) The sea anchor (photo 20) was equipped with a swivel (photo 21).

Floor

Depending upon the load and sea conditions, the mid-located floor might be above the surface of the water. Nevertheless, this would not be likely in a life raft

20

21

at full capacity. In rough weather conditions, when insulation is most necessary, this life raft would be unsatisfactory for protection against hypothermia. This life raft originally was designed for, and is more appropriate for, survivors in cold-water immersion suits.

Life Raft Equipment

Pump

The life rafts had plastic topping valves, which had a friction-fit opening and a rubber butterfly-flap valve. Each valve also was equipped with a friction-fit rubber cap (photo 22) that was attached to the valve by a tether of small-diameter nylon cord. The cap for the

22

valve on the boarding-ramp buoyancy tube came untied from its tether, which was a concern. These caps seemed adequate to retain pressure.

The RFD/Revere manual inflation pump (photo 23) was equipped with a large-diameter — approximately one-inch outside diameter — flexible rubber hose, approximately 36 inches long, with a plastic male friction fitting on the end. This fitting was inserted into the valve; it had to be inserted tightly or it would work loose. Inserting the fitting did not open the check valve; airflow under pressure of the manual inflation pump opened the check valve.

23

The long hose would allow survivors to position themselves for best performance and comfort, and when one survivor became tired, the manual inflation pump could be passed among the other survivors near that particular valve. The long hose was essential for the R Series life rafts because some of the manual topping valves were not inside the life raft.

The manual inflation pump was of the type that might be used to inflate an air mattress or an inflatable boat. The pump had a fabric bellows chamber with top and bottom plates and a single-loop handhold/restraint at the top. The pump collapsed to a flat package, aside from the long hose attached to it.

There was no way to operate the manual inflation pump with one hand. It was even difficult to use the pump with two hands, because the flexible fabric chamber moved around when under pressure. The hose was attached with a right-angle fitting that made it difficult to get a good grip on the bottom of the pump; a good grip was required. This pump was deficient, in our opinion.

The inflation valves for the canopy-support tubes and inflatable boarding ramp were on the exterior of the life raft. Each main buoyancy tube had two inflation valves, one for operation from each side. The inflation valve for the lower buoyancy tube was accessed via a gusset in the life raft's floor and was difficult to work with. In cold weather, it could be more difficult. Volunteers expressed concerns that the remaining inflation valve, with its valve-closure flap, was on the underside of the life raft and unreachable, a problem typical of all reversible life rafts with similar topping valves.

Bailer and Sponge

The RFD/Revere bailer was wide (approximately 12 inches in diameter), but of shallow (three inches deep), flexible-rimmed (wire inside cloth), coated-cloth construction. Four quarts of water was the most that volunteers could hold within the bailer, because the rim sagged under load and the seams leaked. The volunteers could gather only 4.0 pints to 5.0 pints (1.9 liters to 2.4 liters) at a time by scooping, unless they put down the bailer, collapsed it and picked it up in deep-enough water to substantially fill it. The bailer functioned reasonably well, but it was awkward and tiring to use because the rim had to be gripped tightly with both hands. The bailer received the worst marks from the volunteers and was a deficiency, in our opinion. The bailer was packed in the SEP, folded up around other supplies and was not available immediately upon boarding. There was no tether and no place to attach one, a deficiency, in our opinion.

Two 3.25-inch (8.26-centimeter) by 3.25-inch by 0.75-inch compressed sponges were included.

Heaving Line

The RFD/Revere life raft heaving/trailing line was an orange 1/8-inch (0.3-centimeter) twisted polypropylene line and was attached to the traditional round rubber quoit. The line was stored inside a lightweight clear plastic sheath. On the R Series life raft, it was inside the SEP; until the SEP was retrieved (it might be in the water over the side), the heaving line would not be available for use. The heaving line was relatively stiff, not as flexible as other heaving lines that were evaluated, and not as easy to recoil for a second throw. It tangled when thrown, a deficiency, in our opinion.

Raft Knife

For a raft knife, RFD/Revere provided a short wood-handled device with a 1 3/8-inch (3.5-centimeter) straight blade and a rounded blunt tip. The small handle and short blade made this the most difficult to use of all of the raft knives evaluated and was a deficiency, in our opinion.

Lighting

The approved exterior locator light (photo 24) for the R Series life raft was on the top of one canopy-support arch. Until the canopy was raised, the light was on the side of the life raft, underneath the cover that protected the canopy-support tube. A small clear plastic "window" was over the light, and the window itself was bisected by the exterior lifeline. Depending on how carefully the life raft was packed, the light might or might not be located directly behind the lifeline (photo 25); we saw lights that were almost not visible because they were off-center of the window.

24

25

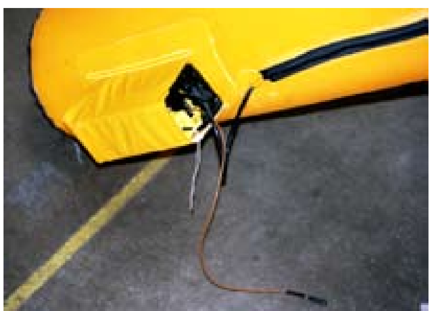
This light was covered, partially obscured at best, and was ineffective because it was held down on one side of the life raft until the canopy was raised, which, depending on weather, might not occur and generally would not occur until all survivors were aboard. This installation did not appear to comply with the TSO-C70a (paragraph 4.12) requirement that it be "visible from any direction by persons in the water" and was a deficiency, in our opinion.

The light was powered by a lithium battery, which was located on the exterior of the canopy-support tube and near the bottom where the canopy-support tube attached to the upper buoyancy tube. This battery could be switched off, conserving power, a great feature, but the switch was not easy to reach and was not readily identifiable.

An interior canopy light was not supplied as standard equipment, a deficiency, in our opinion. RFD/Revere said that it was available as an option; this is a desirable option, in our opinion.

ELT

A 406-MHz ELT and an auto-deploying Artex 121.5-MHz ELT were optional on the Part 135 RFD/Revere life rafts. The raft in the evaluation was equipped with the 121.5-MHz ELT, which was attached to the side of the boarding ramp in a foam-padded pocket. This allowed the water sensor, a length of flexible wire with the sensor on the end (photo 26), to function, no matter which side of the reversible life raft was up. A length of wire connected the ELT to the strip antenna that was glued to the adjoining canopy support. This canopy support was either beside the raft or, when erected, was at about a 40-degree angle from vertical. The ELT manufacturer said that with the canopy down, the ELT signal could be received by an aircraft overhead or nearby, but the manufacturer could not guarantee that the signal would be received by the Cospas–Sarsat International Search and Rescue Satellite System.



26

The ELT manufacturer said that unless the antenna was near vertical, the company would not guarantee that the ELT would function to specifications or be received by the satellites. The further the ELT was from vertical, the greater its loss of signal strength. With the canopy up, Artex would not guarantee that the ELT would function 100 percent of the time at the extreme angle. This was a deficiency, in our opinion.

Survival Equipment Packs

With the R Series life raft, the SEP was placed in the life raft but secured with a long tether. If the SEP is not in the life raft, it must be retrieved from the water. The location of the SEP was noted with a large placard, black on white, but there are more than a few lines attached to the life raft near that point, so retrieving the SEP could be confusing. RFD/Revere used semi-transparent plastic drawstring bags to hold the survival equipment.

On the R Series life raft were two bags (photo 27), one with supplies and equipment, the other with hand paddles, a heaving line and a manual inflation pump. The ability to see inside the bag, even if not perfectly, was especially useful because there was nowhere else on the life raft to store equipment or supplies. The drawstring top was a bit difficult to use, but better than a tie closure. The bags were not waterproof.

27

Survival Equipment

Repair

RFD/Revere included a graduated set of three tapered life raft plugs for smaller holes (1.25 inches [3.18 centimeters] diameter and less). These were black rubber cones with threads that were screwed into the hole until they were sufficiently tight to seal the opening. The conical repair plugs functioned reasonably well for small holes, but they should be a supplement to mil-spec repair clamps, not a replacement for the clamps. They were not as secure as the clamps and should not be relied upon as the only repair equipment on the life raft. Having only one repair clamp was a deficiency, in our opinion.

Utility Knife

There was no utility knife, a deficiency, in our opinion.

Signaling Devices

Included were a Pains Wessex Mark 14 Day/Night hand flare and a Miniflare 3, which included eight red aerial meteor flares and a pen-style launcher. These were not among the most effective flares. Although, with the Miniflare, there were enough flares to be of more value.

RFD/Revere said that its life rafts would be equipped with Coast Guard-approved metal signal mirrors in the future, but they are heavy and difficult to aim, and not among the most effective mirrors on the market.

Paddles

The R Series life raft had the worst "paddles" (photo 28) that the volunteers encountered. They were really hand paddles, not conventional paddles with handles. The wide and thin boards were covered with coated cloth and measured approximately 8.5 inches by 14.0 inches (21.6 centimeters by 35.6 centimeters). Each paddle had a one-inch strap at the top, and a hand had to be inserted under the wide strap covering most of the midsection of the paddle. A survivor would have to lean over the side of the life raft and immerse a hand and arm in the water to use a paddle. The paddles were nearly useless and difficult to operate, and would be unusable in cold water unless the survivor using them was wearing survival suit gloves/mitts that protected the hands. The paddles were a deficiency, in our opinion.

28

Fishing Kit

RFD/Revere said that the R Series life rafts will include Revere's Coast Guard-approved fishing kit, equipped with an assortment of line, hooks leaders, lures, etc.

First Aid

RFD/Revere said that the R Series life rafts will be equipped with Revere's Coast Guard-approved first aid kit, a well-equipped 13-piece kit in a tough plastic waterproof zipper-lock container.

Water and Food

No water-storage bag and no survival rations were included in the demonstration life raft. Absence of packaged ready-to-drink water and a water-storage bag were deficiencies, in our opinion.

Survival Manual/Life Raft Manual

There was no survival manual or immediate-action list in the demonstration life raft supplied for the evaluation; the manufacturer later supplied the manual and the list.

An immediate-action list is not "immediate" unless it is immediately available upon boarding a life raft. Nevertheless, the second item on this immediate-action list was to "haul in the emergency pack and emergency bag" in which the list would be found. This was a deficiency, in our opinion.

The immediate-action list was on two pages of the LRM. It had bold headings, but otherwise the text was too small to read easily under minimal light (no interior light in the life raft). The LRM was a nine-page foldout of water-resistant fabric. Included were illustrations of how to erect the canopy, simply a copy of the placard in the life raft, and an illustration of the life raft with parts identified.

The survival manual was very basic, in a simple and easy-to-read format on waterproof paper. It was a flip-style booklet with seven pages of sea-survival information going one direction and seven pages of land survival information going the other direction.

Service

The life raft had a one-year service interval.

Charles Rogers, president of Survival Products, was chief engineer for a Florida-based air transport operator when inadequate servicing of its inflatable products was resolved by starting its own service and repair operation. Rogers had helped establish the new operation and when faced with moving when his employer relocated to Europe, he elected to remain in the U.S. and start his family-owned inflatable life raft service and repair facility in Hollywood, Florida. About 1986, he and his wife, Donna, the company's vice president of marketing, decided to manufacture non-TSO life rafts.[8] About 1998, the company introduced its line of TSO-approved aviation life rafts based on the unapproved designs. He had been involved with flight attendant training during his career, and he had learned that large, bulky and heavy life rafts were difficult to deploy, and that if a life raft couldn't be deployed, survivors couldn't use it. So he designed his square-shaped life rafts and teepee canopies to be lightweight, compact and low-cost — the lightest, most compact and lowest-cost TSO-approved aviation life rafts in this evaluation.

Survival Products declined to participate in the 1993 evaluation and the 1996 evaluation, and its unapproved life rafts were obtained from dealers and service centers. In 2000, Survival Products declined to participate, and a four-person Type I life raft and a six-person Type II life raft were purchased by others for the evaluation. In 2002, the company was invited to participate but did not respond to e-mails and telephone messages. A six-person Type II life raft was borrowed for the 2002 evaluation.

The life rafts were constructed of double-coated neoprene over two-ply bias-cut nylon fabric. The Type I life raft was available in six-person, eight-person and 10-person rated capacities, and the Type II life raft was available in four-person and eight-person rated capacities.

Valise

The life rafts were packed in a two-piece dark red vinyl-coated nylon valise. One half of the package contained the life raft, and the other half was the SEP. The two packages were joined with Velcro on all four sides, resulting in a very secure attachment that was not likely to separate. A black one-inch-wide nylon-webbing handle was attached to both the life raft and the SEP on one side, with a black plastic cable tie that secured the two valise halves together.

Volunteers found it particularly difficult to locate the inflation line and to read the instructions. There were no instructions or guidance on either the primary face of the valise or at the top where the carry handles were located. On the side, at the corner, printed in small black letters that provided low contrast on the dark red fabric were the words: "TO INFLATE PULL HANDLE" (photo 1, page 317). In minimum lighting, this would have been even more difficult to find and read. This was a deficiency, in our opinion.

Mooring/Inflation Line

A black 3.5-inch (8.9-centimeter) loop of 3/4-inch-wide (1.9-centimeter-wide) nylon webbing, which was the inflation handle,

1

was Velcro-secured to the valise. This hand loop did not appear to comply with the requirements of TSO-C70a (paragraph 5.2), a deficiency, in our opinion.

The mooring/inflation line, black 3/4-inch-wide nylon webbing, was 20.25 feet (6.17 meters) long. Although there was no separate immediate-inflation handle, inflation occurred at 3.17 feet (0.97 meter), effectively making the mooring/inflation line an immediate-inflation line. If a survivor would prefer not to have the life raft inflate immediately next to the ditched aircraft — that is, if there were sharp edges to avoid — that option would not exist with these life rafts. The short length of line until inflation also would preclude securing the life raft to the aircraft before inflation, something recommended by all survival training of which we are aware. The mooring/inflation line was a deficiency, in our opinion.

Inflation

As noted, the instructions were not easy to read, and the inflation handle was not located readily by the volunteers. All the life rafts deployed properly.

Righting

On the Type II life raft, a righting handle of black 3/4-inch-wide nylon webbing was attached to the bottom of the single water-ballast bag located in the center of the life raft. Stenciled next to the bag was "RIGHTING AID" (photo 2), which could be covered by the water-ballast bag, depending upon which way it flopped, rendering the instruction useless. Even when not covered, a survivor in the water could have difficulty seeing the instructions. These are deficiencies, in our opinion.

2

The inflation cylinder was attached to the bottom of the floor of the Type II life raft. Thus, the righting location was not as obvious as when the inflation cylinder was located on the exterior side of the buoyancy tube; no directions on the single buoyancy tube showed the inflation cylinder's location. A short person in the water might have difficulty reaching the righting handle from the water and likely would need to climb onto the exterior bottom of the capsized life raft; without aids to assist them, survivors might may find this task difficult or impossible.

The righting handle on the Type I life raft was located on the bottom of the life raft to the left of the inflation cylinder (when viewed from the water), which was located conventionally on the exterior side of the buoyancy tubes. The "RIGHTING AID" stenciling (photo 3) was located on the exterior bottom at the edge of the life raft. On a capsized life raft, the exterior bottom was lifted well above the water by two buoyancy tubes; the instruction was not visible from the water.

The life rafts were easily righted, but the instructions on the life rafts would not be readily visible to survivors, and this was a deficiency, in our opinion.

3

Boarding Aids

No foothold was provided to board the Type II life raft. The lifeline was attached above center (photo 4), high on the exterior side of the buoyancy tube on both sides of the two opposed entries. A grasp line was stretched across the floor between the two entries. Volunteers said that these lines were of little value as boarding aids. The inflation cylinder's inflation valve poked from underneath the bottom of the life raft at the center of an entry point; this was a potential source of injury and a deficiency, in our opinion. Entry was difficult for many volunteers, and the life raft easily was swamped (filled with water so that the top of the life raft was at or near water level with little — if any — freeboard) during boarding. This was undesirable because, in this situation, a large volume of water must be bailed out. This was a deficiency, in our opinion.

4

Type I life raft boarding aids were minimal. A black loop of one-inch-wide nylon webbing served as a foothold (photo 5, page 318), but it was easily overlooked because it hung down in the water. This

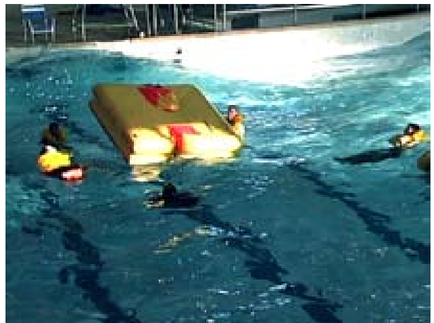
5

was a deficiency, in our opinion. The lifeline, a grab handle on the upper exterior side of the upper buoyancy tube and the interior grasp line on the lower buoyancy tube completed the boarding aids. Nevertheless, most volunteers had difficulty entering the life raft over the two 9.5-inch (24.1-centimeter) buoyancy tubes; some were unable to board without assistance. Not having satisfactory water ballast, the life raft capsized frequently on top of the volunteers (photo 6) during boarding. These were deficiencies, in our opinion.

Canopy

The TSO-approved life rafts were equipped with a unique teepee-style canopy (photo 7). After retrieving the coated rip-stop-nylon canopy and the attached orally inflatable mast from the SEP, the volunteers determined how to erect it in a few minutes; first-time erection (photo 8) required an additional 12 minutes to 15 minutes. Instructions were stenciled on the center of the life raft floor, but because the process was self-evident to the volunteers, the directions were unnecessary.

The center mast was inflated by mouth through a mil-spec-style oral-inflation



6

7

8

valve (photo 9). The mil-spec valve confused many volunteers because most had to discover for themselves that the valve had to be depressed manually to open it for inflation. After inflation, the loose end of the inflated mast was secured

9

to a loop in the center of the life raft using a short piece of nylon cord attached to that end of the mast.

The bottom edges of the canopy were secured to loops (photo 10) in the lifelines on the exterior of the buoyancy tube, at the corners and middle of each side, with a plastic tab that slipped through the loops.

10

A one-inch-wide Velcro closure allowed the two slit-flap entries to be closed. A loop was attached at the bottom of one flap, and the plastic tab at the bottom of the other flap slipped through that loop before going through the loop in the lifeline on the buoyancy tube to secure both sides of the opening to the lifeline.

Volunteers questioned how easy these tasks would be to accomplish with gloves or with cold, wet, numbed hands.

Volunteers said that sitting under the canopy was very uncomfortable. Because the cone-like canopy slanted steeply downward from the top of the buoyancy tube, the only way to sit was hunched over and in contact with the canopy fabric, a deficiency, in our opinion. On the Type II life raft, only 14 inches of headroom were available in a seating position, and 40 inches (102 centimeters) were available in the center. In the Type I life raft, headroom was 21.0 inches to 25.0 inches (53.3 centimeters to 63.5 centimeters) at the sides and 50 inches (127 centimeters) in the center. There was no provision for the collection of rainwater. No retroreflective tape was fitted.

When the life rafts were capsized, the canopies on both life rafts tore at the peak (photo 11) where the orally inflated mast was attached, a deficiency, in our opinion. Volunteers also said that with the canopy fully closed and the tabs at the bottom of the flaps engaged, egress from the capsized raft was difficult and provoked anxiety for some volunteers, a deficiency, in our opinion.

11

Rain Simulation

Canopies immediately collapsed during the rain simulation, and water poured into the life raft from under the bottom edge of the canopy and through the Velcro-secured entry slits. Volunteers complained about the chill transferred through the canopy to their bodies because they were unable to avoid contact with the collapsed canopy (photo 12). Even in a light shower, avoiding contact with the canopy side would be difficult because of the canopy design. These canopies offered only minimal shelter, inadequate to protect survivors in rough weather conditions, a deficiency, in our opinion.

12

Lifelines and Grasp Lines

Black 3/4-inch-wide nylon webbing was routed around the middle exterior of the buoyancy tube on Type II life rafts, except at the entries where the webbing was attached at the top of the tube. On the Type I life rafts, the lifeline was routed on the upper buoyancy tube with little slack, which created a long reach for some volunteers, but the lifeline was satisfactory, nonetheless.

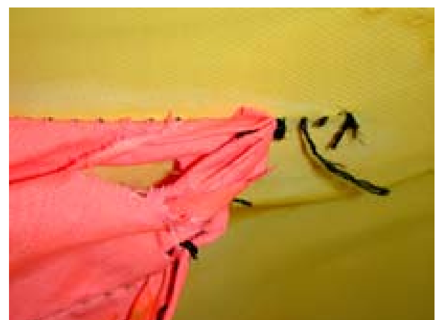
The Type II life raft had no interior grasp line, a deficiency, in our opinion. The Type I life raft had an interior grasp line of black 3/4-inch-wide nylon webbing running completely around the interior, attached to the upper section of the lower buoyancy tube.

Stability

The two water-ballast bags each held a total of approximately 124 pounds (56 kilograms) of fresh water — a total of 248 pounds (112 kilograms) — but there were not enough of them and they were not well constructed, deficiencies, in our opinion. A weight and a one-way flapper valve in the bottom of the bag hastened filling, which was accomplished satisfactorily. This was important because each bag was open only slightly on top and on its sides (photo 13). There were no other large inflow entries, as were typically included along the upper sides of most other life rafts' water-ballast bags.

The water-ballast bags were constructed of lightweight canopy fabric for sides, buoyancy-tube fabric for the bottom. The lightweight canopy fabric tore at the seams near the top attachment points (photo 14), a deficiency, in our opinion. A marginal advantage of this design was that the bag became effective as the life raft lifted from the water faster than conventional designs because there was less distance between the bottom of the life raft and the effective open top of the bag, approximately three inches,

13



14

compared with four inches or more for others.

Located under the center of the Type II life raft was a single water-ballast bag. It proved minimally effective at preventing the life raft from capsizing during the boarding evaluation. The Type I life raft was equipped with two of the water-ballast bags, located on opposite sides of the life raft at the entry points. They did not prevent volunteers from capsizing the life raft during boarding.

After the life raft was deployed, the valise was intended to perform the functions of a sea anchor.

The SEP was attached to the valise, so when the SEP was retrieved, whatever stability this equipment provided while in the water was absent. The SEP was attached to the valise with a tough black cable tie looped through black webbing; this could be difficult to discern in low light conditions. Until the cable tie was severed, requiring a knife or the presence of mind to use other improvised methods, the valise could not function fully as a sea anchor. No raft knife was included in the company's Part 91 SEP, and this was a deficiency, in our opinion.

After the cable tie was severed and the valise was returned to the water, it was supposed to perform as a sea anchor. The sea anchor (valise) was attached to a 24.0-foot (7.3-meter), 1/4-inch-wide (0.6-centimeter-wide), flat-braided nylon line; the opposite end was attached to a corner of the life raft. This was coiled and retained by a cloth tube; the line tangled when it was deployed (photo 15). Including the length of the sea anchor's four one-foot shrouds, the total length met the requirement of 25 feet specified by TSO-C70a (paragraph 5.3). No swivel was attached to the sea anchor, a deficiency, in our opinion. The sea anchor (valise) on the Type II life raft performed satisfactorily until its Velcro seams attached to each other and the sea anchor was rendered useless (photo 16).

15

The longer sea anchor (valise) from the larger Type I life raft became attached immediately to its Velcro seams; despite repeated deployments, the sea anchor (valise) tended to foul itself very quickly and was rendered useless.

16

Although Survival Products has attempted to produce an innovative and weight-saving sea anchor, it was deficient, in our opinion.

Floor

No insulated floor was available, which is unsatisfactory in cold water, in our opinion.

Life Raft Equipment

Pump

A Mirada bellows manual inflation pump (photo 17) provided approximately 40 percent more capacity than the TSO-C70a (paragraph 5.5) requirement. Nevertheless, some valves located between buoyancy tubes interfered with the filling and operation of the pump. The pump was tethered to a loop in the center of the life raft floor, stored inside the bailer.

A multifunctional valve from Mirada performed as both the PRV and the topping valve. The valve was identified as "INFL/DEFL VALVE" (photo 18; survivors must decipher the abbreviations); no information noted the function as a PRV. This was a deficiency, in our opinion. This valve included a protective screen fitting (photo 19) that should be removed after the life raft inflates. An attached metal cap with a seal was used to plug the valve afterward. Plugging the valve is important, especially when the canopy is erected and closed; otherwise, the PRV will vent carbon-dioxide gas into the enclosed life raft, a deficiency, in our opinion. The stenciled instructions on the floor of the life raft were easily obscured and were overlooked by the volunteers.

17

18

19

Bailer and Sponge

The 5.0-quart (4.7-liter) bailer was of sewn construction (photo 20, page 321), made of life raft fabric and tethered to the loop in the center of the life raft floor.

Heaving Line

Give Survival Products credit for creative thinking in its pursuit of smaller and lighter devices. The quoit for its

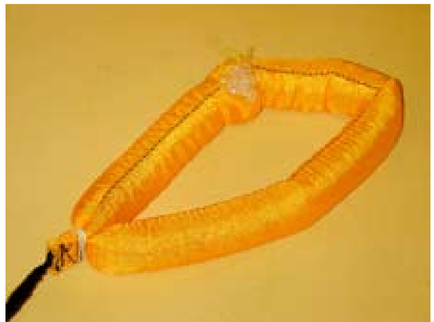
20

heaving line was a yellow nylon-fabric tube (photo 21) filled with polymer granules that expanded after being immersed in water for a few minutes, creating a flexible, sausage-like loop. This flexible loop could be difficult to hold onto with cold, wet, numbed hands while the loop is under tension, such as when it is being used to pull a survivor to the life raft. The dry quoit weighed only a few ounces and packed flat.

21

One quoit split its seam during expansion (photo 22), spilling hundreds of sticky, jelly-like polymer globules in the interior of the life raft. Whatever functionality the heaving/trailing line possessed was compromised, and the volunteers found the sticky globules annoying.

The heaving/trailing line, which was black 0.5-inch-wide nylon webbing (photo 23), was coiled inside a fabric Velcro-secured sleeve and retained with a pair of rubber bands, one on each end. It was attached above the inflation cylinder on the exterior of the



22

23

life raft with the quoit hanging out so that it normally would fall into the water, absorb water and expand. "HEAVING LINE" was stenciled in black on the sleeve. The heaving/trailing line location also was stenciled on the buoyancy tube, but that was overlooked by some volunteers because the information was behind their backs while they sat in the life raft. The 35.0-foot (10.7-meter) line exactly meets the TSO-C70a (paragraph 5.4) requirement for a Type II life raft, but falls far short of the 75 feet required for the Type I life raft. Volunteers were unsuccessful in throwing the quoit very far or accurately. This was a deficiency, in our opinion.

Raft Knife

The raft knife was stowed in a dark-red sheath attached to the mooring/inflation line (photo 24). There was no placard or labeling on the sheath. Inside the life raft, "MOORING LINE KNIFE" was stenciled on the buoyancy tube in a list of other equipment, all of which was overboard in the SEP. The raft knife was sewn onto the line through the finger hole, and there was just sufficient slack to pull the knife from its sheath, a deficiency, in our opinion.

Lighting

An approved locator light was attached with Velcro to a corner on the top surface of the buoyancy tube. One light detached from the Velcro during inflation and fell into the water.

After the canopy was erected, the light did not function as a locator light because it was under the canopy (photo 25), located low and in a corner. In our opinion, this did not comply with the requirements of TSO-C70a (paragraph 4.12). Moreover, its location made it an ineffective interior light. The water-activated battery was secured with Velcro to the exterior bottom of the life raft. The battery was within reach, so it could be removed from the water and saved for later use. (No volunteer considered this possibility, and this action was not noted in any instructions.)

24

25

ELT

A manually operated EBC-502 121.5-MHz ELT was offered as an option, packed in the SEP.

Survival Equipment Packs

The SEP, with its Velcro closure system, remained secure. All the Survival Products life rafts noted the location of the SEP with a stenciled placard (photo 26) on the buoyancy tube. Even the most conspicuous of these was easily overlooked in a full life raft, and in one instance, the SEP was overlooked by the volunteers, who had to be told to retrieve it from the water. The SEP was not waterproof.

26

Survival Equipment

Repair

Two three-inch mil-spec repair clamps were included. PRV plugs, as noted earlier, were integral with the multi-functional valves; the metal cap plugged simultaneously both the manual topping valve and the PRV valve.

Utility Knife

A poor quality knife, without a tether, was included in the Part 135 SEP.

Flashlight

A water-resistant flashlight with a conventional bulb and powered by two D-cells was included; a tether was not included, a deficiency, in our opinion.

Signaling Devices

Three Skyblazer XLT aerial meteor flares were included. A lightweight, flimsy metal mirror with no aiming aid also was included, along with an ACR Electronics SOLAS-specification survival whistle with no tether — a deficiency, in our opinion — and a small and inadequate package of Skyblazer sea dye marker.

Paddles

A pair of blue plywood mil-spec paddles with wrist tethers was included.

Fishing Kit

A well-stocked Coast Guard-approved fishing kit was included.

First Aid

A small quantity of packaged first aid supplies was stored in a plastic bag.

Water

A mil-spec chemical desalting kit were included. No water or storage container was provided; these were deficiencies, in our opinion.

Food

Vacuum-packed S.O.S. Food Lab survival rations were provided.

Miscellaneous

The life rafts included 75 feet (23 meters) of flat 1/4-inch-wide braided-nylon line and a space blanket.

Survival Manual/Life Raft Manual

A waterproof *U.S. Air Force Aircrew Survival Manual* was provided.

Service

Survival Products life rafts required annual service.

WINSLOW® LifeRaft Company

Founded in 1941 as the New York Rubber Co., in upstate New York, the company supplied life rafts to U.S. and allied military services during World War II. The company had relocated to Sarasota, Florida, when John C. Winslow, a U.S. Navy pilot and recreational boater, tried to buy a life raft from the company. Accustomed to selling to the government, not the public, the company would sell life rafts only in quantities of 100. Winslow bought 100 life rafts and discovered that they were easily sold; he bought the company in 1953 and renamed it the Winslow Co. Essentially, the design remained unchanged until his death in 1983. In 1989, the company was acquired by a semi-retired entrepreneur, Fred Shoaff, who ceased production of the company's long-time models and designed an entirely new marine life raft. He later gave the company its current name.[9]

By the early 1990s, Winslow's lightweight marine life rafts were attracting the attention of pilots who also were racing sailors. Demand encouraged Shoaff to secure TSO approval in 1994 and to expand the aviation line, moving into its current facility in 1999. In 2002, a private investment banking partnership, Dakota Capital, backed a management buyout of most of the company; the remaining stock remains among several employees. Shoaff's executive vice president, Gerard Pickhardt, became president, and Shoaff has become a special consultant to the company.

Winslow provided life rafts for all the evaluations. Evaluations were conducted of four-person, 10-person and 12-person Type I life rafts of both the FA-AV(SL)

Continued on page 324

All Aboard … Except Me

The wave pool was in full motion and the water lifted the life raft — and me — up and down while I held its lifeline. Several people already had clambered aboard the Viking RescYou 6 Pro marine life raft and I would learn later that the two buoyancy tubes provided about 12 inches (31 centimeters) of freeboard, with six people aboard. Nevertheless, those inches seemed mountainous. I struggled to pull myself up by using the hand straps on the life raft's buoyancy tubes, but the flexible strap of nylon webbing carried my feet under the raft, while my upper body went in the opposite direction. Despite my best effort, I was unable to complete the process of getting on a small inflated platform, get over the top tube and reach far enough to grab a floor-mounted hand strap, which I could use to pull myself into the life raft.

The people who already had boarded were seated on either side. They were cheering for me, but refrained from giving me any physical assistance. As I struggled to get over the water-slick tubes, I pulled them outward and the hand strap on the floor moved farther from my reach. I was within an inch or two of grasping it. A couple of times, after bobbing up and down in the water to help propel myself over the top of the tubes, I actually touched the hand strap.

I kept trying. I kicked, pulled, and grabbed but that hand strap might just as well have been on Mars. Moreover, I was wearing a fully inflated life vest that was pressing against my chest and stomach, and adding additional inches between me and that hand strap. The pressure against my body was preventing easy breathing, not made any easier by my 255 pounds (116 kilograms) and sedentary lifestyle. I needed to grab that hand strap to pull myself aboard, but I soon exhausted myself. My heart was pounding, and I was gasping for breath. I couldn't believe what was happening to me.

This was not my first experience in boarding life rafts, and I had received water survival training with life rafts … nearly 30 years ago. Moreover, until recently, I had lived aboard a sailboat for nearly 20 years, so swimming and propelling myself in and out of small inflatable boats and hard dinghies — without any boarding aids — wasn't new to me. No way should I be humbled by a life raft.

I elected to abandon the attempt to get aboard the life raft and let the evaluation continue without me. Gasping, I called to a lifeguard to pull me to shallow water, just to be safe (I was already walking on the pool bottom as the lifeguard reached me). I was stunned.

Had I been alone in open water, this scenario might have been a life-or-death experience even with the added benefit of surging adrenaline that survival specialists claim will be present in an emergency. Had I been injured, boarding this life raft would have been impossible, unless someone had been aboard to assist me.

A few minutes later, I caught up on my breathing, plopped into the wave pool and splashed my way to the nearest life raft – a Winslow 108 OCN 8-person marine model with an unloaded freeboard of more than 20 inches (51 centimeters). The inflatable boarding platform was well-supported at water level and provided plenty of room and grab handles for me to pull myself onto the platform. Then, while kneeling on the platform, I was able to pull myself to the top of the two tubes, where I could easily grasp the wide-webbed, V-shaped interior ladder that was attached with buckles to the top buoyancy tube; the other and smaller end was buckled to the center of the floor. From the platform, I was able to pull myself hand-over-hand into the otherwise empty life raft. Heck, it was almost easy. ■

— Roger Rozelle

What was a frustrating experience in a pool could have been a life-or-death situation in open water.

Super-Light Ultima and FA-AV(UL) Ultra-Light models fitted with various options, and the four-person Type II GA-ST and related FA-ST Uni-Light, non-TSO life rafts.

In 2002, Winslow provided a 10-person Type I FA-AV (SL) Super-Light Ultima, 10-person FA-AV(UL) Ultra-Light, six-person FA-AV(UL) Ultra-Light and a prototype six-person Type II FA-ST Uni-Light; the life rafts were fitted with a variety of options.

Evaluating Winslow's life rafts required several examples of the products because the company offered several distinct lines with the broadest combination of options in the industry.

The life rafts were constructed of double-coated neoprene over two-ply bias-cut nylon fabric. The Type I life rafts were decagonal (10-sided) in four-person through 16-person rated capacities. Sizes were in one-person increments.

Valise

The life rafts shared common valise designs, and Winslow offered a wide range of custom valises and cases, numbering 500 at the end of 2003. The standard valises (photo 1) were constructed of yellow polyurethane-coated nylon with braided-nylon laces on both sides and a two-inch wide Velcro closure across the top center and across each end, like box-top flaps.

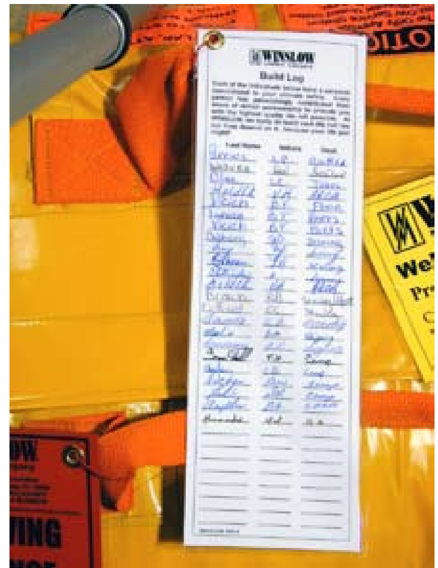
Aircraft-specific valises were available in a variety of shapes and were designed to lie flat. A pair of orange two-inch-wide nylon-webbing handles was attached, one on each long side and each long enough to reach over the center seam when laid flat on top of the valise. The central portion of the grab handle was sewn around a foam core to provide a comfortable carrying handle. Smaller life rafts could be gripped by one person using one hand; larger life rafts could be gripped with separate grab handles by two people. The flat-carry method could be somewhat awkward inside an aircraft, but the life raft was easily dragged using the standard handles. There were no grab handles on either end of the standard valise; no-cost optional pairs of side grab handles were available to allow retrieval if the life raft was stored on its side or end, or if necessary to pull it from underseat stowage. We recommend that end handles (photo 2) be specified on larger life rafts for easier movement inside an aircraft.

1

2

Volunteers were unable to separate the Velcro-secured top covers of the valise by pulling apart the grab handles.

The life rafts were "decorated" with a variety of tags and placards. Two laminated tags were attached with thin plastic ties to the valise grab handles: a double-sided tag, with black text — "HANDLE WITH CARE" — on a red background, and a white build log tag (photo 3). (Each of the workers who had a hand in building the life raft signed the build log card, which was then laminated and attached to the life raft.) These tags were not required, so the customer could remove them.



3

Another laminated tag provided detailed inflation instructions on one side and immediate-action instructions on the other; both sides were printed in black text on a white background. This was a useful provision, allowing anyone with the time or interest to review more complete instructions for use of the life raft, but notices should be included on each side to tell the reader that both sides of the tag provide information; some volunteers failed to turn over the tag. One tag was lost in handling.

In current configurations, placards were in bold black text printed on high-visibility orange fabric and sewn to the valise; sufficient contrast allowed the text to be read easily. These placards commanded a survivor's attention. Moreover, these placards provided sufficient information so that a survivor could recognize and use the life raft's equipment — from sealing the canopy against rain to using the ELT.

Winslow provided required manufacturing, service and other information — not of use to a survivor inflating the life raft — on different placards that were white background with much smaller black text and the Winslow logo. It was immediately obvious which placards contained essential information for survival and which did not.

The standard inflation instructions were immediately identifiable in bold text "TO INFLATE" with clear six-step instructions. To the right of this large placard was another stand-alone placard with the text "PULL TO INFLATE" and with an arrow pointing to the corner of the protective flap that covered the mooring/inflation line, out from under which protruded a loop of red nylon webbing (photo 4). Pulling on the loop automatically lifted the flap and pulled out the end of the mooring/inflation line and its stainless-steel snap clip (photo 5,), which had been secured by the closed flap's Velcro fastener. The instructions were clear, and the small loop and its location offered minimal opportunity to be inadvertently caught on something during movement.

4

5

The immediate-inflation handle — a 2 5/16-inch-diameter (5.9-centimeter-diameter) stainless steel ring — was located on the opposite end of the life raft. The ring provided a narrower grip area than the ripcord grip required by TSO-C70a (paragraph 5.2). A survivor would be able to grip it by only two fingers or three fingers (average male or female grip, respectively). This did not appear to be an acceptable substitute or an "equivalent means," and was a deficiency, in our opinion. The orange placard (photo 6) on a protective covering flap was clearly labeled

6

"EMERGENCY INFLATION" and provided clear instructions. Volunteers liked the caution to "GRASP SECURELY." On occasion, we had seen volunteers using the immediate-inflation mechanism be startled by the nearly instant inflation and instinctively let go of the life raft, which could be disastrous in a survival situation. A pocket with a Velcro-secured tab retained the immediate-inflation handle under the flap (photo 7).

7

The immediate-inflation placard was on the side of the valise, not the face. Nevertheless, some volunteers did not notice it as they stood above the valise in its normal resting position.

In 2002, Winslow introduced vacuum packing as standard for all its TSO-approved life rafts. While not an essential feature, it provides the protective benefits of sealing the life raft and its contents; the packaging also contributes to smaller pack sizes. The life rafts provided for the evaluation were equipped with prototype packaging that since has been put into production with only minor cosmetic changes. Winslow's "UltimaWrap" vacuum-packing material (photo 8) was a six-ply laminated-aluminized film that proved to be abuse-resistant and puncture-resistant.

8

The life rafts could be packed in optional white molded-plastic cases (photo 9), which were usually designed to fit a particular aircraft installation. The two halves of the molded case were secured with plastic strapping bands. A laminated tag was attached that warned not to cut the bands and said that they would break during inflation. Placarding was similar to that on the valises, but on the hard cases, the identification/data plate was

9

red with white text; the other placards were white with black text or red text. Winslow said that the company planned to convert the placard colors to the valise standard. A pair of black grab handles was provided; instructions said that the grab handles should face the aisle. The hard cases generally were designed for particular aircraft installations, and thus have become "standard options," but they cost more than a valise.

The mooring/inflation line was stowed under a white nylon-fabric cover, and the spring-clip end was under a Velcro-secured flap, as was the immediate-inflation handle; there was no risk of inadvertent inflation. The mooring/inflation line retained one half of the case after inflation; this was a deficiency, in our opinion, because the case could endanger the boarding survivors in the water or the life raft.

Mooring/Inflation Line

Winslow's stainless-steel snap clip at the end of the mooring/inflation line was not as large as Air Cruisers', but it was robust and functioned smoothly; a large hand loop was sewn into the end of the mooring/inflation line.

Concurrent with the change to vacuum packing, the company changed from a very easily gripped red one-inch-wide nylon-webbing mooring/inflation line to red 3/8-inch-wide (1.0-centimeter-wide) nylon webbing. The narrower line was not as easy to grip as the wider webbing, but it was more substantial than the thin webbing used by EAM and Hoover, or the Goodrich parachute cord, and about equal to that of Air Cruisers.

The larger mooring/inflation line was preferable, being much easier to grip, especially with cold, wet, numbed hands. Winslow said that the change was necessary to offset the increased bulk and weight of the new boarding platform and other improvements. Its marine life rafts remain fitted with the one-inch line, and aviation customers who can accommodate a slightly larger pack should request the larger line, which was available as a no-cost option.

The 30.0-foot (9.1-meter) mooring/inflation line led directly to the primary boarding aid.

Inflation

As noted earlier, the company's current placarding of the mooring/inflation line was satisfactory, and survivors will recognize its location.

The life rafts inflated easily (photo 10), without noticeable difference from the inflation of other life rafts that were not vacuum packed. On one vacuum-packed life raft that we specifically measured, the force required to activate the inflation bottle was 23.0 pounds (10.4 kilograms), within the TSO-C70a (paragraph 5.2) requirement of 20 pounds to 30 pounds. Inflation time ranged from 16 seconds for the smaller life rafts to 20 seconds for the larger ones.

10

On larger life rafts, the large quantity of vacuum-packing material (photo 11), which remained attached to the mooring/inflation line next to the primary entry, was a minor annoyance to some volunteers gathering at the boarding platform prior to boarding, but it did not interfere with anyone boarding the life raft. One volunteer said that the attached aluminized material could be cut from the line and likely could be used in a survival situation.

11

Righting

A unique "righting locator light" was located on the underside of the life raft at the outer edge adjacent to the righting line at the righting location. This light, the same approved-type water-activated locator light used elsewhere, guided survivors to a capsized life raft and to the righting location at night, a significant advantage, in our opinion. It provided sufficient illumination to see the righting instructions and righting aids. Inside the upright life raft, a placard instructed survivors to retrieve the light's water-activated battery from the water (photo 12) and store it in a Velcro-secured holder provided for that purpose. This was done out of concern that the light under the life raft might attract unwanted attention from marine life. Winslow provided very noticeable and bold, easy-to-read righting instructions. At the righting location on the bottom buoyancy tube (the top buoyancy tube when the life raft was inverted) was an orange placard with a black text/pictorial instruction: "RIGHT LINE" (photo 13, page 327),

12

13

next to a pictorial instruction showing a life raft being righted, under which were instructions to "GRASP LINE – STAND – LEAN BACK." The righting line and placard were located directly over the inflation cylinder. Some volunteers said that the terminology might be confusing to survivors for whom "right" means the opposite of "wrong" or "left," a deficiency, in our opinion, but the pictorial instruction was clear.

On the opposite side of the life raft, where the opposite end of the righting line or ladder was secured, was another bright orange placard with the same pictorial instruction: a big "X" over the pictorial instruction and the instructions "TO TURN OVER RAFT GO TO OTHER SIDE" (photo 14).

14

The blue two-inch-wide nylon-webbing righting line extended from one side to the other side with loops along its length to grasp (photo 15). These handholds were made of two-inch orange nylon webbing and contrasted with the blue nylon webbing. In addition, they were twisted, so they did not lie flat and were easy to grasp. Righting was straightforward and easy to accomplish.

15

The 10-person Ultima life raft was equipped with an optional righting ladder, which also was constructed of blue two-inch-wide nylon webbing with orange two-inch-wide nylon-webbing rungs (photo 16), which further aided righting.

16

Retroreflective tape was applied in an equilateral cross to the center of the underside of the life raft.

Boarding Aids

At the primary entry, an inflatable boarding platform was standard on all the company's Type I life rafts, along with an interior boarding ladder constructed of blue two-inch-wide nylon webbing. All the grab handles were blue two-inch-wide nylon webbing sewn around a foam core. This ensured that the grab handles were erect and were easily seen and grasped. Volunteers commented positively about this feature.

The boarding platform had a bottom of buoyancy-tube fabric with drainage holes at the four corners. Nylon webbing braces were attached at the outer end of the platform and were supported on the upper buoyancy tube. The webbing braces were encased in buoyancy-tube fabric to form sides on the platform. One volunteer said, "The sides helped stabilize me getting in. I felt more secure." A handhold was incorporated on each side, halfway up the webbing brace, but only one volunteer was observed using it.

Retroreflective tape was applied to the sides and outer edge of the boarding platform. In addition to an array of "ENTER HERE" placards, there was a clear pictorial instruction — black printed on orange fabric — with text instructions printed on the lower buoyancy tube. While entry appeared self-evident and intuitive to all the volunteers, they commented on the positive value of the pictorial instructions.

A grab handle was centered on the exterior lower buoyancy tube; a wider grab handle was centered on the exterior upper buoyancy tube; and another grab handle was centered on the top of the upper buoyancy tube. The boarding platform proved to be an effective boarding aid, noteworthy considering the high freeboard of some of the Winslow life rafts (photo 17, page 328).

Volunteers experienced boarding-platform bending (under some combinations of weight and force) similar to that experienced with the EAM boarding platform. Subsequently, Winslow modified the platform by increasing the diameter of the inflatable support tube for added stiffness, as well as by relocating and adding more webbing braces. We have since had an opportunity to evaluate the prototype of this redesigned boarding platform, which was expected to be in production by the time of publication, and the changes appeared to have solved the bending problem without an adverse effect on ease of boarding. We were able to jump up and down on the end of the boarding platform without any

17

adverse effect on the platform's integrity or usability.

Winslow's original, very effective exterior boarding ladder (photo 18), in combination with the interior boarding ladder, remained a no-cost option for applications where weight or volume was critical. Attached to the exterior midpoint of the buoyancy tube (the upper buoyancy tube on two-buoyancy-tube life rafts) was a large three-rung or four-rung boarding ladder, depending on life raft size and freeboard, that hung well below the exterior

18

bottom of the life raft. The ladder was constructed of blue two-inch-wide nylon webbing with a center web between the rails to maintain the flexible ladder's shape during boarding. This appeared to be a satisfactory alternative to the flat rungs used by Hoover and Air Cruisers. The boarding ladder, combined with the interior boarding ladder, was a satisfactory primary boarding aid, but the inflatable boarding platforms, such as Winslow's, were preferred by the volunteers.

The alternate entry incorporated a similar exterior boarding ladder (photo 19) with a single grab handle on top of the upper buoyancy tube and a short interior boarding ladder of two-inch nylon webbing. The placards for the entry identified it as "REAR BOARDING" and included a pictorial instruction showing its use. The differentiation in placarding might help to prevent confusion about which entry is primary. The addition of the interior boarding ladder to the alternate entry made it effective enough that all the volunteers were able to use it to board.

19

At the primary boarding entry, the internal three-rung boarding ladder was stretched from the top of the upper buoyancy tube to the bottom buoyancy tube directly opposite the entry and secured with quick-release buckles at the bottom end of the rails. Placards on the two-inch nylon webbing instructed survivors "ONCE ON BOARD UNCLIP BUCKLES," apparently an instruction added after an evaluation in which the boarders did not realize that the interior ladder could be disconnected. The interior boarding ladder for the auxiliary entry was fixed to the floor and was equipped with quick-release buckles (photo 20) to allow it to be stowed after use.

20

Canopy

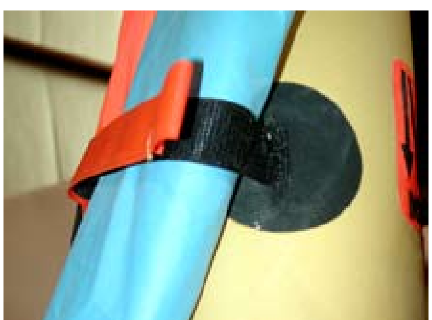
The standard canopy (photo 21) on the Type I life rafts was a self-erecting, stay-erect tri-arch design with a 5.0-inch-diameter (12.7-centimeter) canopy-support tube. The primary arch was located forward of the life raft centerline so that the canopy covered approximately 60 percent of the life raft when open. The other square arch extended at a right angle to the primary arch, from the center of the arch down to the upper-buoyancy tube in the rear. The stay-erect tri-arch tube included its own topping valve (photo 22, page 329). The closed rear section of the convertible canopy was attached to the

21

22

arches with one-inch Velcro on the top and sides and three nylon straps on the main arch, which were secured around the tube with metal snaps.

The open half of the canopy was split in two, and the flaps were rolled up to the arch tube, secured by two-piece Velcro straps, three for each flap (photo 23). A tab on the end of each flap facilitated release of the Velcro. The tabs ensured that in cold weather or with gloves, these straps could be grasped easily to release the flaps.



23

The canopy flaps had large no. 10 plastic vertical and horizontal zippers, a feature common to the entire Winslow line. The large zippers had large nylon-cord pull tabs with a plastic grip attached inside and outside; all three zippers closed to the center. A large storm flap covered all the zippers. Velcro on the storm flaps ensured that the zipper was covered and well sealed. A plastic quick-connect buckle at the center bottom of the canopy secured the canopy entry to the buoyancy tube, providing additional canopy support in rough weather conditions.

Ventilation was provided with the canopy closed via the double-action center zipper, which could be zipped open at the top. Velcro tie-backs allowed the two edges to be pulled back to form a diamond-shaped opening for increased ventilation (photo 24).

24

The bottom zippers extended back past the canopy-arch tubes and could be unzipped completely; the convertible canopy could be pulled off the arch tubes and then rolled up on the main tube at the rear of the life raft. The third support arch leg and alternate entry prevented the canopy from being rolled up and secured in place, as on Winslow's Type II life rafts. The canopy tended to crush the bottom of the rear arch (photo 25), which served to secure the canopy in the open position. While this was satisfactory, a Velcro strap on either side to hold down and collect the canopy against the tube would have been useful.

25

A combination observation port and water collector was fitted in one section of the rear of the canopy. This canopy-fabric duct (photo 26), 12 inches in diameter, was sufficiently large to allow a volunteer to put her head through the canopy (photo 27) and would be useful in allowing survivors to see outside in inclement weather while protecting the interior of the life raft. The duct also would ventilate the life raft in cold, but

26

27

dry, weather. Nevertheless, this would not be practical, in our opinion, when the life raft was pitching, although it might keep the interior drier than opening the entry zipper to look outside. An attached nylon cord tie could be wrapped around the duct and cinched tight to close it off, or could be cinched partially to allow water collection into a container. A Velcro-secured flap was on both the interior and the exterior to secure the duct when not in use, so water was prevented from entering the life raft, and the duct was prevented from hanging into the life raft. A placard with clear instructions was attached to the flap.

The required second entry was located in the left rear quarter (opposite the one with the observation port). This was a zippered arched entry door that was rolled down and secured by a pair of Velcro straps on the upper buoyancy tube upon inflation. The single large plastic double-action zipper went completely around the sides and top of the entry (photo 28). A Velcro-secured storm flap was fitted.

28

The Ultima life raft canopy provided satisfactory headroom throughout the life raft, except at the center of the entry: four-person life raft, 37 inches to 42 inches (94 centimeters to 107 centimeters) at the arch, 18.5 inches (47.0 centimeters) at the entry, 23 inches at the "quarter" sides; 10-person and 12-person rafts, 43 inches to 48 inches (109 centimeters to 122 centimeters) at the arch, 27.0 inches (68.6 centimeters) at the entry, 32 inches at the "quarter" sides. The Ultra-Light life raft had smaller buoyancy tubes, especially on the larger life rafts: four-person life raft, 34.0 inches to 39.0 inches (86.4 centimeters to 99.1 centimeters) at the arch, 18.0 inches (45.7 centimeters) at the entry, 23 inches at the "quarter" sides; 10-person life rafts and 12-person life rafts, 33.0 inches to 38.0 inches (83.8 centimeters to 96.5 centimeters) at the arch, 19.0 inches (48.3 centimeters) at the entry, 24 inches at the "quarter" sides. Volunteers said that they preferred the headroom of the Ultima life raft to the Ultra-Light life raft. The life rafts with larger buoyancy tubes and greater freeboard — regardless of manufacturer — generally were preferred over those with smaller buoyancy tubes and less freeboard.

Winslow's standard canopy fabric had a bright orange exterior and sky-blue interior of double-coated nylon fabric. This heavyweight fabric, 6.9 ounces per yard (0.2 kilograms per meter), was opaque. Many volunteers said that they preferred the blue interior. All SOLAS life rafts have blue canopy interiors because the specifications require that the interiors "shall be of a colour that does not cause discomfort to the occupants."

On the Ultra-Light life raft and Super-Light Ultima life raft, the same translucent orange rip-stop fabric was used as that used by other manufacturers, with the same shortcomings, though it does save considerable weight (60 percent less) over the standard canopy fabric (2.25 ounces per yard [0.15 kilogram per meter]). Strips of retroreflective tape were applied to the canopy and to the canopy support arch(es). Strips of radar-reflective fabric were applied to the canopy support arch(es).

A unique Winslow innovation was the optional view ports (photo 29) added to the standard canopy. These clear plastic semicircular ports were a feature that contributed to a more comfortable environment in a closed-up life raft and as a potential antidote to seasickness, always a serious problem for survivors in a closed-up life raft. Two were fitted to the entry, one on either side, and one was fitted to the rear; they were expensive — US$470 —

29

because of the special materials needed to meet FAA's fire-resistance standards. Their value, however, was summed up by one volunteer with a tendency to seasickness: "The only life raft I didn't start becoming nauseous in, best innovation seen."

Rain Simulation

Winslow's canopies proved dry when sealed according to the illustrated placards. This required more effort than just zipping the zippers; the volunteers had to ensure that the storm flaps' Velcro seals and the bottom clip on the primary entry were secured. The reward was improved weathertightness. Even without the extra effort, the life rafts remained dry for the most part. Some minor leakage occurred where the view ports were sewn into the canopy on the life rafts so equipped.

In the 2002 evaluation, the canopy on the larger life raft tended to collapse under the full impact of the fire-hose spray (photo 30,), something not experienced in previous evaluations. Investigation revealed that the canopy-support tube was

30

not fully inflated after the life raft had been manually re-inflated by volunteers. After topping off, in a second dousing, there were no problems. This shows that the inflation of the life raft must be maintained for maximum performance.

Lifelines and Grasp Lines

Blue two-inch nylon webbing was used for lifelines and grasp lines on the Ultima life raft. Blue one-inch webbing was used on Ultra-Light and Super-Light life rafts. The lifelines were staggered up and down (photo 31), from the midpoint of the upper buoyancy tube to the midpoint of the lower buoyancy tube on the double-buoyancy-tube life rafts. This pattern made the lifeline easier to grab, no matter what the position of the life raft. Subsequently, the lifeline was extended from beside the entry platform and attached to the sides of the boarding platform for improved security as survivors pulled themselves to the front of the platform.

31

The interior grasp lines were located on the upper buoyancy tube on the Type I life rafts with sufficient slack to be easily grasped (photo 32).

32

Stability

Winslow's water-ballast system was among the largest-capacity and best-performing ballast systems evaluated.

The five ballast bags around the periphery of the Type I life raft held approximately 80.9 pounds (36.7 kilograms) of fresh water each, for a total weight of 404.5 pounds (183.5 kilograms). The five-bag "pentagonal" water-ballast system distributed the water ballast evenly around the life raft.

The construction of the water-ballast bags differed between the Super-Light Ultima life rafts and the Ultra-Light rafts. The Ultima ballast bags were constructed entirely of buoyancy-tube fabric. On the Ultra-Light and "Light" life rafts, the water-ballast bags were constructed mostly of white, coated-nylon fabric (the same fabric used on Winslow's sea anchors), with ends constructed of buoyancy-tube fabric. In performance, no discernible difference was observed between the two types.

A length of parachute cord — a "trip line" — was attached to each water-ballast bag so that the bag could be pulled up, emptied and tied to the lifelines in a retracted position for "sailing" or paddling. Although life rafts with large ballast bags were more stable, they also were very difficult to paddle and less susceptible to drift with the wind, because the water-ballast bags created an enormous amount of drag. Large bags also can present problems for a landfall because they can snag on rocks and reefs, which can damage or capsize a life raft. The Winslow water-ballast bags could be lowered again for maximum stability.

Winslow also offered an approximately 50 percent greater capacity "Cape Horn" water-ballast system as an option on its Type I life rafts. This was the same water-ballast system used on its offshore marine life rafts. The system totaled 624 pounds (283 kilograms) of fresh water. If pack size and weight constraints allow, specify the greater ballast.

A parachute-style sea anchor of white coated nylon was provided. The sea anchor was 38 inches in diameter at the open end and was attached with six 0.5-inch-wide nylon-webbing shrouds that were fitted with spreaders to prevent tangling. The sea anchor was deployed automatically upon inflation and was attached at the rear of the life raft. The sea-anchor line was coiled and was contained within a fabric tube to aid inflation without tangling. A stainless-steel swivel (photo 33) was fitted at each end of the 30.0-foot (9.1-meter) long parachute-cord line.

33

A small, but telling, finishing touch that was evident wherever lines were tied off on the life rafts, was that the knot and loose end of each line were covered by shrink tubing. This not only looked tidy, but more importantly, provided added security to prevent the knots from coming undone, as has been reported frequently in these evaluations.

Floor

Winslow upgraded its integral inflatable insulated floor in 2002. Standard on the Type I life rafts, the upgraded floor had 21 reeds, more than any other similar floor among the life rafts that were evaluated. The result was something akin to tufted upholstery and provided more comfortable seating and more even insulation while reducing the total volume of air required to inflate the floor to an equalized air space (photo 34, page 332). The inflated floor was reasonably firm, like an air mattress, and it was impossible to feel someone punching the bottom, even with just a single person in the life raft. Only EAM's optional floor in its VIP line appeared to be similar, although with fewer reeds;

34

the EAM life rafts in the evaluations were not equipped with that option, so that floor was not evaluated.

The floor-inflation valve was in the center of the floor, equally accessible by all aboard. An orange placard with black printing surrounded the valve and provided clear text and pictorial instructions; on the rear canopy-support tube, a placard, which was readily visible, suggested closing the canopy and inflating the floor in cold weather.

Manually inflating an insulated floor while sitting on the floor and using the manual inflation pump provided in any of the life rafts was hard work (this was a generic problem, not just a Winslow problem). Winslow addressed this by providing an optional independent inflation cylinder to inflate the insulated floor. The inflation cylinder either could be activated automatically when the life raft was deployed, or the inflation cylinder could be activated manually by a survivor; the purchaser must choose the desired method. On larger life rafts, 12-person and more, this system might not inflate fully the floor at extreme cold temperatures, but significant floor insulation would be available immediately and would give the survivor a head start. This feature was well liked by the volunteers. In addition to increased cost, 4.0 pounds to 6.0 pounds (1.8 kilograms to 2.7 kilograms) of weight were added to the life raft. Nevertheless, flying over the cold water of the North Atlantic, this option would be desirable, space and weight constraints permitting.

Life Raft Equipment

Pump

The manual inflation pump by Mirada was a bellows design, but was unique in having an internal spring that expanded the bellows automatically. Volunteers observed that it was much easier to use than the other pumps. The spring allowed easy one-handed pumping; there was no tendency for the bayonet fitting to be pulled from the valve, so there was no need to hold it in place with the other hand. The pump provided about 40 percent greater capacity than required by TSO-C70a (paragraph 5.5).

The manual inflation pump was stored with the bayonet fitting attached inside a yellow foam-padded polyurethane pouch with a Velcro-secured flap and affixed with an orange placard boldly labeled in black: "PUMP." The pump was tethered to the life raft with parachute cord and was available for use immediately upon boarding. A Velcro strap kept the spring-loaded pump compressed for storage.

An oral inflation tube was included as a backup to the manual inflation pump. A rubber mouthpiece was on one end and a bayonet fitting for the valve was on the other end. A yellow laminated placard with instructions in black text was attached to the oral inflation tube. During the manual inflation pump comparison, we determined that the oral inflation tube (photo 35) could be very effective, providing more than six times the volume of the average manual inflation pump with each full inhalation-exhalation cycle. Care must be taken not to hyperventilate (excessive rate and depth of respiration, leading to abnormal loss of carbon dioxide from the blood, which can cause dizziness, numbness in hands and feet, and fainting) when using such a device. Survivors should count on using a mechanical pump, not their lungs, to top off a life raft.

35

Mirada quick-connect topping valves were used. Orange placards with black text and arrows on the upper portion of the buoyancy tube pointed down to the valve. Because of the orange color and a location where they were readily seen, finding the valves on the Winslow life rafts was easy. The placards at the valves included pictorial instructions for using the manual inflation pump.

Bailer and Sponge

The bailer was a collapsible bucket (photo 36) with a handle, rigid wire-reinforced rims — top and bottom — and a reinforced bottom. It was constructed of clear flexible vinyl with welded seams that did not leak. While a bit on the large size (nine quarts [eight liters]), making it somewhat unwieldy in the tight confines of a smaller life raft, volunteers believed

36

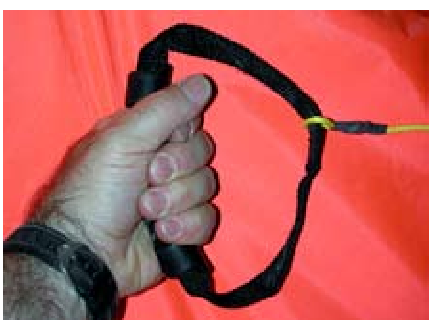
that it was the best bailer. The wide bottom and moderately stiff material allowed the bailer to stand upright. It was secured by a parachute cord tether inside the life raft and was immediately available upon boarding.

When placed in a freezer, the vinyl became very stiff, but after it was removed, its flexibility returned quickly. In cold weather/water conditions, the bailer might stay stiff much longer, making it more difficult to work with.

Winslow included a pair of 6.0-inch by 8.0-inch by 5/8-inch (1.6-centimeter) compressed sponges.

Heaving Line

Winslow used an inherently buoyant yellow 3/16-inch braided polypropylene line attached to a single-handed water-skiing tow-rope handle (photo 37). This was a buoyant and slightly flexible black plastic handle through which was passed a loop of black 3/4-inch-wide nylon webbing that was then secured to the polypropylene line.



37

The line and handle were secured with Velcro to the upper buoyancy tube (the single buoyancy tube on the Type II), to the left of the primary entry next to the canopy-support arch leg. Small strips of Velcro kept the line neat. If the Velcro were tabbed, as were other Velcro keepers on the life raft, deployment of the heaving line would have been easier and faster. The low weight of the handle made it less effective when thrown, compared with the traditional quoit. In our throw evaluations, the line tangled, a deficiency, in our opinion. It was located on the upper buoyancy tube, next to the canopy arch on the left of the primary entry. A large orange placard next to the line was labeled: "THROW LINE."

The handle was easy to grip, but black was not the best color because of the difficulty of seeing it in the water, especially at night, a deficiency, in our opinion.

Raft Knife

The raft knife was stowed inside a black fabric sheath on the interior side of the upper buoyancy tube (the single buoyancy tube on the Type II), adjacent to the primary entry on the right (as survivors board). Next to it were two orange placards labeled in black "KNIFE," with pictorial instructions affixed next to them (photo 38). One placard was oriented to the interior of the life raft above the sheath, and the other placard was angled toward survivors who would be boarding at the primary entry. Volunteers cited this as an excellent presentation, but said that on smaller life rafts, the placard facing the boarding survivors might be covered by the lower edge of the canopy.

38

The raft knife was held in its sheath by friction and an elastic band at the mouth; the parachute-cord tether was coiled around the knife. Removing the raft knife from the sheath was not always easy because it occasionally was jammed tightly in the sheath. With gloves or with cold, wet, numbed hands, it could be much more difficult to remove, a deficiency, in our opinion. After the raft knife was pulled from the sheath, unwrapping the parachute cord from the knife might slow the process. Winslow later added a pull-tab on the raft knife so that it could be deployed easily from its sheath.

Lighting

All Winslow life rafts included an approved interior light and an approved exterior light, both of which used water-activated batteries. The exterior light was located midway on the canopy-support arch tube; the interior light was located about midway between the center canopy support and the outer leg.

Winslow also offered the option of a canopy-arch-mounted strobe light; it was not an automatically activated unit. The ACR Electronics Firefly2 strobe light was retained inside a pocket on the canopy at the top center and was activated by a manual switch. Hanging from the canopy-arch tube was a yellow laminated placard with clear instructions for activating the strobe light.

ELT

Winslow offered a range of ELTs as options, including the auto-deploying DME 121.5-MHz ELT and 406-MHz ELT (photo 39, page 334), which were secured in the life raft interior with the whip antenna on top of the buoyancy tube next to the leg of the canopy-support arch. Another option was a Techtest 121.5-MHz ELT that was available for manual deployment or automatic deployment, in which case it was located on the canopy-support arch-tube leg with an integral whip antenna. A wrist tether was attached to the ELT for security when it was used as a 121.5-MHz transceiver. A third option was a Kannad 406-MHz ELT, which was included in the SEP and was deployed manually into a pocket on the canopy-support tube arch leg. A fourth option was a manually deployed

39

Techtest 406-MHz ELT with integrated voice communication on 121.5 MHz, or a global positioning system (GPS)-enabled version of this ELT.

No matter which ELT was selected, an orange placard with black text and graphics provided instructions on use of the ELT and was affixed to the canopy-support arch leg.

Survival Equipment Packs

SEP bags were fabricated of yellow polyurethane-coated nylon fabric — envelope style. Retrieval of items was easy, but they remained secure in the bag with a two-inch Velcro-secured flap for closure. On the top face of the bag was an orange placard with black text, "SURVIVAL EQUIPMENT," with instructions to "PLACE CONTENTS IN INDIVIDUAL POCKETS ATTACHED TO LIFE RAFT." The bag was equipped with a pair of nylon-webbing loops at the sides that were used to tie it securely to the life raft's floor. The bag size was adjusted for the size of the SEP. Two bags were used on larger life rafts.

Inside the SEP, Winslow used the same vacuum-packing material that was used to pack the life raft. Each SEP had individually vacuum-packed modules of items grouped by use, with a list affixed of what was inside; items were packed into the SEP bag in logical order, with those most likely to be needed immediately on top. There was no need to open those not yet needed; the survivors just put the items in one of Winslow's storage bags. The module with the survival manual and LRM was on top, labeled "OPEN FIRST" and labeled underneath "FIRST AID NOT INCLUDED." The second adjacent bag included all the first aid supplies and personal protection supplies, clearly labeled. Another bag included all the life raft repair and maintenance gear.

The Survivor-06 hand-operated water maker was not vacuum packed; it was inside a heavy plastic zipper-lock bag. The vacuum-packed food remained in its own packaging and was at the bottom of the SEP bag.

Each vacuum-packed bag had a slit cut in it that, together with a "TEAR TO OPEN" label pointing at the slit, made opening the bag relatively easy. Nevertheless, survivors with little hand strength or with cold, wet, numbed hands might have difficulty opening the vacuum-packed bags. Subsequently, Winslow included a placard with a pictorial instruction showing the raft knife being used to open the vacuum-packed bag, should that be necessary as backup method to manually tearing open the bag; the placard was a helpful addition.

Winslow, the first life raft manufacturer to offer storage pouches, provided five pouches (12 inches by 12 inches by two inches) on the Ultima life raft. These pouches were constructed of buoyancy-tube fabric and had a full-length two-inch Velcro seal along the top flap with an orange placard on the flap: "STOWAGE POCKET," with a pictorial instruction. The pouches were of box-like construction and sufficiently large to hold anything in the SEP, as well as additional supplies and equipment that might be brought aboard by survivors or salvaged from the water. The full-length Velcro seal made it unlikely that anything but the very smallest items could slide out of the bag in the event of capsizing. (Such small items should be kept inside the heavy-duty six-mil plastic zipper-lock plastic bags, which were provided in every SEP.)

The Ultra-Light life raft and Ultima-Light life raft had three (with a no-cost option for five) similar storage pouches made of lighter-weight white nylon fabric (as used for the sea anchor) with buoyancy-tube-fabric reinforcement. These pockets were 13.5 inches (34.3 centimeters) by 7.0 inches (17.8 centimeters) by 2.5 inches, with a flap secured by one-inch Velcro.

Survival Equipment

Repair

A pair of three-inch repair clamps and a pair of Mirada PRV plugs (photo 40) were included. The plugs did not float, but each was equipped with a six-foot orange nylon tether to prevent loss. Adding a tag to suggest that the tethers should be secured before use might prevent them from being lost overboard.

40

Winslow also included a 30-foot roll of duct tape, which was listed as part of the life raft repair kit. The company claimed that it has found the duct tape satisfactory in sealing holes and rips for as long as seven days. Volunteers were surprised to see that during the evaluation, the duct tape did seem to hold in the water.

Moreover, duct tape was a welcome addition to life raft equipment in a survival situation, regardless of its leak-stopping capability.

Utility Knife

A good-quality stainless-steel lock-back knife with a three-inch drop-point blade was included with a tether attached; a lock-back knife is preferred because it may help prevent an injury to a survivor.

Flashlight

Winslow life rafts were first to be equipped with a flashlight available immediately upon boarding. Called the "Quick Grab" flashlight, it was a high-quality waterproof Pelican Products Magnum two AA-cell flashlight with a xenon bulb. The flashlight was stored in a vertical sheath (photo 41) in plain view on the canopy-support arch leg with an orange placard that showed a flashlight pictorial instruction. The flashlight was tethered to the life raft; a second Pelican Products Magnum with a tether was in the SEP.

41

Signaling Devices

Winslow provided three Skyblazer aerial meteor flares and an Orion Coast Guard-approved handheld flare. SOLAS flares or Mark 13 Day/Night flares were available as options. A 3.0-inch by 5.0-inch (7.6-centimeter by 12.7-centimeter) good-quality Ultimate Survival polycarbonate mil-spec mirror with a lanyard attached and a superior-quality SOLAS-specification WindStorm Safety Whistle with a lanyard were included.

Winslow also included the six-inch Rescue Technologies RescueStreamer signaling device. This was far superior to sea dye marker, although a small plastic container of Orion sea dye marker was included. The sea dye marker was deficient, in our opinion, because of its small quantity, but the RescueStreamer made it redundant.

Paddles

Two mil-spec blue paddles with retro-reflective tape and wrist tethers were included.

Fishing Kit

A mil-spec fishing kit was included.

First Aid

An assortment of packaged first aid supplies and a first aid manual were packed in a plastic zipper-lock bag with anti-seasickness tablets (six tablets per survivor) and Nitrile gloves. The gloves were much stronger than latex gloves and were hypoallergenic, an important consideration because of the large and growing number of people who are allergic to latex.

Water

A Survivor-06 hand-operated water maker was included with all SEPs except the standard SEP for the FA-ST Uni-Light life raft. A 2.0-gallon (7.6-liter) water bag was included. Packaged ready-to-drink water was not included, a deficiency, in our opinion.

Food

S.O.S. Food Lab survival rations were included.

Miscellaneous

Winslow included a small Old Testament Bible (a selection of verses; photo 42), 75.0 feet (22.9 meters) of parachute cord, one space blanket for every two survivors and a large six-mil plastic zipper-lock bag for each survivor. Winslow offered the no-cost option of a New Testament Bible (phrases only) or Koran (phrases only) — or the option of a spiritual text supplied by the purchaser, or no spiritual text at all.

42

An assortment of optional equipment and supplies could be customized for purchasers. Winslow also encouraged aircraft operators to provide special items such as prescription eyeglasses and medicines to be packed in the life raft, although weight and space constraints must be considered

Survival Manual/Life Raft Manual

Immediate-action instructions hung from the canopy-support arch tube and were impossible to overlook. The laminated 7.0-inch by 9.0-inch (17.8-centimeter by 22.9-centimeter) card was printed in bold black text on yellow stock with a red-stripe border with identical information on both sides. The waterproof flat placard was resistant to being crumpled in packing, so it was easy to read when the life raft was inflated. The instructions were well prioritized, complete and easy to understand. Volunteers agreed that it was the best card among the life rafts that were evaluated.

Winslow produced its own waterproof survival manual. The manual was stored inside a 4-mil plastic zipper-lock bag in the SEP. This manual included specific information and useful illustrations about the Winslow life raft and its equipment. The 47-page manual covered first aid, survival and life raft information. A pencil was taped into the center of the manual, and blank pages were provided to keep a log.

Maintaining a log was highly recommended in most survival manuals, including many of those used by other life raft manufacturers, yet Winslow was the only one to include a writing implement.

Service

The current UltimaWrap vacuum-packed life rafts had a three-year service interval. The UltimaWrap could be retrofitted to older Winslow life rafts provided their condition warrants a three-year service interval. ■

The bottom line, in our opinion …

- **All of the evaluated life rafts are capable of saving lives; all life rafts are not created equal.**
- **There is a life raft for every constraint of budget, size and weight, but remember that this product will be used only when your life will depend on it.**
- **Do the homework. Collect information from the manufacturers. Ask questions. Get answers. Compare details. Ask for a product demonstration. Understand what you are buying.**
- **Given a choice, airplane operators should choose a TSO-approved Type I life raft with a self-erecting canopy, an insulated floor and an inflatable boarding ramp. Helicopter operators must select approved life rafts appropriately for their specific — and often very different — operational requirements.**
- **We know you're going to ask, so we're going to tell you … throughout these evaluations, most of the volunteers preferred Winslow.**

Notes

1. Ritter, Douglas; Ritter, Sue. Interviews by Rozelle, Roger. Tempe, Arizona, U.S. Aug. 20–28, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.
2. Bant, Jay, sales, general aviation; Henry, Brian, program engineer; Perdoni, Louis, vice president, sales and service. Interviews by Rozelle, Roger. Air Cruisers, near Allaire Airport, New Jersey, U.S. March 14, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
3. Oroshnik, Miriam, president and CEO; Oroshnik, Sam, founder; Schwartz, Martin, chief engineer; Wheeler, Matt, director of sales. Interviews by Rozelle, Roger. Eastern Aero Marine, Miami, Florida, U.S. Aug. 13, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Ableton, Beatrice, vice president; Koniecpolski, Stella, president. Interviews by Rozelle, Roger. S.O.S. Food Lab, Miami, Florida, U.S. Feb. 11, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
5. Hoggle, Paul, engineering trainer and technician; Nelson, Douglas; Saigler, Robert, operations manager; Stegarl, Brian, chief inspector. Interviews by Rozelle, Roger. Goodrich, Phoenix, Arizona, U.S. Aug. 27, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.
6. Edrisinha, Thivi, engineer; Elliott, James, quality control supervisor; Sosa, Alain, vice president of production. Interviews by Rozelle, Roger. Hoover Industries, Miami, Florida, U.S. Feb. 10, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
7. Kaufmann, Howard, president, RFD/Revere. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S. Jan. 19, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S. Loeffler, Michelle, marketing director. E-mail communication with Darby, Rick. Alexandria, Virginia, U.S. Jan. 9, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.
8. Miller, David, director of engineering; Rogers, Donna, vice president of marketing; Rogers, Charles Jr., president. Interviews by Rozelle, Roger. Survival Products, Hollywood, Florida, U.S. Feb. 12, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
9. Geits, Kate, director of administration; Graham, Bill, chief engineer; Hall, Tom, completion center manager; Mittelbach, Linda, director of human resources; Shoaff, Irene, vice president of production; Shoaff, Fred; Williams, David, senior technical representative. Interviews by Roger Rozelle. Winslow LifeRaft Co., Lake Suzy, Florida, U.S. Oct. 20–21, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

Physical Fitness for Life Rafts and Life Vests

Civil aviation authorities certify repair stations, and manufacturers issue recommended maintenance procedures. The operator, however, must take an active role in ensuring the serviceability of life rafts and life vests.

— FSF EDITORIAL STAFF

Having scheduled maintenance performed for water-survival equipment is like having a medical check-up instead of waiting to get very ill before seeing a doctor. The doctor might be able to restore you to health, but if a serious problem on a life raft is discovered at an inconvenient time — such as when your life raft is sliding down 20-foot waves and you are 100 miles from land — recovery might not be possible.

Maintenance intervals and procedures for life rafts, the survival equipment packs (SEPs) they contain and life vests are determined by manufacturers and by any applicable civil aviation authority regulations.[1] The U.S. Federal Aviation Administration (FAA) Technical Standard Order (TSO)-C70a, which sets standards for life rafts under FAA jurisdiction, has no specifications for maintenance other than that the manufacturer must furnish FAA with "maintenance instructions including instructions regarding inspection, repair and stowage of materials." U.S. Department of Transportation (DOT) regulations require pressurized cylinders, including the inflation cylinders on life rafts, to be hydrostatically tested — every five years for metallic cylinders, every three years for some composite-material cylinders.[2]

Manufacturers provide customers with a list of authorized maintenance facilities, which often include independent contractors as well as the manufacturer's facility. Douglas Nelson, manager aviation life rafts for Goodrich Aircraft Interior Products (AIP), described the process by which his company authorizes independent repair stations certificated by FAA or approved maintenance organizations by the European Joint Aviation Authorities (JAA).

"In order to be [authorized], facilities must pass an initial audit screening," Nelson said. "A report is generated from this audit and provided to the facility for review and, as necessary, corrective action. Each provider is trained to perform the various life raft inspection, maintenance and minor-repair procedures at our AIP Aquatic Test Facility in Phoenix [Arizona, U.S.]. Training is structured according to the detailed procedures in Goodrich's technical documentation. Recurrent training must be scheduled within prescribed guidelines for the facility to remain [authorized]. Each [authorized] facility is supported by a Goodrich AIP factory-owned service center in its region, which continues to be available to the facility for technical support. Periodic audits are conducted at each [authorized] location to ensure that the [authorization] terms are being met."[3]

Recommended Maintenance Intervals Can Be Misleading

Manufacturers establish recommended maintenance intervals for life rafts. Intervals range from one year (Survival Products) to six years (Air Cruisers). Two-year and three-year intervals are typical.

Considering the maintenance interval only for the life raft, however, can be misleading. Air Cruisers, despite its six-year recommended life raft maintenance interval, specifies a three-year interval for hydrostatic testing of the inflation cylinder (as U.S. regulations require). On Air Cruisers life rafts, the SEP (which also has a recommended maintenance interval of three years) and inflation cylinder are removable for maintenance without unpacking the life raft. Nevertheless, while the life raft is thus out of service, it seems unlikely that an operator would not have the life raft inspected at the same time.

Maintenance intervals for life rafts can vary among different TSO models made by the same company. Martin Schwartz, Chief Engineer for Eastern Aero Marine (EAM), said that larger life rafts tend to have longer inspection intervals because they are used by commercial operators that have their own inspection programs.[4]

The recommended life raft inspection interval also can change as the life raft ages. Winslow LifeRaft Co. specifies that its aviation life rafts will have initial maintenance two years after the date of manufacture; two years after the initial maintenance; and every year following the second maintenance interval. (If a Winslow life raft is vacuum packed — which the company says that all of its life rafts for corporate aviation customers are — the maintenance interval is three years.) Goodrich recommends a first maintenance for all of its life rafts after two years, and annually after that.

"The annual maintenance involves a thorough system inspection, with component-system testing as required," said Nelson. "We recommend a detailed system overhaul, including a functional test of all components, every five years."

In Advisory Circular (AC) 43.13-1B, *Acceptable Methods, Techniques and Practices — Aircraft Inspection and Repair*, FAA provides guidance for life raft maintenance (see FAA Advisory Circular 43.13-1B, *Acceptable Methods, Techniques and Practices — Aircraft Inspection and Repair*, page 339).

Winslow lists the steps that its factory and authorized service stations perform during a standard inspection, excluding any repairs that must be made if the life raft fails any of the required functional tests (see "One Repair Station's Standard Life Raft Inspection Procedures," page 340).

Life raft inflation cylinders are manufactured of aluminum, steel or composite materials. Aluminum is more expensive and lighter than steel. Composite materials (e.g., aluminum/fiberglass, aluminum/Kevlar and aluminum/carbon) are lightest of all.

Mark Trudgeon, business development manager at Luxfer (a manufacturer of composite cylinders and aluminum cylinders), said that carbon composite cylinders are about one-half the weight of aluminum cylinders and 40 percent of the weight of steel cylinders.[5]

In 2001, DOT extended the hydrostatic test interval from three years to five years for carbon composite cylinders (but not for composites of other materials).

The inflation cylinder hydrostatic test is intended to ensure that the pressurized cylinder retains sufficient strength so as not to risk an explosive failure. The cylinder is placed in a sealed water-filled container and pressurized with water to greater than the cylinder's working pressure (a typical ratio is 5-to-3). That causes the cylinder to expand, and the expansion is measured by the amount of water displaced from the container. When the pressure is released from the cylinder, the amount of displaced water is measured again. The difference between the total amount of water displaced and the amount of water displaced after the pressure is released represents the cylinder's

FAA Advisory Circular 43.13-1B, *Acceptable Methods, Techniques and Practices — Aircraft Inspection and Repair*

The document includes the following, among other provisions:

9-38. Life Raft Inspections. Inspection of life rafts should be performed in accordance with the manufacturer's specifications. General inspection procedures to be performed on most life rafts are as follows.

Caution: Areas where life rafts are inspected or tested must be smooth [and] free of splinters, sharp projections and oil stains. Floor with abrasive characteristics, such as concrete or rough wood, will be covered with untreated tarpaulins or heavy clean paper.

a. Inspect life rafts for cuts, tears or other damage to the rubberized material. If the [life] raft is found to be in good condition, remove the CO_2 [carbon dioxide] bottle(s) [inflation cylinder(s)] and inflate the [life] raft with air to a pressure of two psi [pounds per square inch; 1,406 kilogram-force per square meter (kgf/m^2)]. The air should be introduced at the fitting normally connected to the CO_2 bottle(s). After at least one hour, to allow for the air within the [life] raft to adjust itself to the ambient temperature, check pressure and adjust, if necessary, to two psi and allow the [life] raft to stand for 24 hours. If, after 24 hours, the pressure is less than one psi [703 kgf/m^2], examine the [life] raft for leakage by using soapy water.

In order to eliminate pressure variations due to temperature differences at the time the initial and final readings are taken, test the [life] raft in a room where the temperature is fairly constant. If the pressure drop is satisfactory, the [life] raft should be considered as being in an airworthy condition and returned to service after being fitted with correctly charged CO_2 bottles as determined by weighing them. [Life] rafts more than five years old are likely to be unairworthy due to deterioration.

It is suggested that serviceable [life] rafts be marked to indicate the date of inspection and that soapstone be used when folding them preparatory to insertion into the carrying case. Take care to see that all of the [life] raft's required equipment is on board and properly stowed. If the [life] raft lanyard, used to prevent the [life] raft from floating away from the airplane, is in need of replacement, use a lanyard not less than 20 feet long and having a breaking strength of about 75 pounds [34 kilograms];

b. It is recommended that the aforementioned procedure be repeated every 18 months using the CO_2 bottle(s) for inflation.[1] ■

Note

1. U.S. Federal Aviation Administration (FAA). Advisory Circular 43.13-1B, *Acceptable Methods, Techniques and Practices — Aircraft Inspection and Repair*. Section 3, "Emergency Equipment." Paragraph 9–38, "Life Raft Inspections." Sept. 8, 1998.

permanent expansion, which must typically be not more than 10 percent; otherwise, the cylinder must be replaced.

"Besides the hydrostatic test, an internal and external visual inspection is very important," said Douglas Svoboda, Chief Inspector at Flightpath Services, who performs inspections of life raft inflation cylinders. "We look for corrosion as well as cracking and any other indications of damage, which could lead to failure."[6]

At any approved maintenance facility, a repair technician or final inspector authorized by the repair station signs FAA Form 8130-3, *Airworthiness Approval Tag*, or an approved equivalent document before the life raft can be legally returned to service.

Maintenance: The Inside Story

Maintenance of supplementary items carried inside the life raft is also important.

Ricardo Salisbury, EAM repair station manager, said that the inspection intervals of the available SEPs are designed to coincide with inspections of the company's life rafts for which the SEPs are intended. Life-limited items include flares and rations.[7]

Hoover Industries says that basic items in its survival kits have the following expiration periods after the dates marked on the items: day/night flare, 42 months; rations (2,000 calories), four years; water (four ounces [118 milliliters]), five years; batteries, three years; desalter kit, five years; iodine swabs, three years; and ammonia inhalant, five years.[8]

The Kataydn Survivor-06 hand-operated water maker (also known as a manual reverse-osmosis desalinator) is flushed with biocide to prevent growth of algae and bacteria, according to the water maker manufacturer's instructions (see "Water Maker Maintenance Interval Clarified," page 184).

First aid kits also include life-limited items that must be kept current. In first aid kits supplied by EAM, the life-limited items include pharmaceutical drugs, burn compounds, antiseptic swabs, ammonia

Continued on page 341

One Repair Station's Standard Life Raft Inspection Procedures

1. Log life raft as received in the life raft receiving log;
2. Open service work order, and record the following life raft information:
   a. Customer information;
   b. Shipment information;
   c. Incoming dimensions;
   d. Incoming weight;
   e. Life raft serial number;
   f. Date of manufacture and last service; [and,]
   g. Any special customer requirement(s);
3. Perform visual inspection of valise, canister, hard pack or Pelican Pac [an airtight, watertight suitcase-type container] and general condition;
4. Remove life raft from valise, canister, hard pack or Pelican Pac and unfold life raft;
5. Detach inflation system and record the following information:
   a. Cylinder serial number;
   b. Cylinder weight;
   c. Date of last cylinder hydrostatic test. (If past due, or due prior to the next service-due date, then hydrostatic testing must be performed); [and,]
   d. Firing head serial number;
6. If cylinder is [less than] or [more than] the required weight, then the cylinder must be recharged;
7. Perform inspection of inflation system and components;
8. If inflation system components need to be replaced, then the cylinder must be recharged after required components have been replaced;
9. If firing head and cylinder head are over the five-year service-life span, or will be prior to the next service-due date, then the firing head and cylinder head must be rebuilt;
10. Inflate life raft using filtered dry air;
11. Detach survival equipment [pack];
12. Inspect life raft attachments (grasp lines, sea-anchor line, etc.) for security of attachment;
13. Inspect stencils for condition and conspicuity;
14. Inspect canopy for condition and function;
15. Perform pressure-retention tests for buoyancy tubes, arch tube and floor;
16. Perform pressure-relief valve test;
17. Perform arch-tube-transfer valve test;
18. Verify canopy lights for function and battery condition (swollen water-activated batteries must be replaced);
19. Perform inspection of survival-equipment components:
   a. Verify expiration date of all items with a limited useful life, replace any items [that have] expired or that will expire before the next service-due date;
   b. Inspect all pyrotechnics for general condition ([ensure that] flares are not leaking chemicals [or] crushed);
   c. Inspect all batteries;
   d. Test flashlights;
   e. Inspect food rations and water packs for leaks and general condition;
   f. Inspect first aid kit; [and,]
   g. Perform service of … water maker unit, if included (service includes recertification and biocide treatment);
20. Apply … magnesium silicate dessicant;
21. Repack survival equipment [pack], including any customer-supplied items;
22. Deflate life raft and pull vacuum to [meet specifications];
23. Fold life raft per service manual procedures and data for that life raft model and configuration;
24. Place inside valise, canister, hard pack or Pelican Pac;
25. Place in compaction unit to achieve final required pack height. Life raft is compacted to size utilizing [a] compaction unit;
26. Close and secure valise, canister, hard pack or Pelican Pac;
27. Record the following information:
   "a. Outgoing dimensions;
   "b. Outgoing weight; [and,]
   "c. Next service-due date;
28. Affix … serial-numbered service-validation certificate;
29. Complete all service paperwork;
30. Prepare life raft for shipment; [and,]
31. Ship life raft to customer. ■

Source: Winslow LifeRaft Co.

inhalants and the "eye dressing packet." Salisbury said, "The expiration periods for life-limited items in the first aid kit are those set by the manufacturers. The average is probably something like three years."

In addition to checking expiration dates, a typical inspection of a first aid kit includes scrutinizing items such as bandages, splints, compresses and sterile gloves for damage or contamination. The first aid kit container also is inspected for damage to latches, handles, mounting hardware and inside-lid gaskets.

Life vests are less complex than life rafts, and manufacturers recommend a longer maintenance interval for life vests than for life rafts. RFD/Revere says that its aerospace life jackets can be in service for 10 years before maintenance is needed. Hoover says that the maintenance interval for its life vests is "up to 10 years," although the 10-year interval is recommended only for airlines that qualify by virtue of "proper handling and quality systems"; the standard recommended maintenance interval is two years. EAM specifies a first maintenance 60 months after the life vest is placed aboard an aircraft but no later than 63 months from the date of manufacture, and subsequent maintenance at 60-month intervals.

Some advisories differ from manufacturers' recommendations about life limits or recommended maintenance intervals for life vests.

AC 43.13-1B says, "Inflatable life [vests] are subject to general deterioration due to aging. Experience has indicated that such equipment may be in need of replacement at the end of five years due to porosity of the rubber-coated material. Wear of such equipment is accelerated when stowed on board aircraft because of vibration, which causes chafing of the rubberized fabric. This ultimately results in localized leakage. Leakage is also likely to occur where the fabric is folded because sharp corners are formed. When these corners are in contact with the carrying cases, or with adjacent parts of the rubberized fabric, they tend to wear through due to vibration." The AC says that life vests should be inspected at 12-month intervals for "cuts, tears or other damage to the rubberized material."

AC 91-69A, *Seaplane Safety for [FARs] Part 91 Operators*, says, "Any FAA-approved flotation gear [life vests] used in operations for compensation or hire must be inspected at least every 12 months by persons authorized by [U.S. Federal Aviation Regulations (FARS)] Part 43. This inspection would be included in the annual or 100-hour inspection for the aircraft or under any other inspection program that the operator is authorized to use." Despite the regulatory tone of the AC's language, FAA issues ACs to explain specific ways to meet a regulation. Because it is acceptable to use other methods, the AC is not a requirement.

The inflation cylinder on a life vest is not required to undergo a hydrostatic test, but its integrity is checked. The cylinder is weighed to determine if the measured weight closely matches the weight marked on the cylinder, which indicates whether there has been gas leakage. "Unless the cylinder has been fired or fails the weight test, it doesn't need to be replaced at inspection time," said Gerry Audlee, former EAM repair station manager.[9]

Requirements for inspection, maintenance and airworthiness approval of life vests have been areas of misunderstanding, said Kathleen Kalinowski, aviation sales manager of Switlik Parachute Co.[10]

"Pilots often call us and ask about the safety of carrying aboard their aircraft life vests that have not been not inspected for many years," Kalinowski said. "Because urethane-coated fabric will deteriorate under conditions of high heat and high humidity, life vests in the United States must be inspected by a repair station that has been certificated by FAA to conduct this inspection."

Life Vests Require Approved Maintenance

Some aircraft operators' maintenance technicians assume that they can inspect and repair life vests because they conduct maintenance using similar materials, Kalinowski said. FAA specifically approves repair stations to inspect and repair life vests because proper manufacturer's manuals, procedures, tools, materials, parts lists, test equipment and standards of shop cleanliness are required.

Helicopter operators and other aircraft operators that use constant-wear styles of TSO-C13f life vests (see "Your Life Vest Can Save Your Life … If It Doesn't Kill You First," page 346) often establish with FAA an alternative, ongoing method of complying with inspection and maintenance requirements, she said.

"For example, if helicopter pilots wear the life vest daily, aircraft operators often will develop their own criteria for in-house safety inspections that exceed the FAA requirements, such as regularly checking the life [vest] by unpacking and orally inflating the cell every three months," Kalinowski said. "Sometimes they perform their own routine maintenance, then obtain an annual inspection by a repair station that is FAA-approved for life [vests]."

FAA says that life vests should be inspected in accordance with the manufacturer's specifications, unless climate, storage or operational conditions indicate the need for more frequent inspections. The inspection will include:

- Looking for cuts, tears or other damage to the rubberized (urethane-coated) material;

- Checking the oral-inflation valves and tubing for leakage, corrosion, deterioration and proper operation of the discharge mechanism for the carbon-dioxide gas cylinder;

- Removing, checking and correctly reinstalling the carbon-dioxide gas cylinder(s);[11]

- Testing the ability of the inflation cells to maintain rigidity for 12 hours after inflation with air or carbon dioxide. (Inflation with carbon dioxide every 24 months is recommended because the gas permeates the fabric at a faster rate than air and will indicate if the porosity of the material is excessive.) If repairable leaks cannot be identified by immersion in soapy water, the life vest fails the test because of excessive deterioration and porosity of the material;

- Checking for abrasions, chafing and soiling across folded cell areas and around metal parts;

- Checking for separation of cell fabric and loose attachments along the edges of patches and sealing tapes;

- Checking for deterioration in areas contaminated by oil or grease;

- Operating snaps and/or buckles;

- Verifying that operating instructions are readable;

- Checking stitching for gaps, pulls and tears;

- Visually inspecting the cell containers for snags, cuts, loose stitching and contamination/deterioration by oil or grease;

- Checking hardware for rusted parts or broken parts and serviceable cotter pins; and,

- Checking the condition and operation of the survivor-locator light.[12]

Maintenance Facilities Receive Thorough Oversight

Life raft maintenance facilities must be certificated under FARs Part 145 or any other civil aviation authority having jurisdiction.

Organizations whose work is restricted to maintaining life rafts and other water-survival equipment can qualify for a limited rating under FARs Part 145.61 (formerly Part 145.33). A limited rating applies to "a certificated repair station that maintains or alters only a particular type of airframe, powerplant, propeller, radio, instrument or accessory, or part thereof, or performs only specialized maintenance requiring equipment and skills not ordinarily performed under other repair station ratings."

Life raft and life vest maintenance organizations must have a limited rating under Part 145.61(b)(10), "Emergency equipment." Like all certificated repair stations, those with a limited rating for emergency equipment must follow the requirements in Part 145.207 and Part 145.209 for a repair station manual; and the requirements of Part 145.211 for a quality control system.

Obtaining FAA certification as a Part 145 repair station, which can require six months or more, involves approval by the FAA Flight Standards District Office (FSDO) with jurisdiction for the geographical location of the repair station. Certification procedures follow the FAA *Airworthiness Inspector's Handbook* (Order 8300.10, Vol. 2, Chapter 162).

"A maintenance organization that applies for FAA certification under Part 145 is required to submit a repair station manual," said Manuel Miranda, quality assurance, Winslow. "FAA will come in and audit the organization's records, procedures, policies — even every form used — before it assigns a rating."[13]

Under Part 145.1, a manufacturer formerly could be issued a repair station certificate with a limited rating to maintain its own products without being required to meet many of the requirements of Part 145. Such a repair facility is called a manufacturer's maintenance facility (MMF). A revision to Part 145, effective Jan. 31, 2004, has eliminated the special provisions for MMFs, and MMFs have to transition to meeting all the requirements for a certificated repair station.[14]

A U.S. Part 145 repair station certificate or rating stays in effect indefinitely, unless it is surrendered, suspended or revoked. A non-U.S. repair station certificated under Part 145, such as a repair station used by a U.S.-registered air carrier in another country, must apply for renewal before the certificate expires 12 months after the date on which the certificate was issued. Certification can be renewed for 24 months.

Joint Aviation Requirements (JAR)-145, *Approved Maintenance Organisations*, is a set of requirements established by JAA and adopted by all national aviation authorities (NAAs) that are JAA members. The European Aviation Safety Agency, which became operational Sept. 28, 2003, has assumed the responsibility for civil aviation safety among nations in the European Union. (JAA will continue to have jurisdiction over its member nations that do not belong to the European Union.) JAR-145 specifies that aircraft registered in JAA member countries must be maintained by an organization approved or accepted by JAA.

JAR-145 acceptance can be obtained by a repair station that meets detailed requirements for facilities; personnel; certifying staff; equipment, tools and material; maintenance data; production planning; certification of maintenance; maintenance records; occurrence reporting; maintenance procedures and quality system; and a "maintenance organization exposition" describing in detail the repair station's management, the approved scope of work, manpower resources, notification procedures for changes in the organization, a description of the organization's procedures and quality system, and other items.

A repair station located in the United States and certificated under Part 145 can qualify for acceptance by JAA under JAR-145.10(c), provided it meets special conditions in addition to those for Part 145. JAA acceptance is valid for up to two years.

For JAR-145 acceptance, a Part 145 repair station must provide a supplement to its inspection procedures manual, accepted by FAA on behalf of the applicable NAA, that includes the following:

- "Detailed procedures for the operation of an independent quality-monitoring system;
- "Procedures for the release or approval for return to service that meet the requirements of JAR-145.50 for aircraft and the use of the FAA Form 8130-3 for aircraft components, and any other information required by the owner or operator as appropriate;
- "Procedures to ensure that repairs and modifications as defined by JAA requirements are accomplished in accordance with data approved by [the NAA];
- "Procedures for reporting of unairworthy conditions as required by JAR-145 on civil aeronautical products to [the NAA], aircraft design organization and the customer or operator;
- "Procedures to ensure completeness of and compliance with the customer or operator work order or contract, including notified [NAA] airworthiness directives and other notified mandatory instructions;
- "A statement by the accountable manager, as defined by JAR-145, which commits the repair station to these special conditions. … ; [and,]
- "The repair station must specify the items to be contracted and have procedures in place to ensure that contractors meet the terms of these implementation procedures; that is, using a JAA-accepted source or, if using a non-JAA-certificated source, the repair station returning the product to service is responsible for ensuring its airworthiness."

When an FAA inspector observes a violation of approved procedure, administrative actions result. Those actions can be an informal notice, a formal warning or imposition of a financial penalty. Suspensions and revocations of repair stations certificated under FARs Part 145 are rare. Suspension or revocation of certification is generally limited to situations in which there are multiple noncompliance issues or noncompliance over a lengthy period.

Certification Revocations Reveal Falsified Maintenance

Flight Safety Foundation requested from FAA a list of repair-station certification revocations since Jan. 1, 1993. The Foundation then obtained, through the Freedom of Information Act, details of two recent revocations that involved facilities servicing water-survival equipment.

On Dec. 27, 2001, FAA issued an Emergency Order of Revocation concerning C&M Marine of Addison, Texas, U.S.

The revocation order included the following findings:

- The initials of a C&M employee who was certificated for maintenance of inflatable life vests — not life rafts — appeared in the "Technician" space on work orders for the repair of 10 Goodrich life rafts, although the FAA investigation report said that he performed no work on the life rafts and that his initials had been written by someone else.
- The repairs to the first of the 10 life rafts did not conform to the manufacturer's specifications.

  FAA said, "C&M applied glue to the seams of the life raft to prevent air leakage. The Goodrich repair manual prescribes that a leaking seam either be opened and rebonded, or repaired with the application of a 'bridge' of fabric across the seam, as appropriate. At the time C&M approved the life raft for return to service, the life raft had not passed the Goodrich prescribed air-retention test.

  "Despite the seam leak, C&M returned [the life raft] to its customer, Electronic Data Systems (EDS), as if it had been properly repaired." The life raft was installed in a Gulfstream aircraft that carried passengers on 12 international overwater flights before the unairworthy life raft was removed from service.
- C&M performed maintenance on two life rafts manufactured by Winslow and approved them for return to service on March 19, 2001, and May 11, 2001, respectively. On July 20, 2001, Winslow inspected the two life rafts.

  FAA said, "The Winslow Co. observed the following nonconformities and discrepancies regarding C&M's life raft servicing procedures:

  – "Tangled sea-anchor line packed between folds;

  – "Expired survival-equipment items not replaced;

  – "Installed damaged survival-equipment items;

– "Life raft packed with incomplete survival equipment;

– "Installed water-activated battery manufactured in January 1976;[15]

– "Protective foam not installed over inflation system;

– "Valise laces not trimmed after life raft–sizing operation;

– "Life raft canopy not properly arranged; and,

– "Broken life raft oars."

The individual who was part owner, chief inspector and shop supervisor of C&M Marine pleaded guilty to falsely certifying to FAA that repairs had been made to life rafts used as survival gear on aircraft. He was ordered by a U.S. District Court judge to pay US$2,000 in fines and restitution of $3,413.

FAA revoked the repair station certificate of Life Support Systems Hawaii (LSSH), effective Nov. 1, 2000. FAA found that:

- "Airline life [vests] had been altered with a pull-tab sewn to the top of the vest and a carrying pouch sewn to the lower waist strap. Accordingly, the airline life [vests] had been altered to represent quick-donning life [vests];

- "Approved quick-donning life [vests] had been altered by having the approved pouches removed and replaced. The replacement pouches did not meet the requirements of the manufacturer's Technical Standard Order (TSO)-C13d, C13e or C13f [*Life Preservers*] for testing or markings;

- "Airline-passenger life preserver pouches had been altered by replacing the outer cases with unauthorized clear heavy plastic bags. The bags did not meet the TSO certification requirements;

- "The aforesaid major alterations were made without approved data;

- "LSSH approved a total of 346 altered life [vests] for return to service from November 1997 to February 1999. All of the altered life [vests] were unapproved as described above and, therefore, unairworthy; [and,]

- "On Dec. 31, 1997, the chief inspector of LSSH left the company's employ. From that date through June 18, 1998, LSSH had no authorized personnel to inspect or approve aviation equipment for return to service. Nevertheless, from Jan. 1, 1998, to June 18, 1998, LSSH approved 174 life [vests] for return to service."

[In its settlement with FAA, LSSH denied any wrongdoing, and the parties agreed that the settlement did not constitute an admission by LSSH of the FAA allegations.]

Another administrative action available to FAA is the issuance of an Unapproved Parts Notification (UPN). A UPN can be published when FAA determines that a repair station has improperly maintained and approved for return to service a component, or that an original equipment manufacturer has sold unapproved equipment.

FAA records for recent years show three UPNs related to servicing and sales of life raft equipment and water-survival equipment:

- Sept. 3, 1998: Life rafts manufactured by Survival Products.

  "An [FAA] unapproved parts investigation revealed that Survival Products Inc. manufactures life rafts and advertises them for sale in popular aviation publications as lightweight, compact and 'Government Approved,'" said the UPN. "The 'yellow tags' attached to the life rafts give the appearance that Survival Products Inc. is a certificated repair station and that the life rafts were inspected and approved for return to service. Survival Products Inc. does not hold an FAA production approval for the life rafts, nor is Survival Products Inc. an FAA-certificated repair station."

  [Survival Products now manufactures some life rafts that are approved under TSO-C70a. With the elimination of the MMF provisions of FARs Part 145, the company is not currently performing factory maintenance. It is, however, in the process of obtaining FAA repair station certification.]

- March 4, 2002: Aircraft emergency equipment serviced by J.F. McRae Aero-Craft.

  "Information received during [an FAA] suspected unapproved parts investigation indicated that J.F. McRae Aero-Craft Inc., a former FAA-certificated repair station … , improperly maintained and approved for return to service various emergency equipment, including life vests and [life] rafts," said the UPN. "Specifically, evidence indicates that McRae maintained and approved for return to service the following life vests without using current maintenance manuals, instructions for continued airworthiness and the tooling and equipment required by [FARs] Parts 43 and 145." The life vests cited were Air Cruisers model AC-2, Eastern Aero Marine model KSE-35L8 and Switlik model AV-35.

- July 1, 2002: Emergency inflatable life rafts serviced by C&M Marine.

The UPN was issued for the violations that later resulted in the certification revocation for C&M Marine.

FAA issued the following recommendation in the UPN:

"Aircraft owners, operators, maintenance organizations, manufacturers and parts distributors should inspect their aircraft, aircraft records, and/or parts inventories for emergency inflatable life rafts maintained or approved for return to service by C&M. Verification should be conducted independently of information provided on any work order or return-to-service entry. You should take appropriate action if any of these life rafts have been installed in an aircraft. If any existing inventory includes these life rafts, the FAA recommends that you quarantine the equipment to prevent installation on an aircraft until a determination can be made regarding each life raft's eligibility for installation."

Having the work done by a manufacturer-authorized repair station minimizes the risk of improper maintenance. A greater risk is neglecting timely maintenance. Actual emergency use imposes a severe test on life rafts and life vests, and the cost of their malfunctioning in the water can be considerably greater than the cost of periodic maintenance. ■

The bottom line, in our opinion …

- **Manufacturers set maintenance intervals for life rafts and life vests.**
- **Maintenance should be performed by manufacturer-authorized repair stations.**
- **Life raft and life vest maintenance facilities must be certificated by the government authority having jurisdiction.**
- **Repair station wrongdoing in servicing life rafts and life vests appears to be rare.**

Notes

1. The term *maintenance* is used here to mean any type of regular service, including inspection, repair and time-limited component replacement.
2. Periodic-test requirements and specifications are contained in the U.S. Code of Federal Regulations, 49 CFR 173.34.
3. Nelson, Douglas. E-mail communication with Darby, Rick. Alexandria, Virginia, U.S., Aug. 4, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Schwartz, Martin. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Jan. 15, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.
5. Trudgeon, Mark. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Feb. 4, 2004. Flight Safety foundation, Alexandria, Virginia, U.S.
6. Svoboda, Douglas. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Jan. 15, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.
7. Salisbury, Ricardo. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Dec. 16, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
8. Hull, Tyler, sales, Hoover Industries. E-mail communication with Darby, Rick. Alexandria, Virginia, U.S., Dec. 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
9. Audlee, Gerry. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Aug. 27, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
10. Kalinowski, Kathleen. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 15, 2003. Flight Safety Foundation, Alexandria, Virginia. U.S. Switlik Parachute Co. is a U.S. manufacturer of life vests for aviation use and marine use.
11. A routine inspection of one inflatable life vest worn by U.S. Navy aviators revealed that the device had been packed carelessly and that carbon-dioxide cartridges had not been attached to actuators; further investigation revealed that four of seven life vests had been packed and inspected incorrectly by one inspector. Brodhead, Daniel W. "Saving Lives With Life Preservers." *Mech.* U.S. Naval Safety Center. Spring 2002.
12. FAA. Advisory Circular 43.13-1B.
13. Miranda, Manuel. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Dec. 4, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
14. *Federal Register*, Sept. 29, 2003, p. 55819.
15. Winslow recommends that every battery, including water-activated batteries, be replaced at four-year intervals.

Your Life Vest Can Save Your Life … If It Doesn't Kill You First

The life vest, properly used, reduces your risk of drowning. But if the life vest is inflated at the wrong time, don't count on escaping from a sinking aircraft.

— FSF EDITORIAL STAFF

In water, aircraft cockpits and cabins suddenly can turn into traps for unwary crewmembers or passengers who wear the wrong type of life vest or improperly use a life vest. One wrong decision before an overwater flight — such as carrying a marine life vest made of inherently buoyant materials or wearing one that inflates automatically when immersed — can make escape impossible if water is filling the aircraft. Inflating an aviation life vest *before* evacuating can be just as deadly.

While planning overwater operations, aircraft operators must take informed decisions about the following issues to ensure safe flotation means for individuals:

- The specific type of life vest to be used by crewmembers;
- The specific type of life vest to be used by passengers;
- The nominal time available to don life vests in scenarios of ditching and other water-contact accidents, and whether life vests will be worn during flight;
- Crewmember training and passenger briefings about donning life vests and using them effectively; and,
- Proper stowage and regular maintenance of life vests.

The terms "life vest," "life preserver," "lifejacket," "individual flotation device" and "personal flotation device" describe various inflatable devices cited by civil aviation authorities to provide emergency flotation to an aircraft crewmember or passenger. Life vests are the best option to keep a person afloat, whether conscious or unconscious, but some civil aviation regulations also allow the approval of noninflatable aircraft equipment — such as seat cushions — as "approved flotation means for each occupant" in some contexts (i.e., not-for-hire operations beyond power-off gliding distance but less than 50 nautical miles [93 kilometers] from the nearest shore). For consistency in this publication, "life vest" has been adopted.

Since 1995, when the U.S. Coast Guard published its standards for inflatable life vests designed for recreational boating, the variety of life vests on the market has been a source of confusion. Although U.S. Federal Aviation Regulations (FARs) provide latitude for use of such Coast Guard-approved marine devices when FARs do not specify U.S. Federal Aviation Administration (FAA)-approved life vests or other FAA-approved flotation means, aircraft operators are well advised to follow the conservative strategy of carrying only FAA-approved life vests. Moreover, of two FAA technical standard orders (TSOs) for the approval of life vests — TSO-C13f, *Life Preservers* (1992), and TSO-C72c, *Individual Flotation Devices* (1987) — TSO-C13f[1] standards are superior (see "FAA Technical Standard Order (TSO)-C13f, *Life Preservers [Life Vests]*," page 452, and "FAA Technical Standard Order (TSO)-C72c, *Individual Flotation Devices*," page 459). Many countries have adopted TSO-C13f, and the U.K. Civil Aviation Authority (CAA) — which has approved life vests for public transport aircraft under Specification no. 5 — soon will adopt a European TSO that is harmonized with TSO-C13f.

Newest Standard Requires Best Performance

The following comparison of TSO-C13f and TSO-C72c shows why TSO-C13f life vests provide superior characteristics and performance:

- TSO-C13f buoyancy tests conducted in fresh water at 72 degrees Fahrenheit (F; 22 degrees Celsius [C]) must show that adult life vests and adult–child combination life vests provide a minimum buoyant force of 35 pounds (16 kilograms), child life vests provide a minimum buoyant force of 25 pounds (11 kilograms) and infant–small child life vests provide a minimum buoyant force of 20 pounds (nine kilograms) for at least eight hours. (Buoyant force is the weight of fresh water displaced by the life vest when totally submerged.);
- TSO-C72c buoyancy tests conducted in fresh water at 85 degrees F (29 degrees C) must show that not less than 14.0 pounds (6.4 kilograms) of buoyancy (i.e., the amount of weight the device can support at this temperature) is provided for eight hours;
- TSO-C13f requires that the life vest must right the wearer (turn the wearer to a face-up position) within five seconds, maintain a completely relaxed wearer in the required flotation attitude and keep the wearer's mouth and nose clear of the water line;
- TSO-C72c contains no requirement for righting the wearer or maintaining freeboard (for life vests, freeboard is the distance between the lowest point of the wearer's mouth and the water surface);

The newest U.S. standards for aviation life vests permit designs with a single buoyancy chamber.

- TSO-C13f contains specific performance standards for infant–small child devices and requires tethers for these devices;

- TSO-C72c does not include standards for infant–small child devices but makes seat cushions, headrests, armrests, pillows or similar aircraft equipment eligible for approval as flotation devices if they comply with the minimum requirements for safety and performance. Many safety specialists, however, consider such equipment inferior to life vests (but suitable as a backup to life vests that are lost or damaged in a water-contact accident);

- Typical users of TSO-C13f devices must be able to remove the life vest from its storage package and don the life vest without assistance within 25 seconds by securing no more than one attachment and making no more than one adjustment for fit (the standard excludes the infant–small child device from this requirement, specifies how many test subjects must be able to do this, and contains different requirements for attaching a life vest to a child and for simulating the placement of a child in an infant–small child device);

- TSO-C72c says that life vests "must be capable of being utilized by the intended user with ease";

- Unlike TSO-C72c, TSO-C13f contains requirements for oral inflation, overpressure protection (i.e., no damage if the mechanical inflator discharges carbon dioxide into an inflated life vest), deliberate-deflation capability and reinflation capability, high-visibility color, prevention of inadvertent release of life vest fasteners, adjustment in the water, an unobstructed view, an automatically activated survivor-locator light and legible instructions that can be read while wearing the life vest; and,

- TSO-C13f requires tests for resistance of coated fabrics, seams and webbing to tearing, puncture, wear and deterioration, and operation of inflators and valves, that generally exceed similar testing requirements under TSO-C72c.

The primary purpose of a life vest is to prevent drowning if a conscious survivor or an unconscious survivor of an aircraft water-contact accident enters the water. In this situation, survivors cannot depend on physical fitness or swimming skill alone to prevent drowning. An additional purpose is to delay the onset of hypothermia by enabling the wearer to move from the aircraft into a life raft or into a rescue device with the least-possible physical exertion and by slowing the loss of body heat by keeping the survivor's head out of the water and by providing some insulation to the upper torso (see "Is There a Doctor Aboard the Life Raft?" page 187).

"The main cause of death after ditching is drowning, usually hastened by hypothermia and/or exhaustion."

Ideally, the life vest rights the body and floats the body by changing the wearer's buoyancy — so that the combined body and life vest weigh less than the volume of water they displace — and by repositioning the buoyancy forces to keep the head above the water surface. Body mass/fat, lung size, clothing and whether the water is rough or calm determine whether a person inherently will sink or float without a life vest and without treading water. The Coast Guard said that most adults require 7.0 pounds to 12.0 pounds (3.2 kilograms to 5.4 kilograms) of additional buoyancy to minimally keep their heads above water.

The wearer's ability to escape from a sinking aircraft takes priority in the design of aviation life vests. In some water-contact accidents, aircraft occupants were trapped under water because their life vest prevented them from passing through an emergency exit, door or window or because they could not overcome with human strength the buoyancy of their inflated life vest (or an inherently buoyant device) to descend to an underwater exit. Life vests also are more susceptible to punctures and snagging while inflated.

A U.K. CAA analysis of ditching data from the United States and the United Kingdom, cited in 2000, found that life vests were an important factor in survival after ditching.[2]

"In many cases, the deceased persons did not have life [vests], either worn or available to them," U.K. CAA said. "The main cause of death after ditching is drowning, usually hastened by hypothermia and/or exhaustion."

Data compiled in 2003 by Flight Safety Foundation show that the majority of aircraft occupants survived after ditchings (see "About 75 Percent of Airplane Occupants and More Than 87 Percent of Helicopter Occupants Survived Ditchings, Data Show," page 469) but were inadequate to analyze the role of life vests.

Worldwide, civil aviation regulations governing life vests are based in part on requirements of the International Civil Aviation Organization (ICAO), which specify carriage of "a life [vest] or an equivalent individual flotation device" for extended flights over water in airplanes (see "For Ditching Survival, Start With Regulations, But Don't Stop There," page 395).[3]

The TSO-C13f life vests help to prevent drowning by righting the wearer within five seconds and by maintaining a 30-degree body angle (inclined backward from the vertical position) so that the lowest point of an unconscious wearer's mouth remains clear of the water surface without effort by the wearer.

"The fact that pilots and passengers can easily don and wear inflatable life vests (when not inflated) provides maximum effectiveness and features an uncluttered exterior surface that protects the working components and allows for unrestricted movement," FAA said. "The TSO-C13f life [vests] have excellent self-righting capabilities … pilots should demonstrate or supervise the proper donning of the device so that wearers will not put the device on improperly and defeat this self-righting ability."[4]

The body cools significantly faster in rough seas than in calm seas.

Donning the life vest before entering the water is an important factor in surviving an aircraft water-contact accident. Aircraft operators should ensure ready accessibility to each life vest on the aircraft at all times and verify that any life vests stored in a sealed pouch can be opened easily without tools. In the past, some types of life vests carried in sealed pouches have been difficult to remove and to don in a flooded aircraft, and survivors have had difficulty finding and fastening straps and hooks after evacuating, FAA said.

"It would take considerable effort to accomplish the combined maneuver of pulling a life [vest] over one's head while in the water, trying to stay afloat," FAA said. "If a life [vest] is not worn before [a water-contact accident], it is practically impossible for a survivor with an injured arm, for example, to don the life [vest] in time for it to be effective for survival."

Studies of accidents involving drowning show that if a person must use physical exertion in the water to maintain freeboard for breathing, the heart rate will be faster and the loss of body heat will occur more quickly than if the person can maintain a relaxed floating position. Research also has demonstrated that with or without insulation, from ordinary clothing or special clothing such as a cold-water immersion suit (also known as a survival suit, exposure suit, helicopter-passenger suit, aircrew immersion suit and helicopter offshore transport suit), the body cools significantly faster in rough seas than in calm seas (see "Cold Outside, Warm Inside," page 357).

Although some life vests are approved in an adult–child combination size, child size or infant–small child size, relatively few scientific data are available about the real-world performance of life vests worn by children.

Consistent Briefings Save Lives

FAA has emphasized, in guidance to FARs Part 121 air carriers and to other aircraft operators conducting overwater flights under FARs Part 91, *General Operating and Flight Rules,* that complete passenger briefings about life vests and other individual flotation devices are essential.

For example, FAA Advisory Circular 121-24C, *Passenger Safety Information Briefing and Briefing Cards,* published in 2003, said that appropriate crewmembers must brief passengers on the following:

- Type, location, and use of required flotation equipment. "This briefing must include the type of equipment available at the individual passenger's seat and the method of use in the

Designs vary significantly in the infant–small child category of life vests, which require a tether and incorporate methods of slowing the onset of hypothermia.

water, such as putting the arms through the straps and resting the torso on the cushion," FAA said. "When the aircraft is equipped with life [vests], the briefing must include instructions about the location and removal of life [vests] from stowage areas, including pouches, and the donning and inflation of the life [vests]. If the aircraft is equipped with both flotation cushions and life [vests], [crewmembers] should brief passengers on both types of equipment and must brief passengers on the required flotation equipment"; and,

- Life vests. "[Crewmembers] must point out the stowage locations of life [vests] and demonstrate their removal from stowage, extraction from pouches, donning, and their use including manual and oral inflation methods, instructions on when the equipment should be inflated, and manual operation of survivor-locator lights and accessories," FAA said. "If there are significant differences in the donning or operation of life [vests] at various seats, passengers should be briefed only on the characteristics of the life [vests] located at the individual passenger's seat. It is suggested that [crewmembers] individually brief parents or guardians accompanying small children on the use of life [vests] as it applies to these children." In air carrier operations, briefing cards also must depict stowage locations and life vest instructions, including the fitting of adult life vests on small children and the correct operation of other child flotation devices. Moreover, if a flight will proceed directly over water, passenger briefings about life vests and individual flotation equipment must be completed before takeoff.

In October 2003, the U.S. General Accounting Office (GAO), citing FAA research, said that airlines in the past varied in their instructions to passengers on the use of approved flotation seat cushions.[5]

"For example, some airlines advise that passengers hold the cushions in front of their bodies, rest their chins on the cushions, wrap their arms around the cushions with their hands grasping the outside loops, and float vertically in the water," the GAO report said. "Other airlines suggest that passengers lie forward on the cushions, grasp and hold the loops beneath them, and float horizontally. FAA also reported that airlines' flight attendant training programs differed in their instructions on how to don life vests and when to inflate them." These methods of holding seat cushions in the water underscore the difficulty of swimming/maneuvering to a life raft while grasping a cushion compared with swimming/maneuvering with the arms free while wearing a life vest. Results of a current study of life vest performance are expected to be available in 2004 from the Cabin Safety Research Team at FAA's Civil Aerospace Medical Institute, FAA said.[6]

The importance of donning uninflated life vests before conducting a ditching has been emphasized by civil aviation authorities. For example, the U.K. Air Accidents Investigation Branch (AAIB), in one accident report, said, "Although the ditching was performed in a disciplined manner and everyone aboard the [single-engine] aircraft survived, it was noted that the pilot never had the time to get into his life [vest]. Had the blow that he received to the head at the time of ditching rendered him unconscious, the outcome might not have been so good. … The pilot and passengers of the aircraft had not donned their life [vests] before they set off over the sea because [the life vests] were of the traditional rubberized-vest type, which they found tended to become hot and uncomfortable after a little time. This appears to be a common reason given for not putting life [vests] on before flight over water and is largely related to the types of life [vest] most commonly available in aircraft."[7]

AAIB said that investigation of the ditching of another single-engine airplane revealed that neither the instructor pilot nor student pilot donned the life vests that were carried on their aircraft.

"The aircraft carried two crew life [vests] which were packaged in plastic wallets and stowed behind the pilots' seats," AAIB said. "These [life vests], which were not of the 'constant-wear' type, were not worn by the crew and they did not attempt to don them after the power loss or during the subsequent descent into the sea. (A [test] subsequently carried out in a similar aircraft with both pilot seats occupied showed that it was possible, with some difficulty after first unfastening the restraint harness, to remove a life [vest] from its container and don it in approximately one minute.) Since the accident, the company has ordered 'constant-wear' life [vests] for use in all their aircraft.

"In situations when the occupants of light aircraft are faced with the probability of having to ditch in the water, it is not realistic to expect them to don life [vests] (if carried) while concentrating on making a survivable ditching. It is, therefore, unlikely that an occupant will attempt to put on a life [vest] which is not being worn at the time the ditching emergency starts, until after the ditching has actually occurred. Once ditching has occurred, the situation, as in this case, is likely to demand an urgency for escape from the aircraft which

Donning uninflated life vests before conducting a ditching has been emphasized.

will preclude the opportunity to locate and don life [vests].

"In this particular accident, had the student been wearing a suitable life [vest] which he had inflated after escaping from the aircraft, he would almost certainly have survived, since it would have extended the time which the tug and the search-and-rescue helicopter had available to locate him while he was still alive."[8]

FAA requires carrying TSO-C13d, TSO-C13e or TSO-C13f life vests for all occupants under specified conditions, such as when operating a large/turbine-powered multi-engine airplane more than 30 minutes or 100 nautical miles (185 kilometers) from the nearest shore, whichever is less. FAA has recommended that even when not required, aircraft operators consider voluntarily using approved aviation life vests. One example is FAA's advice to seaplane operators.

"FAA recommends that seaplane operators who are not engaged in for-hire operations use the FAA's TSO life [vests] or individual [flotation devices]," FAA said.[9]

Design elements of some current marine life vests are incompatible with aviation safety requirements. No inherently buoyant marine life vest should be carried in the cabin or the cockpit of an aircraft because of the risk that occupants who don this type of life vest will be trapped, for example. Inflatable life vests approved by the Coast Guard for specific marine uses also have many restrictions for marine safety reasons. For example, they are not approved for children who are less than age 16, and they are not recommended for nonswimmers.

In general, FAA and U.K. CAA have said that if aircraft operators decide to use an inflatable marine life vest at their own risk for any reason, extreme caution is required. In the advice to seaplane operators, for example, FAA said that three types of inflatable life vests approved by the Coast Guard for various marine uses — called Type I offshore life [vests], Type II near-shore buoyant vests and Type III flotation aids[10] — are used by some aircraft operators when FAA-approved life vests or FAA-approved flotation means are not required by regulations.

Nevertheless, U.K. CAA said, in recommendations for general aviation pilots, "Many automatically inflated life [vests], used by the sailing community, are activated when a soluble tablet becomes wet. This type is totally unsuited for general aviation use as they will inflate inside a water-filled cabin, thus seriously hindering escape."[11] The water-activation feature can be disabled on some life vests, and the life vest also can be inflated manually (i.e., by pulling a tab/handle on the inflation mechanism to fill the life vest with carbon-dioxide gas or by blowing air into oral-inflation tubes).

Unlike most aviation life vests designed for adults, this constant-wear design incorporates crotch straps to enable helicopter crewmembers to adjust their flotation attitude in the water.

Aircraft operators especially must consider how the complexity of automatic marine life vests could compromise safety if used in an aircraft.

In recommendations for seaplane pilots conducting operations under Part 91, FAA said, "Please keep the following in mind regarding U.S. Coast Guard-approved inflatable [life vests]: Type I and Type II inflatable [life vests] have a higher minimum buoyancy [33 pounds/15 kilograms] than a Type III [life vest, 22 pounds/10 kilograms]. They will outperform a Type III [life vest] that does not exceed the U.S. Coast Guard minimum requirements. Some [automatic life vests] will allow the user to disarm the automatic portion of the inflation mechanism. If the user improperly disarms the automatic portion of the inflatable [life vest], he/she might also disarm the manual portion. Wearing a [life vest] with the automatic portion armed would most certainly put passengers at risk of being trapped in the airplane or damaging the [life vest], rendering it unusable. If the device is to be used in both a seaplane and a boat, then the device must be rearmed for boating." (Operation of seaplanes in the United States requires compliance with state laws and federal regulations governing use of life vests; U.S. Coast Guard regulations exempt seaplanes from the safety-equipment requirements applicable to marine vessels, however.)[12]

Technical Specifications Help Ensure Performance

Current aviation life vests typically have one or two inflatable buoyancy chambers (cells) made of flame-resistant, urethane-coated nylon. They are donned over the wearer's head while deflated and are held in place by adjustable straps (a waist strap and, in some designs, a crotch strap and/or back panel).

The crotch strap is used on some infant–small child life vests; the waist strap on all other categories is designed and tested to prevent the life vest from becoming detached from the wearer during a jump at any attitude from at least five feet above the water (TSO-C13f) when donned and adjusted correctly. Among current aviation life vests, an example of an exception to this generalization is one model of a constant-wear TSO-13d life vest that incorporates crotch straps in a special design for helicopter crewmembers who wear weapons and other equipment used in law enforcement.

One or two cylinders containing compressed carbon-dioxide gas and an actuator mechanism provide the primary method of inflation. Activating the inflation mechanism causes gas in the cylinder(s) to inflate the life vest in approximately two seconds (typically at 70 degrees F [21 degrees C]). If the life vest has two cylinders, both must be used for full inflation. Each carbon-dioxide cylinder is depleted after one inflation.

Each buoyancy chamber has one oral-inflation tube, containing a one-way valve, to provide a backup system that enables the wearer to fully inflate the life vest or to add air by blowing into a mouthpiece. The valve also allows the wearer to release some inflation gas from the life vest for improved comfort in the water or after boarding a life raft. High-visibility colors are standard on civilian life vests; some life vests are available with retroreflective tape. (Retroreflective materials are engineered to reflect light in the direction of its source and are most effective when the ambient light is low.) Various attached accessories, such as a water-activated survivor-locator light, may be standard or optional. In some countries, life vests also can be purchased with a splash guard, sprayhood or plastic face shield that helps to protect the mouth and airway, to reduce the amount of water flowing across the face and to delay the onset of hypothermia.

Kathleen Kalinowski, aviation sales manager of Switlik Parachute Co., said that proper fit of the life vest to the individual is important for optimum flotation performance.[13] Some life vests designed for constant wear — such as those typically worn by helicopter pilots and pilots of single-engine airplanes during extended overwater operations — are manufactured in a range of sizes, enabling an individual crewmember to select the best-fitting size.

Other life vests are manufactured in one size or in adjustable sizes for adults and children, and must be adjusted to fit snugly at the time they are donned. For example, the TSO-C13f life vest specifies the adult category for wearers who weigh more than 90 pounds (41 kilograms), the adult–child category for wearers who weigh more than 35 pounds, the child category for wearers who weigh a maximum of 35 pounds and the infant–small child category for wearers who weigh less than 35 pounds.

"The life vest is designed, and needs to be adjusted to fit, so that the face of a person who is wearing the correct size will remain above the water surface at the proper angle of flotation," Kalinowski said. "For example, an infant cannot wear an adult–child size life vest because the infant's head would not stay in the life vest or float at the appropriate angle. When the correct size is worn in the correct way, the life vest will remain attached while the wearer jumps into the water [from a minimum height of five feet (1.5 meters) during TSO-C13f testing], even with the life vest inflated, and will provide all flotation to the front of the body to right even an unconscious wearer. The wearer then lies back in the water with the face out of the water. This enables the person to relax, lie back and wait for rescue or to swim to a life raft."

In the United States, life vest designs with two buoyancy chambers and life vest designs with one buoyancy chamber can meet FAA TSO performance requirements for approval, and aircraft operators can choose either design based on their own requirements and preferences.

"With two-cell design, if one cell is punctured, the other cell will provide half of the buoyancy although the life vest will not have the same performance with one cell deflated," Kalinowski said. "The advantages of the one-cell design are lighter weight, simpler design and maintenance, and fewer parts. Although the one-cell design for life vests only has been approved for aviation in the United States for about seven years, this design has been approved by U.K. CAA for the past 40 years with no problems."

Given the unpredictability of an aircraft water-contact accident, however, another specialist said that he would prefer to be wearing a dual-chamber life vest.

"In my opinion, redundancy is desirable in a life-saving application," said Gus Fanjul, a specialist in life vest design for a U.S. manufacturer. "For me, the relevant issue is simply that two-cell life vests provide redundancy, and one-cell life vests provide no redundancy."[14]

Life vest designs with a single buoyancy chamber can be approved under TSO-C13f, which also requires a single waist strap, and TSO-C72b; designs with two buoyancy chambers can be approved under TSO-C13f or TSO-C13d.

To specify accessories to be attached to a life vest, aircraft operators should consider minimum requirements of the civil aviation authority and whether to specify additional accessories based on their plan for aircraft occupant survival in anticipated operating environments. For example, FAA requires a TSO-C85a survivor-locator light on TSO-C13f life vests, but a signaling whistle — a required accessory in the United Kingdom and some other countries — is not required by FAA. U.S. specifications for survivor-locator lights require a device that is similar in performance to a household flashlight, but survival specialists recommend the use of strobe lights that exceed the minimum specifications and increase the probability of detection by searchers in darkness and low-visibility conditions (see "FAA Technical Standard Order (TSO)-C85a, *Survivor-locator Lights,*" page 462).

"Personally, I would choose the higher buoyancy, the survivor-locator light and other safety features of the TSO-C13f life vest," Kalinowski said. Accessory items add to the weight of the life vest, so aircraft operators specify accessories based on the anticipated risks.

"Two-cell life vests provide redundancy, and one-cell life vests provide no redundancy."

In general aviation in the United States, crewmembers and passengers of fixed-wing aircraft — including most business aircraft — are required to carry life vests and/or to wear them only under specific conditions (i.e., wearing life vests while conducting for-hire operations in a seaplane).

"Many general aviation airplane pilots and passengers voluntarily exceed overwater requirements by wearing life vests," Kalinowski said. "Most airplane operators carry airline-style TSO-C13f life vests to meet the requirements."

With current packaging, storage and inspection methods, life vest manufacturers may be able to specify a time between overhaul (TBO) as long as 10 years under some aircraft operators' maintenance programs. In general, however, requirements for inspection and maintenance must be determined for the specific life vest model used by the aircraft operator. When not carried on the aircraft, life vests typically must be stored according to the manufacturer's recommendations in a dry environment.

"Pilots often call us and ask about the safety of carrying aboard their aircraft life vests that have not been not inspected for many years and do not have extended TBOs," Kalinowski said. "Because urethane-coated fabric will deteriorate under conditions of high heat and high humidity, life vests in the United States must be inspected by a repair station that has been certified by FAA to conduct this inspection." (See "Physical Fitness for Life Rafts and Life Vests," page 337.) In the United States, the general rule is that life vests carried in for-hire operations must be inspected every 12 months.[15]

U.K. CAA recommends maintenance of life vests at least every 12 months by an approved servicing organization or an appropriately licensed maintenance technician, or more frequently if required by the manufacturer.[16]

Maintenance technicians must not assume that they can inspect and repair life vests because they conduct maintenance using similar materials. For example, FAA specifically approves repair stations to inspect and repair life vests because proper manufacturer's manuals, procedures, tools, materials, parts lists, test equipment and standards of shop cleanliness are required.[17]

U.S. helicopter operators and other aircraft operators that use constant-wear styles of TSO-C13f life vests often establish with FAA an alternative, ongoing method of complying with inspection and maintenance requirements, such as unpacking and orally inflating the life vest every three months, performing authorized routine maintenance and obtaining annual inspections by an approved service station.

Periodic Hands-on Training Develops Life Vest Skills

Survival specialists recommend that aircraft operators conduct periodic training on correct use of life vests and other survival equipment for overwater operations. Hands-on experience in donning, inflating and buoyancy-testing the life vest in water helps crewmembers and passengers to do the following:

- Understand better why the life vest must be inflated outside the aircraft, the need to guard against snagging and punctures, and how the life vest will perform;
- Ensure proper fit/adjustment so that the chin is above the water surface and they can breathe easily;
- Ensure that all straps, zippers and ties are fastened correctly and that loose strap ends are tucked in to prevent snagging during egress;
- Relax the body in the water with the head tilted back to minimize exertion;
- Determine which of the recommended postures for slowing the onset of hypothermia are possible while floating;
- Swim to a life raft in the water, which typically requires a back stroke; and,
- Become familiar with the operation of each oral-inflation tube, release valve and accessory.

Comfort, Durability Distinguish Constant-wear Life Vests

Life vests that are approved by one or more civil aviation authorities (labeled as compliant with FAA TSO-C13f, for example, and/or with a U.K. CAA appliance-registration [AR] number for non-U.K. equipment)[18] are available in several styles for constant wear, for long-term stowage or for carrying on the body for quick donning. Manufacturers' standard/optional accessories vary but may include a TSO-C85a–approved survivor-locator light (standard equipment with TSO-C13d/TSO-C13e/TSO-C13f life vests), whistle, signaling mirror, sea-dye marker, multilingual pull-tab instructions, customized donning instructions, orange color for crew life vests to distinguish them from the international yellow color worn by passengers, and demonstration models for safety briefings). Examples include the following:

- Durable constant-wear life vests, specifically designed for compatibility with shoulder harnesses and safety belts. For example, one helicopter crew vest — which weighs 2.60 pounds (1.02 kilograms) — has an independent double-chamber design, protection against neck chafing, adjustability for waist size and chest size, a heavy-duty encapsulation cover, heavy-duty wide nylon webbing and pockets for survival equipment. The device has FAA TSO-C13d approval and U.K. CAA approval and provides 38.0 pounds (17.2 kilograms) of buoyancy with two 18-gram (0.63-ounce) carbon-dioxide gas cylinders;
- Double-chamber models that are folded into various configurations and sizes of fire-retardant storage bags. For example, one life vest provides 38 pounds (17 kilograms) of buoyancy with two 16-gram (0.56-ounce) carbon-dioxide cylinders, has a quick-don harness, weighs 1.4

pounds (0.6 kilograms) and is FAA-approved as a TSO-C13f life vest;

- Models that are folded into a small pack to be worn around the waist during flight. For example, one helicopter life vest — a double-chamber design — is designed to be donned with a one-handed motion in less than 10 seconds and is FAA-approved as a TSO-C13e life vest;

- Single-chamber models that have FAA TSO-C13f approval and are folded into various configurations and sizes of fire-retardant storage bags. For example, one life vest provides 37 pounds (17 kilograms) of buoyancy with one 33-gram (1.16-ounce) carbon-dioxide cylinder, has a quick-don harness and weighs 0.96 pounds (0.44 kilograms);

- Single-chamber models that have FAA TSO-C72c approval and are folded into various configurations and sizes of fire-retardant storage bags. For example, one life vest provides 18 pounds (8.2 kilograms) of buoyancy with two 16-gram carbon-dioxide cylinders, has a quick-don harness and weighs 0.6 pounds (0.3 kilograms); and,

- Infant–small child devices. For example, one model — which has FAA TSO-C13f approval and U.K. CAA approval — has an international yellow "survival capsule" design, constructed of flame-resistant urethane-coated nylon. The device incorporates an internal thermal-protection vest, viewing window, towing bridle (72-inch [183-centimeter] tether), lifting handle, air-circulation ports, a ballast bag and retroreflective tape. The device provides 40 pounds (18.2 kilograms) of buoyancy with two 35-gram (1.23-ounce) carbon-dioxide gas cylinders. When packed, the device weighs 2.1 pounds (0.95 kilogram).

Among manufacturers that produce aviation life vests are Air Cruisers Co., Belmar, New Jersey, U.S.; Eastern Aero Marine, Miami, Florida; Hoover Industries, Miami; Switlik Parachute Co., Trenton, New Jersey; and RFD Beaufort of Merseyside, U.K.

In summary, the best option when conducting all overwater operations in airplanes and helicopters is to use aviation life vests that incorporate the superior lifesaving technology of TSO-C13f (or equivalent standards), regardless of what civil aviation authorities require based on aircraft distance from the nearest shore. By voluntarily exceeding requirements, the aircraft operator increases the probability that this equipment will be suitable for a ditching or other water-contact accident. ■

The bottom line, in our opinion …

- **Do not inflate a life vest before evacuating the aircraft.**
- **Many marine life vests have characteristics — such as water-activated inflation or inherently buoyant design — that could trap pilots or passengers wearing them inside a sinking aircraft.**
- **Life vests help prevent drowning and slow the onset of hypothermia more effectively than other approved flotation equipment such as buoyant aircraft seat cushions.**
- **Passenger briefings about all equipment for individual flotation are essential for every overwater flight.**
- **Life vests approved under Technical Standard Order (TSO)-C13f by the U.S. Federal Aviation Administration (or equivalent standards of other civil aviation authorities) provide superior lifesaving technology compared with those approved under TSO-C72c.**

Notes

1. U.S. Federal Aviation Administration (FAA). "Cancelled Technical Standard Orders (TSOs)." <av-info.faa.gov/tso/TSOcan/Canceled.htm> January 2003. The standards for FAA-approved life vests are in TSO-C13f. TSO-C13a, TSO-C13b and TSO-C13c were cancelled March 3, 1988. FAA said that the primary upgrades incorporated into TSO-C13e life vests involved donning features and retention features. Although TSO-C13f is the most current standard, manufacturers may continue to produce and identify life vests that were approved previously by FAA under TSO-C13d and TSO-C13e.
2. U.K. Civil Aviation Authority (U.K. CAA). *Ditching*. General Aviation Safety Sense Leaflet 21A. 2000.
3. International Civil Aviation Organization (ICAO). Annex 6, *Operation of Aircraft*, Part II, I*nternational General Aviation – Aeroplanes*. Paragraph 6.3.3, All [Land] Aeroplanes on Extended Flights Over

Water, says, "All airplanes when operated on extended flights over water shall be equipped with, when the airplane may be over water at a distance of more than 93 kilometers (50 nautical miles) away from land suitable for making an emergency landing, one life jacket or equivalent individual flotation device for each person on board, stowed in a position easily accessible from the seat or berth of the person for whose use it is provided."

4. FAA. *Seaplane Safety for 14 CFR Part 91 Operators*. FAA Advisory Circular (AC) 91-69A Nov. 19, 1999.

5. U.S. General Accounting Office. *Aviation Safety: Advancements Being Pursued to Improve Airliner Cabin Occupant Safety and Health.* Report no. GAO-04-33. October 2003.

6. Herwig, Roland; McLean, Garnet A. Telephone interview and e-mail communication by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Jan. 16, 2004. Flight Safety Foundation, Alexandria, Virginia. U.S. Herwig is a public affairs representative for the FAA Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma, U.S. Dr. McLean is an engineering psychologist and principal investigator for cabin safety research at the FAA Civil Aerospace Medical Institute in Oklahoma City, Oklahoma, U.S.

7. U.K. Air Accidents Investigation Branch (AAIB). Bulletin no. 2/2002. *Piper PA-28R-200, July 23, 2001.* The pilot ditched the aircraft approximately one mile northeast of Lihou Island off northwest Guernsey, England. The pilot and one of two passengers received minor injuries; the other passenger was not injured. They were rescued from their life raft after the airplane sank. AAIB recommended that the U.K. General Aviation Safety Council provide information about aviation life vests that have the desired characteristics and to help pilots and aircraft operators to make informed choices of commercial products.

8. AAIB. Bulletin no. 6/98. *Pierre Robin HR200/120B, Oct. 29, 1997.* The instructor pilot ditched the aircraft in the Cromarty Firth off Nigg Yard, Scotland; the aircraft sank in about one minute, and the instructor pilot and the student pilot attempted to swim to a harbor wall without their aviation life vests. The instructor pilot reached the harbor wall, climbed out of the water and was rescued by the crew of a tug. A search-and-rescue helicopter began an unsuccessful search for the student pilot a few minutes after the instructor pilot reached the wall; the body of the student pilot was recovered several weeks later.

9. FAA. *Seaplane Safety for 14 CFR Part 91 Operators.*

10. U.S. Coast Guard. "Federal Requirements and Safety Tips for Recreational Boats." <www.uscgboating.org> The Coast Guard said, "A Type I [personal flotation device (PFD)] or offshore life jacket provides the most buoyancy. It is effective for all waters, especially open, rough or remote waters where rescue may be delayed. It is designed to turn most unconscious wearers in the water to a face-up position. A Type II PFD or near-shore buoyancy vest is intended for calm inland water or where there is a good chance of quick rescue. … This type inflatable [PFD] turns [the wearer to a face-up position] as well as a Type I foam [inherently buoyant] PFD. A Type III PFD or flotation aid is good for conscious users in calm inland water or where there is a good chance of quick rescue. It is designed so wearers can place themselves in a face-up position in the water."

11. U.K. CAA. *Ditching*.

12. FAA. *Seaplane Safety for 14 CFR Part 91 Operators*. FAA said, "In [AC 91-69A], seaplane refers to an airplane on floats (amphibious or nonamphibious) or a flying boat (water-only or amphibious). … Adherence to [U.S. Federal Aviation Regulations (FARs)] Part 91.115 should ensure compliance with the [U.S. Coast Guard] rules." The U.S. Coast Guard (in Navigation Rules, International-Inland), said, "The word 'vessel' includes every description of water craft, including nondisplacement craft and seaplanes, used or capable of being used as a means of transportation on water." A seaplane is a marine vessel after it lands on the water and is required to comply with U.S. Coast Guard navigation rules applicable to marine vessels.

13. Kalinowski, Kathleen. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 15, 2003. Flight Safety Foundation, Alexandria, Virginia. U.S. Switlik Parachute Co. is a U.S. manufacturer of life vests for aviation and PFDs for marine use.

14. Fanjul, Gus. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Jan. 16, 2004. Flight Safety Foundation, Alexandria, Virginia. U.S.

15. FAA. *Seaplane Safety for 14 CFR Part 91 Operators*. FAA said, "Lifesaving equipment must be maintained in serviceable condition in accordance with the manufacturer's recommendations. Any FAA-approved flotation gear used in operations for compensation or hire must be inspected at least every 12 months by persons authorized by [FARs Part] 43. This inspection would be included in the annual or 100-hour inspection for the aircraft or under any other inspection program that the operator is authorized to use." Brodhead, Daniel W. "Saving Lives With Life Preservers." *Mech.* U.S. Naval Safety Center. Spring 2002. Brodhead said that a routine inspection of one inflatable life vest worn by U.S. Navy aviators revealed that the device had been packed carelessly and that carbon-dioxide cartridges had not been attached to actuators; further investigation revealed that four of seven life vests had been packed and inspected incorrectly by one inspector.

16. U.K. CAA. *Ditching*.

17. FAA. *Seaplane Safety for 14 CFR Part 91 Operators*.

18. Barrow, Cliff. Safety Regulation Group, U.K. CAA. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. Dec. 8, 2003. Flight Safety Foundation, Alexandria, Virginia. U.K. CAA Specification no. 5, which provided requirements for life vests, has some differences and additions compared with FAA TSO-C13f, although aviation life vests can comply with both standards. "Under new arrangements within Europe, appliance-registration approvals [for non-U.K. equipment] are no longer granted, and the CAA specification is shortly to be cancelled on publication of a European TSO for [life vests]," Barrow said.

Cold Outside, Warm Inside

Cold-water immersion suits help survivors tolerate life-threatening temperatures long enough for rescuers to arrive.

— FSF EDITORIAL STAFF

The fundamental problem in designing cold-water immersion suits (also known as survival suits, exposure suits, helicopter passenger suits, aircrew immersion suits and helicopter offshore transport suits) for flights over cold water has been how to enable escape from a flooded/inverted cabin or cockpit while providing sufficient insulation to prevent cold shock and to delay the onset of hypothermia (see "Is There A Doctor Aboard the Life Raft?" page 187).

Immersion suits designed specifically for helicopter occupants were introduced in 1974 by U.K. companies operating offshore oil and natural gas production platforms in the North Sea. Canada published standards for "helicopter passenger transportation suit systems" in 1988 and revised these standards in 1999.[1] Since 1991, U.K. Civil Aviation Authority (CAA) Specification no. 19, *Helicopter Crew Members Immersion Suits,* also has provided an example of required minimum immersion-suit standards, including demonstration of underwater escape without snagging or entrapment caused by inherent suit buoyancy or air trapped in the suit. The European Joint Aviation Authorities (JAA) also has proposed standards for two types of "helicopter crew and passenger immersion suits" for use in operations to/from offshore helidecks (see "JAA Proposes Standards for Immersion Suits," page 361).

Typically, immersion suits have either a full neck seal and a diagonal zip fastener across the front, or a split neck seal and a vertical zip fastener down the front. Although government performance standards may be applicable, the immersion suits typically are not considered part of aircraft survival equipment, such as aviation life vests; typically, such immersion suits are provided by the helicopter operator to crews and by the employer to passengers under safety programs that reflect an industry consensus about best practices, said U.K. CAA.[2]

Immersion suits comprise wet suits, noninsulated dry suits and insulated dry suits. Wet suits provide a thick layer of insulating material between the skin and surrounding water, and allow a small amount of water between the skin and the inner surface of the suit. They are less costly to manufacture than dry suits, more comfortable to wear because rubber seals are absent, and are used widely in some types of diving and in marine recreational activities. Noninsulated dry suits are worn over specified insulating garments that trap a layer of air between the skin and the inner surface of the waterproof suit material. Insulated dry suits incorporate materials that are waterproof and provide insulation, or include various types of linings for insulation. Dry suits are more complex and costly to manufacture than wet suits, and their effectiveness can be reduced somewhat by perspiration and reduced significantly if water leaks into the suit and permeates the garments worn under the suit.

The principles of dry suits (insulated and noninsulated) most often have been applied in the design of immersion suits, which are intended for emergency survival in offshore helicopter operations. The primary reason is that cold water quickly conducts heat away from the body. Generally, an immersion suit is a one-piece coverall garment that provides layers of dry insulation to extend the survival time of a wearer immersed in cold water. Some current immersion suits must be worn with a compatible life vest that is inflated manually after evacuation; other immersion suits have integral buoyancy systems (i.e., manual inflation from cylinders of carbon-dioxide gas and oral inflation valves) and do not require a separate life vest.

The performance of various types of immersion suits has been studied extensively during the past 20 years. To reduce the rate of cooling of the body, insulated dry suits incorporate various materials to maintain a layer of dry air between the skin and the water. Typically, insulation depends on a recommended combination of insulating undergarments, the inner material of the suit that provides a water-boundary layer, layer(s) of insulating material and, in some models, inflation of an outer shell and/or internal chamber.

Characteristics of some current insulated dry-suit systems include donning/removal by means of a single waterproof zip fastener; rubber seals at the wrist and neck to prevent water from penetrating into the dry interior of the suit; an insulated hood stored in a pocket; gloves/mitts stored in pockets; integral boots or attached socks for use with normal footwear; removable thermal liners; flame-retardant fabric; shoulder valves to expel trapped air; retroreflective tape; pockets with drain holes; and a splash guard to help protect the mouth and nose from ingesting water. (Retroreflective materials are engineered to reflect light in the direction of its source and are most effective when the ambient light is low.)

Buying Time to Get Out of the Water

Immersion suits are designed to be donned prior to flight and are worn constantly throughout the flight. Although typical offshore flights do not exceed 20 minutes, weather-related diversions and other types of delays may require occupants to wear immersion suits for many hours. Insulated suits and noninsulated suits — and insulating garments worn under them — therefore must be designed to provide adequate insulation to extend survival time in cold water, minimal positive

Immersion-suit systems are designed to ensure compatibility of life vests and other components.

buoyancy (i.e., force that would cause a survivor in a flooded aircraft to be lifted toward the water surface) and thermal comfort in flight. Thermal insulation is the primary design goal, but flotation and self-righting also must be provided to the extent possible by inflation of the immersion suit and/or life vest with carbon-dioxide gas after emergency underwater escape from a flooded cabin.

U.K. CAA, in a 1995 report, said that although passengers receive general guidance on clothing to wear under an immersion suit, there may be no method of ensuring that passengers have provided sufficient thermal insulation to maintain their body temperature in cold water even when the uninsulated suit keeps the passenger as dry as possible. The difficulty of providing a combination of immersion suit and undergarments with sufficient insulation and without in-flight overheating also was cited.[3]

"Aircrew suits are efficient in their role of keeping the wearer dry, but are considered by many to be uncomfortable to wear for long periods, especially in bright sunshine in warm ambient air temperatures; they can be worn unzipped but would be difficult to zip up while the [pilot or] passenger was coping with an aircraft emergency," the report said. "[A passenger's suit] can be made relatively comfortable if the face seal is partially unzipped, but this will not fulfill its function unless it is fully zipped up before immersion. This is, to some extent, addressed by the oil companies' 'hood up zip up' (HUZUP) rule, which requires suits to be fully zipped during overwater arrivals and departures, on the assumption that if an emergency occurs en route there would be sufficient time to zip up before impact with the surface."[4] U.K. CAA Specification no. 19 requires that the immersion suit be capable of being sealed by crewmembers within 10 seconds during flight and adjusted without assistance.

Minimizing water entry into the immersion suit also is essential. When large amounts of water entered all immersion suits worn by survivors of a 1997 North Sea helicopter accident, for example, the additional weight of the water increased the time required by rescuers to transfer survivors from a life raft to a vessel.[5] (The added weight of water in the immersion suit is an inherent problem of wet-suit designs.)

One report on research in the United Kingdom said, "Suits that retain air or are inherently buoyant may trap the wearer in the upturned helicopter filling with water. It is almost impossible to dive down through water to a submerged emergency exit in these circumstances. A well-fitting suit minimizes buoyancy, and the drill for adjusting the suit for emergency use includes the expulsion of as much air as possible. … Modern suits incorporate valves to assist in this maneuver."[6]

In some helicopter water-contact accidents, survivors did not wear their gloves or mitts (which often were stored in pockets), and, although wrist seals prevented water leakage into the immersion suit, they found that their hands were too numbed by the cold water to don this hand protection or to assist in their rescue by grasping objects such as ropes. Another risk of penetration of water is significant reduction of the thermal protection provided by undergarments and possibly by some of the insulating materials of the immersion suit.

Regulations for immersion suits vary in different countries, reflecting regional accident experience and other factors, said Carl Rector, owner of BayleySuit, a U.S. manufacturer of SOLAS-approved marine-immersion suits, diving suits and a few helicopter immersion suits.[7] (International Convention for the Safety of Life at Sea [SOLAS] sets international standards for procedures and equipment used by specific types of large marine vessels). Helicopter operators therefore must know the applicable regulations in their country when selecting any type of immersion suit for use in flight operations.

"In most cases, helicopter immersion suits are leased or rented for the flight," Rector said. "They are worn one time, brought back from the oil rig to a coastal service to be sanitized and tested, then used again. The amount of time that they are used affects the rate of wear, and maintaining the suit often costs more than the suit itself."

Previously, for North Sea operations, Norwegian manufacturers typically provided insulated suits and U.K. manufacturers typically provided noninsulated suits, he said. Currently, the combination of a minimally buoyant, insulated suit with a life vest typically is required or preferred for helicopter passenger transport, he said.

"Occupants of a helicopter must wear the immersion suit in flight," Rector said. "With enough practice, an airplane occupant carrying a SOLAS-approved marine-abandonment suit could don this suit in the water, but the suit would not be as thermally efficient if the inside became wet. In darkness, I would say that there is only a 50-50 chance of being able to don this type of suit in the water — which shows the need for training. This type of suit also will be more comfortable if donned out of water with some air trapped inside."

Water Leakage Is the Enemy

Researchers and industry groups have identified, among other findings, the following issues that affect the performance of an immersion suit:

- Users should not assume that either an insulated dry suit or a noninsulated dry suit will be fully effective in preventing leakage. Because water leakage into immersion suits significantly reduces their insulating properties and increases their weight, helicopter passengers must be trained to secure the seals of the suit prior to immersion and to overcome reluctance to wear suits correctly because of the temporary in-flight discomfort;[8]

- The neck seal and wrist seals of immersion suits must fit tightly enough to prevent water leakage into the suit but not so tightly as to constrict blood flow. Attempts to prevent chafing of these seals against the skin, by wearing collars or sleeves between the seal and the skin, will allow water into the immersion suit;[9]

- Some tests conducted in helicopter underwater-escape training have shown that a one-minute warning of ditching was insufficient time for some participants to fully close their zip fasteners, adjust neck and wrist seals and/or put on gloves and hood when these immersion suits were worn in a half-zipped condition for comfort during flight;[10]

- Compatibility of immersion suits and life vests should be determined by testing in realistic conditions the ability of a combination to provide passive self-righting of an unconscious wearer and to provide complete protection of the airway. Wearing a suit with a splash guard (also called a face shield or sprayhood) provided better protection against drowning than use of a life vest alone. Performance of equipment in calm water, however, could not predict its performance in rougher sea conditions;[11]

- An immersion suit with integral buoyancy or a combination immersion suit and life vest must raise the head of the wearer above the level of the rest of the body that is floating at the surface; otherwise, the flotation angle may result in an inadequate distance between the wearer's mouth and the water surface to prevent drowning. With the head inclined at about 30 degrees, wearers have a better opportunity to see incoming waves and to turn their backs to the wave to help prevent inhalation of water; and,[12, 13]

- Immersion suits must be assessed for compatibility not only with life vests but also with the seats and the restraint systems of helicopters, other survival equipment such as emergency breathing devices, and the manual dexterity required for underwater escape.[14]

All Repairs Require Expertise

Several manufacturers said that immersion suits worn in civil aircraft operations typically do not have provisions for bodily functions. Helicopter flights typically are not long enough to warrant this capability. Nevertheless, designs with a diagonal front zip fastener help to accommodate bodily functions of men prior to flight. A survivor wearing a suit in the water would be unable to open the suit or to remove the suit; if required, bodily functions are completed in the suit.

To prevent water from penetrating an immersion suit, the suit should be inspected as recommended by the manufacturer. Typically, before

Continued on page 363

Maximum protection against drowning and hypothermia requires correct use of the life vest, splash guard over the nose and mouth, and thermal insulation of the head and hands, as provided by this immersion suit.

JAA Proposes Standards for Immersion Suits

JAA has proposed six Joint Technical Standard Orders (JTSOs) concerning life vests, life rafts and safety equipment for personnel involved in helicopter operations. (For European Union member nations, it is expected that equivalent European TSOs [ETSOs] will be adopted by the European Aviation Safety Agency [EASA].) As part of the ongoing harmonization between FAA and JAA, two of the proposed JTSOs for life rafts and life preservers largely parallel those to be found in FAA TSOs, including TSO-C70a. The other proposed JTSOs, concerning helicopter transport suits, have no parallel in FAA TSOs. A summary of the main provisions of each proposed JTSO follows.

JTSO-2C502, Helicopter Crew and Passenger Integrated Immersion Suits for Operations to or From Helidecks Located in a Hostile Sea Area

An integrated immersion suit is defined as an immersion suit which incorporates the functionality of a life [vest]. The wearing of a separate life [vest] is not required. The integrated suit comprises at least a dry coverall and hand and head coverings. It is assumed that the suit is donned before boarding the helicopter. Among the JTSO's provisions are the following:

- Donning
  - The integrated suit and any attached equipment shall be capable of being donned without assistance and shall be capable of being sealed and adjusted by the wearer without assistance;
  - Air retained inside the suit after donning which could adversely affect egress, the maneuverability or flotation attitude, shall be capable of being exhausted, either automatically or by the wearer; [and,]
  - It must be possible to complete all actions required to don the head covering … and seal the suit within 10 seconds. These actions shall be possible both when seated with harness fastened and when in the water with the suit inflated.
- Freedom of movement
  - The design of the integrated suit shall allow tailoring to fit the individual wearer or, where suits are not individually tailored, the size range must be satisfactory for all wearers whose significant body dimensions range from the fifth percentile female to the 95th percentile male, and adequate for most of the 5 percent at each extreme; [and,]
  - The inflated suit must not hinder the boarding of a life raft with the sprayhood deployed, prevent the wearer from assisting others in the water or obstruct the wearer's field of vision.
- Compatibility
  - The integrated suit shall be designed, and the materials used in its construction chosen, to have no features which would be likely to have any detrimental effect on the operation of any helicopter or its equipment. In particular, any part of the suit which might pose a snagging hazard during flight, emergency egress or recovery, shall be suitably covered, protected or restrained; [and,]
  - Any attached equipment shall not compromise the basic survival function of the suit by causing puncturing, fretting or distortion of the material, or changes in its mechanical properties.
- Materials
  - The materials used shall meet the requirements of paragraph 4.14 of [European Committee for Standardization] EN ISO 15027-1:2002;
  - Due consideration shall be taken of the possible temperature variations during stowage, which may range between –30 degrees C [Celsius] and 65 degrees C (–22 degrees F [Fahrenheit] and 149 degrees F); [and,]
  - The outer fabric used in the construction of the suit shall be of low flammability. It shall not have a burn rate greater than 100 millimeters per minute (four inches per minute).
- Evacuation. A person wearing the uninflated suit shall be able to exit the helicopter through any emergency exit or push-out window down to the minimum acceptable size of 430 millimeters by 355 millimeters (17 inches by 14 inches). This action shall be possible in air or under water.
- Buoyancy and floating position
  - The buoyancy of the inflated suit shall be sufficient to ensure that a person wearing clothing and the integrated suit shall have a floating position such that the angle between the body and the horizontal is not greater than 60 degrees;
  - The mouth must be at least 120 millimeters (4.7 inches) above the waterline (mouth freeboard) and the nose freeboard shall not be less than the mouth freeboard, even when the wearer is incapacitated; [and,]
  - The inflated suit shall allow the wearer to turn from a face-down position into a stable face-up floating position within five seconds.
- Breathing protection — sprayhood
  - The wearer shall be able to deploy the sprayhood within 20 seconds when wearing the inflated suit in or out of the water;

– The sprayhood will not be considered suitable if it can in any way retain water when deployed;

– The sprayhood, whether stowed or deployed, should not cause inconvenience during winching or other rescue and recovery operations; [and,]

– Means shall be provided to ensure that the level of carbon dioxide in the deployed sprayhood is within safe limits.

- Thermal protection. The sealed integrated suit, including the head and hand coverings, shall be so constructed that, when worn in conjunction with recommended clothing, [the suit] shall provide insulation as required by JAR–OPS [Joint Aviation Requirements — Operations] 3.827.

- Water ingress. The integrated suit shall be so constructed that not more than 200 grams (seven ounces) of water shall leak into the suit when measured in accordance with paragraph 3.7 of EN ISO 15027-3: 2002.

- Conspicuity and location aids

  – To facilitate search-and-rescue operations, those parts of the suit which will be visible when in the water shall be of a highly conspicuous color and comply with paragraph 4.5 of EN ISO 15027-1:2002;

  – A passive light system of retroreflective material shall be provided; [and,]

  – The integrated suit shall be fitted with a light that meets the requirements of paragraph 4.2 of EN394:1994 Type B. An additional flashing light that flashes at a rate between 50 and 70 flashes per minute … shall also be fitted. The location of the lights shall be such that maximum practical conspicuity is achieved when in the water with the suit inflated. The lights shall activate automatically and have a manually operated on/off switch.

- Inflation system

  – The primary means [of inflation] shall be a manually initiated stored-gas system together with a standby oral-inflation system capable of repeated use. The required buoyancy shall be obtainable by either method;

  – After inflation by either method, it shall be possible to deflate the suit and then to reinflate it by using the standby system. The standby inflation system shall be readily accessible, simple and obvious in operation, and it shall be impossible for any valve which may be used to be inadvertently left open;

  – Location of the actuating means [of the stored-gas system] shall be such that it can be operated by either hand, in or out of the water;

  – The amount of stored gas provided shall be capable of inflating the suit to achieve the correct buoyancy … within five seconds of actuation at 20 degrees C (68 degrees F);

  – Adequate protection shall be provided to guard against any inadvertent initiation of an inflation when the wearer is passing through an emergency exit or when the suit is dropped from a height of 1.5 meters (five feet); [and,]

  – The oral-inflation tube shall comply with the requirements of paragraph 4.5 of EN396:1993 or equivalent. It shall be positioned such that it can readily be used in and out of the water. After use, the device shall return to a position such that it will not produce facial injuries during a jump into the water.

- Testing. Test criteria are specified for strength under pressure, buoyancy and performance.

JTSO-2C503, Helicopter Crew and Passenger Immersion Suits for Operations to or From Helidecks Located in a Hostile Sea Area

This proposed JTSO is for helicopter transport suits designed to be used with a life vest. Where relevant, the specifications are the same as those in JTSO-2C502 for integrated immersion suits. Specifications for a sprayhood are in JTSO-2C504. Some paragraphs that vary from JTSO-2C502 are as follows:

- The immersion suit shall be tested with each type of life [vest] that the suit is designed to be compatible with. If it is to be approved for use with more than one type of life [vest], the performance testing … shall be repeated with each additional type of life [vest]; [and,]

- The trapped buoyancy due to the suit and recommended clothing, with the suit fully vented, shall be no more than 150 Newtons (33.7 foot-pounds) when measured in accordance with paragraph 3.11.7.2 of EN ISO 15027-3:2002.

JTSO-2C504, Helicopter Constant-wear Life Jackets for Operations to or From Helidecks Located in a Hostile Sea Area

This proposed JTSO is for helicopter constant-wear life [vests]. Where relevant, the specifications are the same as those in JTSO-2C502 for integrated immersion suits. Specifications for a sprayhood closely follow those in JTSO-2C502. Some paragraphs that vary from JTSO-2C502 are as follows:

- The correct method of donning the life [vest] shall be self-evident and means shall be provided to indicate that the life [vest] lobe(s) are correctly oriented. … A means of adjustment to make the life [vest] fit securely shall be provided. The wearer shall be able to make any readjustment without removing the life [vest];

- Subsequent to proper donning, inadvertent release or loosening of the life [vest] such that its flotation characteristics are unacceptably altered, shall be prevented;

- Means shall be provided as necessary in the design of the life [vest], whether it is worn with or without an approved immersion suit, to prevent it from riding up the body of the wearer; [and,]

- Approval of a life [vest] and sprayhood to this specification shall take into account the compatibility between the life [vest] and any approved immersion suit that is intended to be worn with it. … Where a life [vest] is to be approved for use with an immersion suit [or suits] then it shall be tested with each type of immersion suit that the life [vest] is designed to be compatible with. ■

— FSF Editorial Staff

each flight, the user will check for holes, tears, integrity of seals at the wrists and neck, operation of the waterproof zip fastener, serviceable inflation mechanism, puncture of the air bag, intact seams and signs of excessive wear. More thorough annual inspections and all repairs typically must be conducted by certified technicians because of the risk of loss of life if a suit fails to perform according to standards.

The combination of an immersion suit and life vest must be considered as one system, said Steve Portman, technical support manager of Mustang Survival Corp.[15]

"Our system's immersion suit is a coverall-type garment designed using our 'nearly dry' concept," Portman said. "The outer shell provides waterproofness and is constructed from polyurethane-coated nylon fabric with the seams taped to maintain watertightness. Entry and closure of the suit is by means of a front vertical waterproof zipper fastener running from the lower abdomen to under the chin. The coverall is designed with an adjustable ratchet-type neck seal and adjustable neoprene wrist seals that are clamped shut by a Velcro strap.

"The suit also incorporates fitted, Canadian Standards Association–approved nonslip, steel-toe rubber boots. A neoprene hood with an adjustable mouth guard is stowed at the rear neck portion of the suit and can be donned quickly using a retaining strap. Inflatable mitts are stowed and secured in pockets mounted on the sleeves of the suit. The suit is also equipped with SOLAS-approved retroreflective tape, a whistle and a water-activated survivor-locator light. A removable thermal liner provides buoyancy and hypothermia protection. This modular system consists of PVC [polyvinyl chloride plastic] closed-cell foam contained in a nylon shell that will give a high level of protection even in the event of leakage or damage to the suit."

One of the design objectives was to provide comfort during flight between an oil platform and a coastal base.

"Opening of the seals improves comfort and airflow; this, in turn, will help reduce the problems with heat exhaustion," Portman said. "We assume that the safety officer will determine the method by which the suit will be worn during flight — such as seals loose or seals tight with the main entry zipper open at the neck. The design allows for a number of options."

The system's life vest provides approximately 140 pounds (64 kilograms) of buoyancy — which compares with 35 pounds (16 kilograms) of buoyancy specified by the most recent U.S. Federal Aviation Administration (FAA) technical standard order for adult aviation life vests (see "FAA Technical Standard Order (TSO)-C13f, *Life Preservers [Life Vests],*" page 452). The purpose of the extra buoyancy is to support the head and to keep the upper torso out of the water for protection against hypothermia.

Edward Alcock of Helly Hansen Spesialprodukter in Norway said that the company's immersion suits come in six sizes. The appropriate size for each passenger is determined during training. The company also provides an emergency-breathing option for its immersion suits.[17]

"On some models, we are using an inner air chamber that previously was inflated manually at the surface to increase buoyancy and to provide higher freeboard [distance between the water line and the lowest point on the wearer's mouth], but which now has a double function," Alcock said. "Basically, we connect a mouthpiece and hose to the pocket, which then allows the user to rebreathe the air in the pocket; this provides an extra 40 seconds or so of breathing time under water, sufficient to evacuate a ditched helicopter." (Exhaling into the pocket and rebreathing from the pocket does not change the survivor's buoyancy.)

Alcock said that the suits were designed not to impede the survivor's ability to swim to a life raft or to enter a life raft. The design incorporates buoyancy inherent in the material, a sprayhood attached to the collar area and the integrated rebreather system. Length of survival time would depend on many variables such as sea temperature and wind chill.

The company expects the typical suit to be in service for 10 years to 15 years with regular maintenance.

"The suit is designed to be donned before entering the helicopter," Alcock said. "Donning the suit in the water would be extremely difficult."

Offshore workers in Norway receive mandatory training that includes donning the suit, purging air/water, preventing damage and snagging, performing maintenance and performing underwater escape, he said.

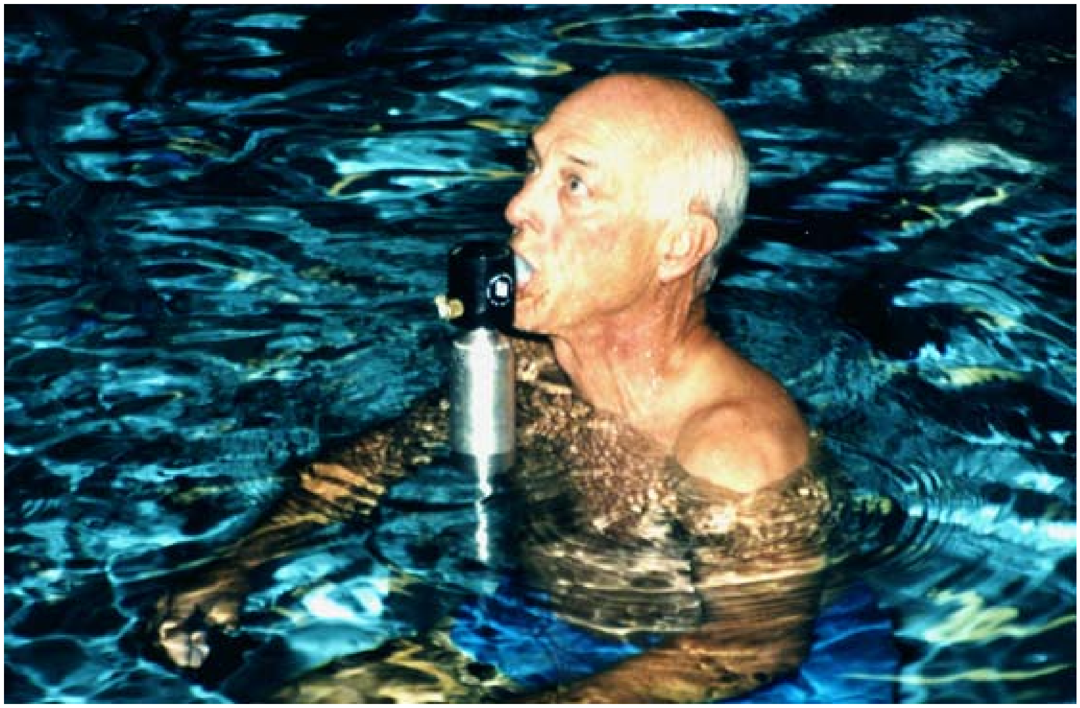
In summary, the evolving technology of immersion suits makes survival possible in many ditching scenarios in cold water when combined with appropriate policies, procedures, training and maintenance. ■

The bottom line, in our opinion ...

- **Leakage of even small amounts of water into garments worn under cold-water immersion suits significantly reduces protection against hypothermia.**
- **Individual components of the immersion suit — such as gloves/mitts or splash guards — can make a life-or-death difference in cold-water survival.**
- **If uninsulated immersion suits are used, passengers must wear the required type of undergarments for sufficient insulation.**
- **Penetration of water into an immersion suit can add weight and prevent a survivor from being lifted into a life raft.**
- **Immersion suits must be compatible with life vests, seats, restraint systems, gloves/mitts and any emergency breathing devices.**

Notes

1. Canadian General Standards Board. "Helicopter Passenger Transportation Suit Systems." Document no. CAN/CGSB-65.17-99. December 1999.
2. U.K. Civil Aviation Authority (CAA). *Report of the Review of Helicopter Offshore Safety and Survival.* Civil Aviation Publication (CAP) 641. February 1995 (reprinted May 2002).
3. U.K. CAA.
4. U.K. CAA.
5. FSF Editorial Staff. "Sikorsky S-76B Strikes Water During Approach to North Sea Oil and Natural Gas Production Platform." *Helicopter Safety,* Volume 28 (January–February 2002).
6. Leese, William L.B.; Norman, J. Nelson. "Helicopter Passenger Survival Suit Standards in the U.K. Offshore Oil Industry." *Aviation, Space, and Environmental Medicine.* February 1979, 112.
7. Rector, Carl. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 17, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
8. Tipton, M.J. "Laboratory-based Evaluation of the Protection Provided Against Cold Water by Two Helicopter Passenger Suits." *Journal of the Society of Occupational Medicine,* Volume 41 (Winter 1991), 161–167.
9. Brooks, C.J. "Ship/Rig Personnel Abandonment and Helicopter Crew/Passenger Survival Suits: The Requirements in the North Atlantic." *Aviation, Space, and Environmental Medicine.* March 1986, 277–278.
10. Brooks. 278.
11. Light, I.M.; Slater, P. "A Further In-water Performance Assessment of Lifejacket and Immersion Suit Combinations." U.K. Health and Safety Executive Report no. OTI 91 550, 1991.
12. Herrman, Rolf. "Do We Survive With Survival Suits?" *Journal of the Royal Navy Medical Service.* Volume 74: 1988, 147–152.
13. Brooks. 278.
14. U.K. Health and Safety Executive. *Compatibility Test Protocol for Lifejackets and Immersion Suits on Offshore Installations.* Offshore Technology Report no. OTO 2002/021. 2002.
15. Portman, Steve. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. May 7, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
16. Alcock, Edward. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 24, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.



HEED This

Emergency breathing devices come to the rescue when one deep breath is not enough under water.

— FSF EDITORIAL STAFF

One study of helicopter underwater evacuation — using a submerged trainer configured for 15 passengers to 18 passengers — found that the breath-holding time required for the last passenger to evacuate varied from 28 seconds to 92 seconds.[1] The buoyancy of the cold-water immersion suits (also known as survival suits, exposure suits, helicopter-passenger suits, aircrew immersion suits and helicopter offshore transport suits) worn by participants hampered their escape, the report said (see "Cold Outside, Warm Inside," page 357).

"Breath-holding times were too long for the later subjects to escape without resorting to an emergency breathing system, in spite of the fact that they were highly trained," the report said. "For regular crew and passengers flying over water, this would explain the [20–50 percent mortality rate in survivable accidents]. Therefore, a new helicopter standard should be developed requiring fuselage design to accommodate total evacuation within 20 seconds from under water. For current helicopters, where this cannot be achieved, passengers should be provided with some form of air supply, or, after ditching, the helicopter should be modified so that it will stay afloat on its side and retain an air space in the cabin."

The study participants were highly experienced instructors or U.S. Navy divers, the report said. They were physically fit, healthy, uninjured, highly qualified by training, highly practiced and mentally and physically prepared for a breath-hold before each simulated ditching-submersion scenario.

"The subjects all had very good generic training and a lot of underwater-escape experience with groups of two, four or six people, but had never experienced a mass evacuation, and it caught all of them by surprise," the report said. "[During the first daylight exercise,] they were astonished at the confusion inside the confined fuselage and the requirement to queue to make an escape."

Extending the time available to escape from a submerged aircraft has driven research and development of several types of emergency breathing devices during the past 20 years. Devices that have been adopted by military organizations and law-enforcement organizations also are used by commercial helicopter operators in a few industries and by a few airplane operators, manufacturers said. They typically are not used by pilots conducting commercial passenger operations.

Manufacturers use various names for their devices. Most are not regulated by civil aviation authorities. Civil aviation authorities have approved specific applications of some devices with guidelines on safety and training. For example, the U.K. Civil Aviation Authority has approved one device for use by trained helicopter passengers over the North Sea.

A U.S. Navy survival publication said that to use any device that requires underwater breathing from a cylinder of compressed air, training is required to enable the user to prevent pulmonary barotrauma (injury to the lungs caused by expanding air as a human body moves from below water to the water surface) and/or cerebral arterial gas embolism (air embolism, formation of air bubbles that block blood flow in the brain).[2] An air embolism is a risk whenever a person inhales compressed air under water. The air in the lungs expands during ascent to the surface and, if not exhaled at the correct rate, may enter blood vessels and sufficiently disrupt blood flow to the heart or the brain to cause injury or death.

The primary risk factor for air embolism while breathing from a compressed-air device is a rapid uncontrolled ascent to the surface, which occurs when a survivor under water inflates a life vest. Therefore, training for helicopter emergency underwater escape incorporates preventive measures. For example, the U.S. Navy trains aircrews that are using this type of device not to inflate their life vests until they reach the surface. Training also helps ensure that users will check that their emergency breathing devices are serviceable before flight and while preparing for a ditching.

Hands-free Device Gaining Acceptance

The helicopter aircrew breathing device (HABD) can be configured for various applications, said David Stancil, vice president, military and professional operations, for Aqua Lung America, the manufacturer.[3] Basic components are a small aluminum tank (bottle) of compressed air, a valve, a high-pressure air hose and a regulator assembly with mouthpiece. Standard air pressure in a full tank currently is 3,000 pounds per square inch (207 bar). The hose provides flexibility in wearing the device on a survival vest that contains other equipment.

Changes in design over time have been prompted primarily by evolving military requirements and by technological innovations that make the devices simpler.

"The key issue is matching the placement of the bottle to the type of vest worn by varying the hose length and the bottle size," Stancil said. "For example, some military helicopter pilots wear the bottle over their right kidney with the hose over the right shoulder as part of a survival vest with a radio and other equipment. What is important is to have training and to have this device mounted

Shallow-water egress training provides practice using some emergency breathing devices at a depth of four feet (one meter).

properly on the person's body — not on an airframe, because a person is not going to have time to find this device otherwise."

The remote regulator/hose design leaves two hands free to maneuver for egress and prevents the tank from striking the chin or other parts of the wearer's face during egress, he said. "Emergency breathing devices are relatively new survival equipment that have been used only by a few commercial aircraft operators," Stancil said. "Acceptance will remain minimal until an infrastructure for the required training makes more venues available."

The HABD training requires a swimming pool. Some military aviators currently receive HABD training at about 12 centers in different parts of the world; the centers also provide training to some law enforcement personnel.

Commercial aircraft operators have a very difficult situation if they want to add emergency breathing devices to standard survival equipment, he said.

"A commercial helicopter tour operator, for example, cannot just hand to a passenger a life vest and an emergency breathing device because training is required for safe use," he said.

Training is conducted in a shallow-water egress trainer, simulating a submerged aircraft cabin in which the wearer's lungs are not deeper than four feet (one meter) to help prevent an air-embolism accident. A few accidents involving air embolism have been reported only in military-training settings, he said.

"A person should train to be able to survive by using one breath-hold to get out of the aircraft," Stancil said. "The first part of training — currently required for crewmembers and passengers on some military aircraft — teaches how to apply escape skills without the use of emergency air. You apply basic skills to find a reference point, release restraints and get out of the aircraft in five seconds to 10 seconds — you cannot wait longer. Emergency air is a supplement to breath-holding. If the seat belt is stuck or a person has to cross the cabin to a secondary exit, it is calming to know you have an extra minute or so of air. HABD especially is valuable if submersion happens so fast that a person cannot take and hold a full breath. We have been told anecdotally that the HABD has saved lives."

One significant area of technological development has been in purging water from the regulator mouthpiece while under water.

"In current designs, the user has to exhale enough air to purge water remaining in the mouthpiece before inhaling air in an egress situation," Stancil said. "We are developing a new type that requires very little breath to clear the device."

"A person should train to be able to survive by using one breath-hold to get out of the aircraft."

HABD has one of two types of indicators of air tank status: a small dial indicator that points to a green zone to indicate that the air is in a range of full to 90 percent full, or a tactile gauge.

"The green zone is a 'go' indication," he said. "The tank must be topped off before flight if not in the green zone. The military uses a tactile gauge so that the user can feel a needle sticking out of the indicator."

One-piece Device Reduces Size, Weight

Many one-piece emergency breathing devices remain in use and are the best-known type, he said. Known as helicopter emergency egress devices (HEED), they have a valve, regulator and mouthpiece assembly attached directly to the air tank.

The current generation of HEED — HEED III — evolved from a design that originally was for emergency use by scuba divers, said Christeen Buban, vice president of marketing for Submersible Systems, the manufacturer.[4]

"The president of our company is an aerospace engineer and a recreational diver who had an out-of-air emergency," Buban said. "He was shocked that nothing existed at the time for recreational divers other than carrying an additional full-size air tank with a separate regulator. He wanted an emergency breathing device that would be streamlined and very small, but there were no small high-pressure tanks available and no market for them. Early models of small aluminum air cylinders were developed to

"People

who are not

in good physical

condition require

more air."

contain air at a pressure of 1,800 pounds per square inch (124 bar). They met the same specifications as scuba tanks." By comparison, HEED III uses aluminum cylinders pressurized to 3,000 pounds per square inch.

The next step was to design a simple regulator with performance characteristics different from divers' high-performance regulators, which are relatively complex and designed for greater sensitivity (low breathing effort) at the deeper range of recreational diving — a maximum depth of 130 feet (40 meters). The requirements were compact size and light weight, readiness for daily use, and few parts for reliability, long service life and affordability.

HEED currently is being replaced by HABD for some military helicopters, but HEED III still is used in some countries for military helicopter operations and military fixed-wing operations, she said. The device also is used by personnel in the engine rooms of some military vessels to escape from smoke or flooding.

The company has not marketed HEED to operators of fixed-wing civil aircraft; nevertheless, reports from distributors show that some corporate flight departments that have adopted HEED III for pilots of their helicopters also have provided the device to crews of fixed-wing aircraft, Buban said. Some individual pilots of fixed-wing aircraft — such as Canadian seaplane-charter pilots and pilots of seaplanes used in fishing — also have bought the device, she said.

The company supplies the HEED III in a nylon holster. Most commonly, a pocket specifically designed for the HEED III is incorporated into a survival vest.

"In civil aviation, crew clothing is not standardized, although most users prefer wearing a vest or a flight suit with pockets in the arms and legs," she said. "We also have a waist-band-mounted device for those who do not wear a vest."

The standard model of HEED III is less than 12 inches (30 centimeters) in length, has a capacity of 1.7 cubic feet (48 liters) of air and provides the average user 38 breaths of air, enough to remain less than four feet below the water surface for two minutes to five minutes, she said. At greater depths, proportionately less breathing time will be available. Devices vary in length from nine inches (23 centimeters) to 13 inches (33 centimeters); the largest device has a capacity of three cubic feet (85 liters) and provides the average user 57 breaths close to the water surface.

"Many factors will affect actual duration of air, such as physical condition, training, exertion during egress, panic and temperature," she said. "Everyone's lung capacity is different, but the average breath used in our calculations is 1.6 liters [0.06 cubic feet] of air. Some large people take five-liter [0.18 cubic feet] breaths; some small people take breaths less than one liter [0.04 cubic feet]. People who are not in good physical condition require more air."

Pressure indicators are basically of two types: a pop-up white pin that indicates that refilling is required before use or a dial gauge that shows 0-1-2-3, representing pressure from zero pounds per square inch to 3,000 pounds per square inch.

Purging air from the mouthpiece of a HEED III varies according to customer-specified requirements. In some civilian configurations, the user presses a purge button so that air from the cylinder clears water from the mouthpiece, depleting a small amount of the supply available for breathing in the process. One disadvantage is that some users press the purge button, depleting air, at times other than during emergencies, Buban said. In typical military configurations, a hard-purge system is used, requiring users either to expel their last breath to clear the regulator or to swallow water in the mouthpiece while submerged.

The HEED III operating manual provides many safety warnings — including the risk of air embolism — and recommends that recreational divers receive scuba certification and that pilots complete underwater-escape training with the device before the device is carried for emergency use, she said. For aviation uses, the manual covers preflight checks, use during an emergency and postflight actions.

Passenger-oriented Devices Aim for Simplicity

In the United Kingdom, significant attention has been focused on methods of providing emergency air to passengers of military helicopters and civilian helicopters to complement the devices that have been carried by crewmembers.

For example, the passenger–short term air supply system (P–STASS) was developed initially as a military device, said Bill Batchelor, operations manager for MSI-Defence Systems (Weymouth), which markets the device.[5] The P–STASS is designed and manufactured by Apeks Marine Equipment.

"The P-STASS has first-stage and second-stage regulators," Batchelor said. "These allow breathing down to a depth of 50 meters [164 feet]. P–STASS has now completed a long series of trials. All service trials to date have been concentrated toward helicopter-passenger use, but certain operators are looking at fixed-wing use. This would be civilian aircraft — mainly executive business jets or charter aircraft. The civilian product is the same as the military version, but the cylinder size can be altered easily to increase duration."

The system — which has a central hose, low inherent breathing resistance, a double nonreturn valve to prevent water ingress and a nose clamp — was designed primarily for use by untrained troops and passengers on helicopters. After fitting the mouthpiece, the user's hands are free. The standard model provides two minutes of emergency air at a depth of five meters (16 feet), the manufacturer said.

"There is no in-water training of passengers; the system depends fully upon passenger briefings and briefing cards," Batchelor said. "There is a small risk of air embolism caused by surfacing too fast and not breathing out during ascent. The risk is always there. The options are drowning or an embolism. The P-STASS can give up to four minutes of extra escape time. This is dependent on the element of panic that the user is in, but it gives the user sufficient time to get over the initial in-water shock and allows a breath to get orientation correct and effect escape. The time is therefore a combination of many factors, including depth, temperature and personal attitude."

The P-STASS integrates into life vests for helicopter aircrews and passengers, and can be adapted to any current life vest. Alternatively, the device can be carried in a pouch on a waist belt, a method that has been preferred by U.K. firefighters, he said.

Rebreathing From Air Bag Counteracts Cold Shock

Other devices for passengers, developed in the United Kingdom, are the Air Pocket and the Air Pocket Plus helicopter emergency underwater-breathing systems, said Jane Nolan, chief executive officer of Shark Group. The device was designed to help passengers overcome the effects of cold shock and to escape under water after a helicopter water-contact accident (see "Is There a Doctor Aboard the Life Raft?" page 187). Air Pocket/Air Pocket Plus fits between the buoyancy chambers of a life vest. The principle is that the user exhales through a mouthpiece into a small air bag — rather than into the

The passenger short-term air supply system includes passenger briefings and briefing cards to enable use without training.

surrounding water — and then rebreathes from the bag a few times until reaching the surface.[6,7]

"The original Air Pocket enabled the user to rebreathe the volume of air in his or her lungs on immersion," Nolan said. "The second-generation product, Air Pocket Plus, is fitted with a small cylinder containing 3.5 liters [0.12 cubic feet] of breathing air, the equivalent of one breath, which is added automatically on immersion with manual override to the counterlung [air bag]. This means that even if the user is unable to breath-hold, there is air available during the underwater escape. We do not quote an escape time, but underwater-escape experiments … during the development process showed that the ability to rebreathe with Air Pocket after maximum breath-hold extended the average survival time under water by a factor of 2.5."

Air Pocket Plus has been designed to minimize the risk of air embolism. The risk is reduced, compared with compressed-air systems, because the air bag is sized to contain the air charge plus any breath from breath-hold, without producing over-pressure, she said.

Integration of a breathing device with flotation equipment simplifies training and increases the probability of correct use under emergency conditions, Nolan said. For example, Lifejacket Air Pocket combines a life vest and an Air Pocket Plus.

A dry-training familiarization device replicates the breathing resistance experienced when using Air Pocket Plus and provides practice, she said.

"The equivalent of one breath … is added automatically on immersion."

A report on experiments comparing users' ability to conduct simulated helicopter underwater evacuations while remaining submerged for 60 seconds said that participants were able to complete the immersions with the Air Pocket and the Short Term Air Supply System, comprising a small air cylinder, valve, regulator and mouthpiece. The participants, wearing immersion suits and aircrew helmets, traversed a ladder positioned 1.25 meters (4.1 feet) below the surface of water at 15 degrees Celsius (C; 59 degrees Fahrenheit [F]) and at 5 degrees C (41 degrees F).[8]

"Both Air Pocket and Short Term Air Supply System significantly extended the underwater-survival time of individuals, when compared to their maximum breath-hold time," the report said. "It is clear from the measurements made of gas concentrations in Air Pocket, the volume of air used from Short Term Air Supply System, and subjective responses that the 60-second submersions were achieved more easily with Short Term Air Supply System than with Air Pocket. … It is concluded that in conditions similar to those of the present experiment, Short Term Air Supply System will give longer underwater duration than Air Pocket, but this benefit must be offset against the possible risk of pulmonary barotrauma associated with the use of Short Term Air Supply System, as well as increased training and maintenance costs. Irrespective of the emergency underwater-breathing aid which is provided, in-water training, preferably including exposure to cold water, will significantly improve the ability of an individual to use it."

Researchers who conducted the experiment on breath-holding requirements for escape from a flooded helicopter cabin occupied by 15 passengers to 18 passengers said that use of an emergency breathing device — either a rebreather design or a compressed-air design — is the most appropriate method of providing sufficient evacuation time in current helicopters.

"Indeed, our experiments demonstrate that an air supply gives confidence to a passenger in an aisle seat who is waiting for a colleague in the window seat to escape, rather than causing mass panic where there is a huge rush to the exit and no one escapes," the report said.[9] ■

The bottom line, in our opinion …

- **Emergency breathing devices provide a backup system that supplements underwater escape with one breath-hold.**
- **Duration of air from an emergency breathing device varies because of factors such as lung capacity, physical condition, training, exertion, stress and water temperature.**
- **Breathing compressed air under water presents a risk of injury — caused by the expansion of air in the body during ascent to the surface — and requires training.**
- **Retrieving emergency breathing devices from stowage typically is not practical for crewmembers in a water-contact accident; they must be worn and used correctly.**
- **Integrating the emergency breathing device into a survival system simplifies training and helps survivors to take correct actions under emergency conditions.**

Notes

1. Brooks, C.J.; Muir, H.C.; Gibbs, P.N.G. "The Basis for the Development of a Fuselage Evacuation Time for a Ditched Helicopter." *Aviation, Space, and Environmental Medicine.* Volume 72, 2001, 553–561.
2. Swan, Brian D. "Survival — A Guide for the Occasional Flyer." U.S. Naval Aviation Medical Institute. 2001. <forum.nomi.med.navy.mil/cd/CD013/DATA/operationalmed/Safety/Survival.htm>.
3. Stancil, David. Interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 11, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Buban, Christeen. Interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 16, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
5. Batchelor, Bill. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 23, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
6. Nolan, Jane. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 16, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
7. Nolan said, "Cold shock, an involuntary physiological response to immersion in cold water, drastically reduces breath-hold, increases the heart rate and constricts the blood vessels, causing blood pressure to rise, thus increasing the risk of heart attack and stroke. Reflex gasping and hyperventilation can occur, so that the immersion victim may aspirate water and drown."
8. Tipton, M.J.; Franks, C.M.; Sage, B.A.; Redman, P.J. "An Examination of Two Emergency Breathing Aids for Use During Helicopter Underwater Escape." *Aviation, Space, and Environmental Medicine.* Volume 68 (10), 1997, 906–913.
9. Brooks; Muir; Gibbs.

Upside down in a 'dunker' for underwater-escape training.

Train to Survive the Unthinkable

Aircraft operators must go beyond basic regulatory requirements in developing training programs that will keep their crewmembers and passengers prepared to survive a ditching and the wait for rescue.

— FSF EDITORIAL STAFF

For most passengers, the preflight briefing provides the only opportunity for familiarization with the use of flotation equipment and with evacuation procedures. In the United States, specific training on ditching procedures is required for commercial crews who conduct overwater operations, but not for general aviation pilots and cabin crewmembers (although many corporate aircraft crewmembers receive overwater training).

The International Civil Aviation Organization (ICAO) requires aircraft operators that conduct international commercial flights to assign to crewmembers the functions that they are to perform in an emergency or in a situation requiring an emergency evacuation.[1]

"Annual training in accomplishing these functions shall be contained in the operator's training program and shall include instruction in the use of all emergency and lifesaving equipment required to be carried, and drills in the emergency evacuation of the airplane," said ICAO.

Such training is not required by ICAO standards and recommended practices for international general aviation flights, which include overwater operations in corporate airplanes.

Training Rules Vary Among Countries

Regulations governing training for overwater operations and the use of emergency/survival equipment vary among countries. Following are a few examples:

- In Europe, commercial pilots are required by Joint Aviation Requirements (JARs) to be trained and checked every 12 months on "the location and use of all emergency and safety equipment carried [aboard the airplane]."[2] The annual training must include the donning of life vests and "instruction on the location and use of all types of exits." Every three years, the training must include the operation of exits, operation of pyrotechnics and demonstration of the use of life rafts;[3]

  JARs require flight attendants to receive initial training in water survival (including donning life vests and use of life rafts in water), first aid and "methods used to motivate passengers and the crowd control necessary to expedite an airplane evacuation."[4] Flight attendants are required to receive annual training in "emergency procedures, including pilot incapacitation; evacuation procedures, including crowd-control techniques; touch drills … for opening normal and emergency exits for passenger evacuation; [and] the location and handling of emergency equipment." Every three years, the annual training must include the opening of all normal and emergency exits, operation of pyrotechnics and demonstration of the use of life rafts;[5]

  The Joint Aviation Authorities (JAA) recommends that pilots and flight attendants be trained together.[6] "The successful resolution of airplane emergencies requires interaction between flight crew and cabin crew, and emphasis should be placed on the importance of effective coordination and two-way communication," JAA said;

- In Australia, crewmembers of aircraft used for charter operations and for regular public-transport operations must pass annual proficiency tests on their assigned duties in emergency situations (including ditching). To receive initial qualification to conduct ditching procedures, crewmembers must demonstrate competence in the use of a life vest in water and in removing a life raft from storage in the airplane and deploying the life raft;[7]

- In Canada, crewmembers of turbine-powered, pressurized airplanes and large airplanes involved in noncommercial passenger transportation must receive initial training and annual training in emergency procedures; flight attendants must receive training also in first aid.[8] Initial training and annual training in emergency procedures also are required for crewmembers of multi-engine aircraft with a maximum takeoff weight (MTOW) of 8,618 kilograms (19,000 pounds) or less or with fewer than 19 passenger seats, and turbojet airplanes with a maximum zero fuel weight of 22,680 kilograms (50,000 pounds) or less used in air transport service;[9] and,

- In New Zealand, the pilot-in-command (PIC) of an aircraft is required before beginning a flight to "be familiar with … the emergency equipment installed on the aircraft, which crewmember is assigned to operate the emergency equipment and the procedures to be followed for the use of the emergency equipment in an emergency situation."[10] Crewmembers of aircraft used in commercial operations are required to receive initial training in the location and operation of emergency equipment and the location and use of all normal exits and emergency exits. Transition training on "the use of all safety and emergency equipment and procedures applicable to the aircraft type or variant" also is required.[11,12]

Ditching Dropped From Type-rating Requirements

In the United States, ditching no longer is specified by Federal Aviation Administration (FAA) practical test standards as an emergency procedure of which adequate knowledge must be demonstrated by pilots seeking a type rating (which is required to serve as PIC of a large airplane or a jet) or an airline transport pilot (ATP) certificate (required to serve under U.S. Federal Aviation Regulations [FARs] Part 135, the regulations governing on-demand and commuter operations, as PIC of an airplane with more than nine passenger seats or as PIC of a jet in on-demand operations, or as PIC of a multi-engine airplane in commuter operations).[13]

FAA Advisory Circular (AC) 91-70, *Oceanic Operations*, says that to be considered as qualified for overwater operations, crewmembers must have a knowledge of subjects such as "emergency procedures, including required emergency equipment [and] search-and-rescue techniques."

For most general aviation operators — including corporate aviation departments — no specific requirements for training crewmembers in subjects such as ditching, evacuation, use of emergency equipment or water survival currently are included in the general operating and flight rules of Part 91.

Part 91 requires only that before each flight, crewmembers of large airplanes (with an MTOW of 12,500 pounds [5,670 kilograms] or more) and turbine-powered multi-engine airplanes must "become familiar with the emergency equipment installed on the airplane to which the crewmember is assigned and with the procedures to be followed for the use of that equipment in an emergency situation."[14]

A portable egress trainer ('dunker') is easily assembled and lowered into a swimming pool (top). The dunker provides practice in escaping from a submerged, overturned aircraft.

An amendment to Part 91, effective Nov. 17, 2003, initiates specific training requirements for crewmembers of airplanes operated under fractional (shared) ownership programs.[15] The training must include "individual instruction in the location, function and operation of … equipment used in ditching and evacuation [and] instruction in the handling of emergency situations including … ditching and evacuation."

The new requirements for crewmembers conducting fractional ownership operations include drills (i.e., hands-on training) in ditching procedures, emergency evacuation, operation of emergency exits, donning and inflation of life vests, removal of life rafts from the aircraft, inflation of life rafts, use of lifelines and boarding passengers and crew in life rafts.

The Right Thing to Do

Despite the absence of regulatory requirements for other general aviation operators, most companies that conduct overwater operations have their crewmembers participate regularly in specialized training, said David Tobergte, manager of airplane operations for Procter & Gamble Co., which conducts about 60 flights a year outside North America in its Gulfstream IV-SPs.[16]

"We send our cabin attendants and cockpit crews to FlightSafety International in Savannah, Georgia, for initial training and then recurrent training every two years," Tobergte said. "They cover ditching, fire fighting, water survival and other topics. Most companies operating long-range aircraft on international, overwater missions take it upon themselves to get this type of training from an outside vendor. We go beyond regulatory requirements in many other areas, such as crew duty-day [limits] and crew-rest requirements because it is the right thing to do."

The Texas Instruments aviation department, which conducts about one-third of its flights over water in its Challenger 604s, sends its crewmembers to FACTS Training International to receive annual emergency procedures training.

"We have FACTS bring their [mobile] simulator to our facility for intensive recurrent training of our crewmembers at least every other year," said Keith Rumohr, flight operations training coordinator.[17] "We feel that it is important to have *all* crewmembers participate, as a crew, in this important training. Crew coordination, including the flight attendant, is extremely important during these acutely stressful emergency situations. In the years that FACTS does not come to our facility, our flight attendants attend training separately.

"Why all the training and expense? Overwater operations are not always the most forgiving of environments. We want our crews to 'get it right' the first time and every time."

At Citizens Communications, executives who frequently are flown overwater in the company's Challenger 604 also receive training, said Jack Stockmann, director of aviation.[18] Every 24 months, the executives receive training in evacuation procedures, don life vests, deploy a life raft and become familiar with other emergency equipment and survival equipment carried aboard the airplane. Crewmembers receive annual training at FlightSafety International or at FACTS.

Increasing the Likelihood of Survival

Specialized training is important for pilots, flight attendants and passengers because it increases the likelihood that they will survive, said Roger Storey, an instructor at the FAA Civil Aerospace Medical Institute (CAMI) Airman Education Programs Branch.[19]

"Training will create — or reinforce — an appreciation for the environment in which the person flies," he said. "It also will help to build confidence in their ability to survive a harsh environment — confidence in themselves, as well as their ability to effectively use any survival equipment stored in the aircraft.

"Training also can reduce time and mistakes when evacuating the aircraft, boarding a life raft, treating medical concerns, using signal devices, procuring water, making decisions and much more."

Storey said that each year, about 160 people attend CAMI's Post Crash Survival Training for General Aviation; the course is similar to global survival training administered by CAMI to FAA flight-inspection crews.

"We do not spend much time on airmanship," he said. "The course is designed to help individuals prepare for and react to a ditching situation. The course then focuses on water-survival skills. Specific topics include: preparation for the ditching; egress (including underwater escape); boarding life rafts; survival without a life raft; and improvised methods for heat retention and flotation."

Emergency Drills on Syllabus For On-demand Crews

Part 135 includes the ICAO requirement that operators assign to each crewmember the functions that they are to perform in an emergency or in a situation requiring emergency evacuation.[20] Descriptions of these functions must be included in the operations manual.

The regulations also require that the operator's training program include the following instruction for each crewmember for each type of aircraft to which he or she is assigned:[21]

- "Instruction in emergency assignments and procedures, including coordination among crewmembers;
- "Individual instruction in the location, function and operation of emergency equipment, including equipment used in ditching and evacuation, first aid equipment and its proper use; [and,]

With no life raft available, survivors must huddle to conserve body heat and provide a bigger target for SAR.

Practice in donning life vests and inflating a life raft is best accomplished with in-the-water training.

- "Instruction in the handling of emergency situations, including … ditching and evacuation."

The training program also must include "emergency drills" unless the operator receives FAA approval to conduct the training by demonstration. The required emergency drills include the following:

- "Ditching, if applicable;
- "Emergency evacuation;
- "Operation and use of emergency exits;
- "Removal of life rafts from the aircraft, inflation of the life rafts, use of lifelines and boarding of passengers and crew, if applicable; [and,]
- "Donning and inflation of life vests and the use of other individual flotation devices, if applicable."

FAA requires the training to alternate every 12 months between "instruction and demonstration" and "hands-on" training.[22] This means that during a recurrent training session, a crewmember whose company conducts overwater operations might be told or shown how to operate the airplane's emergency exits, don and inflate a life vest, and remove, deploy and board a life raft. During the next recurrent session, the crewmember would perform these actions.

In-water Training Not Required

FAA does not require that the hands-on training be conducted in a realistic environment, however.

A professional pilot who has flown for several on-demand operators said that some operators conducted training in pools, others conducted training in classrooms.

"Instruction in the pools included how to climb into the life raft, which is not easy with a life vest on, and how to turn the life raft over if it inflated upside down," he said. "Other instructors inflated life rafts in the classroom. We all stepped into the life rafts, then stepped out. Sad, isn't it? And it complies with the FAA regulations, which is just as disgusting."

Bill Gibson, president of Gibson Aviation, said that the Part 135 training regulations are vague and that when his company used Learjets for on-demand overwater operations, he conducted training in donning life vests and deploying life rafts in indoor pools.[23]

"We used a pool because it provides for a better simulation than inflating a life raft on a hangar floor," he said. "I always had the more agile pilots get into the life raft first and help the others aboard. It gave them a better idea of what they would be up against in a ditching situation."

TAG Aviation USA, which operates a variety of turbine airplanes in corporate operations and in on-demand operations, requires newly hired crewmembers to get wet, said David Huntzinger, Ph.D., director of safety and security.[24]

"We have both Part 91 and Part 135 crews here, but they are trained to the same standard," he said. "During new-hire training, all aspects of ditching are covered, from cabin preparation to [crewmember] roles and responsibilities to sea survival. This includes a wet drill, where life vests are donned, a life raft is inflated and floated in a pool, and everyone gets wet. The wet drill is not done during annual recurrent training, but the same topics are covered."

Several training companies use an egress trainer ("dunker") in a pool to teach people the basics of how to escape from an airplane that is under water and inverted (see "Train to Rise to the Top," page 378, and "If You Need It, They Have It," page 382).

Bryan Webster, president and head instructor at Aviation Egress Systems, said that without this training, underwater escape after a ditching is not likely.[25]

"I would not want passengers hoping that the captain is going to get them out of the airplane if he has not been trained, because he won't," he said. "He probably won't even get himself out."

Webster, who has more than 10,000 flight hours in operations ranging from bush flying to corporate flying, said that even simple tasks, such as donning a life vest, are more difficult when a person is in water — and likely impossible if the person has not been trained.

"The worst time to figure out how to put on a life vest is outside a wrecked airplane with a bunch of people who cannot swim," he said. "Donning a life vest is simple, but when I put people in the pool and say, 'Here, put on the vest,' they have no idea how to do it. They've never opened the plastic bag to look at what's inside."

Webster said that in-water training is especially important for people who fly over cold water.

"The majority of people who ditch off Canada, where the water is cold, die if the airplane overturns and submerges," he said. "It is not because they are incapacitated; it's because they cannot find the door handle. Most people unfasten their seat belt before the airplane has stopped. They cannot see very well and cannot find the door handle. They become disoriented and panic. Their heart rate skyrockets, and their ability to hold their breath goes down to three to five seconds.

"If you stay in your seat belt until the airplane stops, then reach over and open the door, hold onto the door frame for a reference point and then — and only then — undo your seat belt, you will not become disoriented. We've proved this time and again in the pool. If you remain calm and rational under water, your heart rate stays relatively low and your breath-hold time goes up significantly."

'One Error Could Cost Your Life'

In-water training is especially important also for crewmembers and passengers of helicopters, which are likely to roll over during a ditching (see " Imagine the Worst Helicopter Ditching — Now Get Ready for It," page 85).

Helicopter underwater-escape training shows why it is essential for a person to adopt the correct brace position, to take a breath of air and to understand how the exit window operates, said Peter Gibbs, training and operations manager for Survival Systems Training.[26]

During training, wearing the cold-water immersion suit and life vest that will be used during overwater flights and understanding the hazards of underwater escape for a particular cabin layout are important. Training provides memory aids, orientation methods and practice, so that actions are performed as "almost an instinctive response," he said.

"A person may believe 'I have unlatched this door thousands of times,' but if you make one small error or become snagged inside a helicopter cabin under water, the error could cost you your life," Gibbs said. "Our training is sufficiently realistic to just begin the panic sequence in a person. In the modular egress training system, 17.5 metric tons [38,581 pounds] of water enter the cabin in five seconds as the [simulator] rolls through 180 degrees."

During their first attempt to get out of the egress trainer, students typically become disoriented and frightened, and have difficulty pointing to which way is up.

"Loss of visual reference makes it very easy to become disoriented; the buoyancy felt by the person increases this disorientation," Gibbs said. "Amazingly, students become convinced after the first rollover that the exit is located on the other side of their body. By the fourth attempt, many

Continued on page 380

"The worst time to figure out how to put on a life vest is outside a wrecked airplane."

Train to Rise to the Top

Flight Safety Foundation identified many companies worldwide that include aircraft underwater escape, life raft use and water survival in their program curricula; some offer a broader range of training programs.

Contact specific companies to determine program content, certification of participants or identification of programs that meet training requirements specified by regulatory bodies. *Only the training companies that responded to our requests for information are listed below.*

Aviation Egress Systems
200 Hart Road
Victoria, British Columbia
Canada V9C 1A1
Telephone: +1 (250) 704-6401
Fax: +1 (250) 478-2678
E-mail: <dunkyou@hotmail.com>
Internet: <www.dunk-you.com>

Highlights of initial and recurrent training courses are aircraft ditching and dynamics of water impact; pilot and passenger impact preparation; use of a ditching simulator with adjustable angles of impact; underwater inversion and escape; boarding a life raft and donning a life vest while in water; and rescue of injured people.

CAE SimuFlite
P.O. Box 619119
2929 West Airfield Drive
Dallas/Fort Worth International Airport, TX 75261 U.S.
Telephone: +1 (972) 456-8000
Fax: +1 (972) 456-8383
E-mail: <info@simuflite.com>
Internet: <www.caesimuflite.com>

CAE SimuFlite training centers offer flight crewmembers of business aircraft and helicopters courses tailored to popular aircraft models currently in production. One of many ancillary courses arranged by CAE SimuFlite is a program designed to train cabin crewmembers in emergency (land and water) evacuation procedures and safety procedures, crew coordination, passenger handling, and use of safety and survival equipment.

Cape Technikon Survival Centre
P.O. Box 652
Cape Town 8000 South Africa
Telephone: +27 +21 460 3236
Fax: +27 +21 460 3698
E-mail: <survival@ctech.ac.za>
Internet: <www.ctech.ac.za>

The center offers helicopter underwater-escape training (HUET) with an egress trainer (dunker); aviation safety and survival training; HUET offshore; basic survival and personal safety; basic sea survival; life raft proficiency; and use of water safety and survival equipment for marine, offshore and aviation applications.

CareFlight Safety Services
P.O. Box 15
Tugun, Queensland 4224 Australia
Telephone: +61 7 5506 8400
Fax: +61 7 5506 8401
E-mail: <marketing@careflight.org.au>
Internet: <www.huet.com.au>

CareFlight offers life raft and life vest training courses to individuals and as part of HUET. The curriculum provides theoretical and practical learning through use of an aircraft simulator, simulated threats and simulated sea-survival situations. Course content may address obstructed exits; rescue of injured persons; sea survival; life raft and life vest use; life raft medicine and emergency medical services.

Centre d'Etude et de Pratique de la Survie
(Center for the Study and Practice of Survival)
37 Avenue des Colverts
44380 Pornichet France
Telephone: +33 2 40 61 32 08
Fax: +33 2 40 61 61 08
E-mail: <contact@ceps-survie.com>
Internet: <www.ceps-survie.com>

Training for helicopter crews and offshore-industry passengers includes HUET and emergency-air breathing; use of a shallow-water escape trainer; psychological and physiological stressors and reactions; and use of life rafts, flotation devices, signaling devices and other survival equipment.

Fleetwood Offshore Survival Centre
Fleetwood Nautical Campus
Broadwater
Fleetwood, Lancashire FY7 8JZ U.K.
Telephone: +44 (0) 1253 779123
Fax: +44 (0) 1253 773014
E-mail: <offshore@blackpool.ac.uk>
Internet: <www.blackpool.ac.uk/fosc/index.htm>

Some courses incorporate HUET and emergency breathing systems; in-water survival principles, difficulties and techniques; first aid; search and rescue; correct use of life rafts and other survival equipment; and safety and emergency training for offshore petroleum workers.

FlightSafety International
110 Toffie Terrace
Atlanta, GA 30309 U.S.
Telephone: +1 (678) 365-2700
Fax: +1 (678) 365-2699
E-mail: <brenda.seaman@FlightSafety.com>
Internet: <www.flightsafety.com>

Programs are designed to provide flight crew, cabin crew and frequent passengers with knowledge and procedures for emergency situations. Course curricula may include ditching, exiting and water evacuation, sea survival, and use of life rafts, life vests and other survival equipment. Teaching aids may include classroom presentations, simulated training devices, operationally oriented drills and in-water experiences.

Helicopter Survival Rescue Services (HSRS)
81 Ilsley Ave., Unit 7
Dartmouth, Nova Scotia
Canada B3B 1L5
Telephone: +1 (902) 468-5638
Fax: +1 (902) 468-3083
E-mail: <aviation@hsrs.ca>
Internet: <www.hsrsaviation.ca>

Courses include HUET using a portable aircraft simulator/trainer, first aid and practical use of life rafts, life vests and other survival equipment. HSRS provides offshore and search-and-rescue expertise to the offshore petroleum industry.

Hota
Malmo Road
Sutton Fields
Hull HU7 OYF U.K.
Telephone: +44 (0) 1482 820567
Fax: +44 (0) 1482 823202
E-mail: <info@hota.org>
Internet: <www.hota.org>

Hota provides first-time and recurrent training to those who travel on water or over water, primarily in the petrochemical, maritime, academic and commercial industries. Offshore courses may include HUET and emergency breathing systems, first aid, personal survival techniques, and personal safety and social responsibilities.

Industrial Foundation for Accident Prevention (IFAP)
128 Farrington Road
Leeming, Western Australia 6149
Australia
Telephone: +61 8 9310 3760
Fax: +61 8 9332 3511
E-mail: <ifap@ifap.asn.au>
Internet: <www.ifap.asn.au>

IFAP's international programs for the offshore oil and gas industry include components such as helicopter ditching preparation, HUET using an in-water helicopter simulator, water rescue by helicopter, life raft deployment, life vest use, short-term and long-term life raft management techniques and warm/cold water survival.

International Association for Safety and Survival Training (IASST)
Location: none listed on Internet site
Telephone: +45 761104 76
Fax: +45 751621 51
E-mail: <kel@muv.dk>
Internet: <www.iasst.com>

IASST is a venue for the exchange of maritime knowledge and expertise which are drawn from, and available to, academia, training schools, aviation and maritime industries, equipment manufacturers, and professional organizations. Its membership list identifies resources by country. Training providers/members offer programs on topics such as sea survival, training techniques, and skills and competencies of emergency response.

LTR Training Systems
230 East Potter Drive, Unit One
Anchorage, AK 99518 U.S.
Telephone: +1 (907) 563-4463
Fax: +1 (907) 563-9185
E-mail: <survival@alaska.net>
Internet: <www.survivaltraining.com>

LTR's "Learn to Return" programs are "hands-on" and experiential. Its domestic and international programs may be customized, such as by developing instructor-trainer programs. Some topics are helicopter and airplane underwater-escape techniques and use of emergency breathing devices; ditching; in-water aircraft escape simulators; ocean, coastal and arctic water survival; living aboard a life raft; and use of survival and rescue equipment.

Megamas Training Co.
Integrated Safety Training Centre
Tol 3593, Jln Mumong/Kuala Balai
Kuala Belait KD1132
Brunei Darussalam
Telephone: +673-3-332842
Fax: +673-3-332845
E-mail: <info@megamas.com>
Internet: <www.megamas.com>

The Integrated Safety Training Centre provides specialized courses for civil aviation and the oil and gas industry in South East Asia. Programs may include HUET; aircraft egress techniques; use of a modular egress training simulator; in-water individual and group survival procedures; self-rescue with and without respiratory protection; use of life rafts, life vests and survival suits; and first aid.

Nutec Centre for Safety (U.K.)
Nutec Global Safety Group
Haverton Hill Industrial Estate
Billingham TS23 1PZ U.K.
Telephone: +44 (0) 1642 566656
Fax: +44 (0) 1642 563224
E-mail: <teesside@nutecuk.com>
Internet: <www.nutecuk.com>

Safety specialists with facilities worldwide offer training for flight crewmembers and cabin crewmembers, offshore personnel and others. Participants learn survival techniques and train in ditching procedures for helicopter and fixed-wing aircraft, using shallow-water escape trainers and dunker systems.

Pro Aviation Safety Training
22143 Old Yale Road
Langley, British Columbia
Canada V2Z 1A3
Telephone: +1 (604) 514-1630
Fax: +1 (604) 514-1589
E-mail: <jackie@proaviation.ca>
Internet: <www.proaviation.ca>

Initial and recurrent training are available to flight crewmembers and passengers, and courses can be tailored to specific types of operations. Training may include causal factors, preparation and procedures for aircraft ditching; aircraft egress (dry, wet and underwater) techniques; use of an underwater-escape trainer; in-water simulation of life raft boarding; assisting the injured; minimizing effects of hypothermia; and other survival skills.

STARK Survival Co.
6227 East Highway 98
Panama City, FL 32404 U.S.
Telephone: +1 (850) 871-4730
Fax: +1 (850) 871-0668
E-mail: <starkinc@aol.com>
Internet: <www.starksurvival.com>

STARK (Sea, Tropical, Arctic and Regional Knowledge) offers classes to crewmembers and passengers of aircraft being flown under U.S. Federal Aviation Regulations (FARs) Parts 91, 121, 125 and 135. Classes may include the following: ditching preparation and procedures; use of a dunker for evacuation and ditching practice; HUET with emergency breathing apparatus; and open-water (Gulf of Mexico) training using life rafts and other survival equipment.

Survival Systems Training
40 Mount Hope Ave.
Dartmouth, Nova Scotia
Canada B2Y 4K9
Telephone: +1 (902) 465 3888
Fax: +1 (902) 465 8755
E-mail: <sst@sstl.com>
Internet: <www.survivalsystemsgroup.com>

International programs are offered to flight crewmembers and to trainers of similar survival programs. Program elements may include underwater-escape techniques; survival and water-rescue skills; emergency breathing system; and use of a helicopter-egress-training simulator and shallow-water-egress trainer to replicate specific aircraft configurations in ditching situations.

Survival Systems USA
144 Tower Ave.
Groton, CT 06340 U.S.
Telephone: +1 (860) 405-0002
Fax: +1 (860) 405-0006
E-mail: <sstmail@survivalsystemsinc.com>
Internet: <www.survivalsystemsinc.com>

Training is tailored to the aviation, marine and offshore industries. Instruction in aircraft ditching and escape procedures is offered to pilots, cabin crewmembers and passengers. Courses may include HUET using emergency breathing apparatus and a modular egress-training simulator; personal survival techniques; launching and operation of a life raft; and in-water survival activities while wearing a cold-water immersion suit and life vest.

The Marine Survival Training Center
University of Louisiana at Lafayette
P.O. Box 42890
Lafayette, LA 70504 U.S.
Telephone: +1 (337) 262-5929
Fax: +1 (337) 262-5926
E-mail: <mstc@louisiana.edu>
Internet: <louisiana.edu/InfoTech/MSTC/index.html>

The training center is developing agreements with similar training facilities around the globe to offer offshore and aviation standardized courses. Current courses may include HUET using a dunker; personal survival techniques and survival with or without equipment; communication and location aids and signaling; life raft boarding and righting; and use of life vests, cold-water immersion suits and other survival equipment.

U. S. Federal Aviation Administration, Civil Aerospace Medical Institute (CAMI)

CAMI Building, AAM-400A, Room 383
P.O. Box 25082
Oklahoma City, OK 73125 U.S.
Telephone: +1 (405) 954-4837
Fax: none listed
E-mail: none listed
Internet: <www.cami.jccbi.gov/aam-400/survival_intro.htm>

Basic survival training (water, desert and arctic) is offered to general aviation (GA) flight personnel. Water-related topics may include the psychology of survival; underwater-escape training in a ditching tank; search-and-rescue operations; helicopter pickup devices; use of life rafts and safety equipment carried aboard GA aircraft; and personal-survival-kit assembly. ■

—FSF Library Staff

students realize that they can cope with disorientation and focus on correctly doing the escape maneuvers. The lesson is that you always must use a physical reference point to grasp the door lever or get to a window exit."

Taking Training to The Student

Although most aircraft operators know the value of training, some are reluctant to accept the costs and logistics associated with sending crews to training facilities. Some facilities, therefore, bring their training to the operator.

"I bring the training directly to the operator," said Ken Burton, president of STARK Survival Co.[27] "I conduct a thorough ground school on ditching procedures, passenger preparation, exits, underwater escape, underwater-breathing devices and water survival. Then, I set up a portable dunker in a swimming pool. While it is not a sophisticated system, it is sufficient to provide the students with some practical in-the-water experience that can make the difference between survival or death.

"When the students complete this training, I am confident that they have sufficient training to take action to rescue themselves from a submerged aircraft." ■

Notes

1. International Civil Aviation Organization (ICAO). International Standards and Recommended Practices. *Annex 6 to the Convention on International Civil Aviation: Operation of Aircraft*. Part 1, *International Commercial Air Transport — Aeroplanes*. Chapter 9, *Aeroplane Flight Crew*. 9.2, "Flight crew member emergency duties." Chapter 12, *Cabin Crew*. 12.1, "Assignment of emergency duties."
2. Joint Aviation Authorities (JAA). Joint Aviation Requirements — Operations 1, *Commercial Air Transportation (Aeroplanes)*. Subpart N, *Flight Crew*. JAR-OPS 1.965, "Recurrent training and checking."
3. JAA. JAR-OPS 1. Subpart N. Appendix 1 to JAR-OPS 1.965.
4. JAA. JAR-OPS 1. Subpart O, *Cabin Crew*. Appendix 1 to JAR-OPS 1.1005, "Initial training."
5. JAA. JAR-OPS 1. Subpart O. Appendix 1 to JAR-OPS 1.1015, "Recurrent training."
6. JAA. JAR-OPS 1. Acceptable Means of Compliance (AMC) 1.965(d), "Emergency and safety equipment training."
7. Australian Civil Aviation Authority (CAA). Civil Aviation Orders Part 20, Section 20.11, Issue 10, *Emergency and Lifesaving Equipment and Requirements for Passenger Control in Emergencies*.

The bottom line, in our opinion …

- **Crewmembers on international commercial flights are required by the International Civil Aviation Organization to receive training on emergency equipment and evacuation.**
- **In the United States, there are no specific requirements to train corporate airplane crewmembers on ditching procedures, use of emergency equipment or water survival.**
- **Although it's not required, many companies ensure that their pilots and flight attendants — and sometimes even their passengers — regularly receive specialized overwater training.**
- **The "hands-on" training required for commuter/on-demand crewmembers can be accomplished, in part, by deploying a life raft on a hangar floor and having the crewmembers step in and step out of the life raft.**
- **In-water training is especially important for those who fly offshore in helicopters, which are likely to roll over during a ditching.**
- **You cannot depend on intuition for emergency actions. Specialized training is essential.**

8. Transport Canada (TC). Canadian Aviation Regulations Part VI, *General Operating and Flight Rules*. Subpart 4, *Private Operator Passenger Transportation*. Part 604.73, "Training Programs."

9. TC. Canadian Aviation Regulations Part VII, *Commercial Air Services*. Subpart 4, *Commuter Operations*. Part 704.115, "Training Program."

10. New Zealand CAA. Civil Aviation Rules Part 91, *General Operating and Flight Rules*. Part 91.219, "Familiarity with operating limitations and emergency equipment."

11. New Zealand CAA. Civil Aviation Rules Part 135, *Air Operations — Helicopters and Small Aeroplanes*. Part 135.557, "Initial training for crew members." Part 135.559, "Transition training for crew members."

12. New Zealand CAA. Civil Aviation Rules Part 125, *Air Operations — Medium Aeroplanes*. Part 125.557, "Initial training for crew members." Part 125.559, "Transition training for crew members."

13. U.S. Federal Aviation Administration (FAA). *Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Airplane*. FAA-S-8081-5D, February 2001.

14. FAA. U.S. Federal Aviation Regulations (FARs) Part 91, *General Operating and Flight Rules*. Subpart F, *Large and Turbine-powered Multiengine Airplanes*. Part 91.505, "Familiarity with operating limitations and emergency equipment."

15. FAA. FARs Part 91. Subpart K, *Fractional Ownership Operations*. Part 91.1083, "Crewmember emergency training."

16. Tobergte, David. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 30, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

17. Rumohr, Keith. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. Nov. 11, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

18. Stockmann, Jack. Interview by Werfelman, Linda. Hollywood, Florida, U.S. April 23, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

19. Storey, Roger. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. Nov. 3, 2003, and Dec. 3, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

20. FAA. FARs Part 135, *Operating Requirements: Commuter and On-demand Operations and Rules Governing Persons On Board Such Aircraft*. Part 135.123, "Emergency and emergency evacuation duties."

21. FAA. FARs Part 135. Part 135.331, "Crewmember emergency training."

22. FAA. Order 8400.10, *Air Transportation Operations Inspector's Handbook*. The handbook provides "direction and guidance" for FAA inspectors who oversee Part 135 operations and Part 121 (air carrier and commercial) operations.

23. Gibson, Bill. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. March 12, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

24. Huntzinger, David. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. Nov. 6, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

25. Webster, Bryan. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Dec. 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

26. Gibbs, Peter. Interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. April 11, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

27. Burton, Ken. Interview by Rozelle, Roger. Alexandria, Virginia, U.S. Dec. 29, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

If You Need It, They Have It

Many companies, in addition to those mentioned elsewhere in this publication, offer products and services that can improve your odds of survival in a water-emergency situation. Flight Safety Foundation has compiled a selective list of those companies in four categories: emergency radio beacons; first aid kits and wilderness-oriented first aid training; emergency rations and water; and a wide variety of related equipment.

Each company is listed once, and may offer products in categories besides that in which it is listed. The Foundation does not endorse the identified companies and organizations. Nevertheless, many of these companies' Internet sites offer a useful starting point for educating yourself about these topics.

Bringing Home the Beacon

Companies that manufacture or supply emergency locator transmitters (ELTs), personal locator beacons (PLBs), emergency position-indicating radio beacons (EPIRBs) and automatic deployable emergency locator transmitters (ADELTs) are printed below.

More companies and resources are available at the Internet site, *Cospas-Sarsat International Satellite System for Search and Rescue* <www.cospas-sarsat.org/beacons/beacon_navigation_frame.html>. The site contains information about manufacturers; product reports; coding protocols; an interactive beacon-message protocol-selection tutorial; guidelines for coding, registration and type approval; and other information. Most of the documents are available in English, French and Russian.

ACR Electronics
5757 Ravenswood Road
Fort Lauderdale, FL 33312 U.S.
Telephone: +1 (954) 981-3333
Fax: +1 (954) 983-5087
E-mail: <webmail@acrelectronics.com>
Internet: <www.acrelectronics.com>

Artex Aircraft Supplies
14405 Keil Road Northeast
Aurora, OR 97002 U.S.
Telephone: +1 (503) 678-7929
Fax: +1 (503) 678-7930
E-mail: <info@artex.net>
Internet: <www.artex.net>

ELTA
BP 48
14 Place Marcel Dassault
31702 Blagnac Cedex
France
Telephone: +33 5 34 36 10 00
Fax: +33 5 34 36 10 01
E-Mail: <des@elta.fr>
Internet: <www.elta.fr>

Japan Radio Co.
Nittochi Nishi-Shinjuku Building
10-1 Nishi-Shinjuku 6-chome
Shinjuku-ku, Tokyo 160-8328
Japan
Telephone: +81 3 3348 3604
Fax: +81 3 3348 3648
E-mail: none listed
Internet: <www.jrc.co.jp>

McMurdo
Silver Point
Airport Service Road
Portsmouth PO3 5PB U.K.
Telephone: +44 2392 623 900
Fax: +44 2392 623 998
E-mail: <sales@mcmurdo.co.uk>
Internet: <www.pwss.com>

Northern Airborne Technology
1925 Kirschner Road
Kelowna, British Columbia
Canada V1Y 4N7
Telephone: +1 (250) 763-2232
Fax: +1 (250) 762-3374
E-mail: <general@natech.com>
Internet: <www.northernairborne.com>

Pains Wessex Australia
P.O. Box 25
Glen Iris, Victoria 3146
Australia
Telephone: +61 3 9885 0444
Fax: +61 3 9885 5530
E-mail: <genenq@painswessex.com.au>
Internet: <www.painswessex.com.au>

Pointer
1027 North Stadem Drive
Tempe, AZ 85281 U.S.
Telephone: +1 (480) 966-1674
Fax: +1 (480) 968-8020
E-mail: <david.koster@att.net>
Internet: <www.pointerinc.com>

SERPE-IESM
Zone Industrielle des Cinq Chemins
56520 Guidel
France
Telephone: +33 2 97 02 49 49
Fax: +33 2 97 65 00 20
E-mail: <contact@serpe-iesm.com>
Internet: <www.serpe-iesm.com>

Seimac
271 Brownlow Ave.
Dartmouth, Nova Scotia
Canada B3B 1W6
Telephone: +1 (902) 468-3007
Fax: +1 (902) 468-3009
E-mail: thensley@seimac.com
Internet: <www.seimac.com>

Techtest
HR Smith Group of Companies
Street Court, Kingsland
Leominster, Herefordshire HR6 9QA
U.K.
Telephone: +44 1568 708 744
Fax: +44 1568 708 713
E-mail: <street@hr-smith.com>
Internet: <www.hr-smith.com>

Repair Kits for People

First aid kits may be included in prepackaged survival equipment packs (SEPs). Kits and specific items for kits also may be purchased separately.

Some companies manufacture or sell first aid kits for use in water-related environments;

others offer components that can be added to ready-made first aid kits for additional capability or used to assemble individualized kits.

Also listed in this section are organizations that provide training programs for first aid in a wilderness setting — and that directly applies to the circumstances of a ditching.

Additional sources may be found at the Internet site <www.equipped.org>.

First aid kit suppliers

Adventure Medical Kits
P.O. Box 43309
Oakland, CA 94624 U.S.
Telephone: +1 (510) 261-7414
Fax: +1 (510) 261-7419
E-mail: <questions@adventuremedicalkits.com>
Internet: <www.adventuremedicalkits.com>

BCB International
Clydesmuir Road
Cardiff CF24 2QS U.K.
Telephone: +44 2920 433 700
Fax: +44 2920 433 701
E-mail: <info@bcbin.com>
Internet: <www.bcbin.com>

Exploration Products
P.O. Box 32090
Bellingham, WA 98228 U.S.
Telephone: +1 (360) 676-4400
Fax: +1 (360) 676-4340
E-mail: <epcamps@epcamps.com>
Internet: <www.epcamps.com>

First Aid Pak
3055 Brighton-Henrietta TL Road
Rochester, NY 14623 U.S.
Telephone: +1 (585) 427-2940
Fax: +1 (585) 427-8666
E-mail: <contactus@firstaidpak.com>
Internet: <www.firstaidpak.com>

Life Support International
Rittenhouse Circle
Building 4 West
Bristol, PA 19007 U.S.
Telephone: +1 (215) 785-2870
Fax: +1 (215) 785-2880
E-mail: <lsi@lifesupportintl.com>
Internet: <www.lifesupportintl.com>

MedAire*
Corporate Headquarters
80 East Rio Salado Parkway, Suite 610
Tempe, AZ 85281 U.S.
Telephone: +1 (480) 333-3700
Fax: +1 (480) 333-3592
E-mail: <info@medaire.com>
Internet: <www.medaire.com>
*FSF member

The Preparedness Center
Preparedness Industries
311 East Perkins St.
Ukiah, CA 95482 U.S.
Telephone: +1 (707) 472-0288
Fax: +1 (707) 472-0228
E-mail: <sales@preparedness.com>
Internet: <www.preparedness.com>

Wilderness Medical Systems
P.O. Box 584
Absarokee, MT 59001 U.S.
Telephone: +1 (406) 328-7126
Fax: +1 (406) 328-6176
E-mail: <kurtvn@wildernessmedical.com>
Internet: <www.wildernessmedical.com>

First aid training for wilderness environments

Sirius Wilderness Medicine
300 Chemin de la Rivière Rouge
Harrington, Quebec
Canada J8G 2S7
Telephone: +1 (819) 242-2666
Fax: +1 (819) 242-4597
E-mail: <info@siriusmed.com>
Internet: <www.siriusmed.com>

SOLO
P.O. Box 3150
Conway, NH 03818 U.S.
Telephone: +1 (603) 447-6711
E-mail: <info@soloschools.com>
Internet: <www.soloschools.com>

Wilderness Medical Associates
189 Dudley Road
Bryant Pond, ME 04219 U.S.
Telephone: (888) 945-3633 (U.S.);
+1 (207) 665-2707
E-mail: <office@wildmed.com>
Internet: <www.wildmed.com>

Wilderness Safety Council
214 East Duncan Ave.
Alexandria VA 22301 U.S.
Telephone: +(703) 836-8905
E-mail: <Chris@wfa.net>
Internet: <http://wfa.net>

Back to Basics: Food and Water

Food rations and water rations appropriate for consumption and storage in water-related environments may be purchased from manufacturers, distributors and retailers.

Survival equipment packs (SEPs) may be customized by suppliers or by customers to reflect individual preferences. Replacement food items and water items may be purchased from vendors in quantities from single items to case lots. Food and water rations also may be purchased as part of prepackaged SEPs. Prepackaged SEPs typically contain supplies of food and water in predetermined quantities (e.g, rations for six adults for four days).

In addition to companies listed here, more sources may appear at the Internet site <www.equipped.org/sources.htm>.

Compact AS
Smoget
N-5212 Søfteland, Bergen
Norway
Telephone: +47 5630 3500
Fax: +47 5630 3540
E-mail: <info@compact.no>
Internet: <www.compact.no>

Datrex
P.O. Box 1150
13878 Highway 165
Kinder, LA 70648 U.S.
Telephone: +1 (337) 738-4511
Fax: +1 (337) 738-5675
E-mail: <datrex@datrex.com>
Internet: <www.datrex.com>

Exploration Products
P.O. Box 32090
Bellingham, WA 98228 U.S.
Telephone: +1 (360) 676-4400
Fax: +1 (360) 676-4340

E-mail: <epcamps@epcamps.com>
Internet: <www.epcamps.com>

F.A.S.T. First Aid & Survival Technologies
8850 River Road
Delta, British Columbia
Canada V4G 1B5
Telephone: +1 (604) 940-3222
Fax: +1 (604) 940-3221
E-mail: <fast@fastlimited.com>
Internet: <www.fastlimited.com>

Katadyn Products
Birkenweg 4
8304 Wallisellen Switzerland
Telephone: +41 1 839 21 11
Fax: +41 1 830 79 42
E-mail: <info@katadyn.ch>
Internet: <www.katadyn.ch>

S.O.S. Food Lab
9399 Northwest 13th St.
Miami, FL 33172 U.S.
Telephone: +1 (305) 594-9933
Fax: +1 (305) 594-7667
E-mail: <sosfood@icanect.net>
Internet: <www.sos-rations.com>

They Can Relate to That

Companies offering a wide assortment of related products directly to aviation customers are listed here. Some are marine outfitters that offer safety and survival products that are also useful in aviation water-contact accidents. Additional sources may be found at the Internet site <www.equipped.org>.

Aqua Lung America
2340 Cousteau Court
Vista, CA 92083 U.S.
Telephone: +1 (540) 459-4495.
Internet: <www.aqualung.com>

BoatUS
880 South Pickett St.
Alexandria, VA 22304 U.S.
Telephone: +1 (703) 823-9550
Fax: +1 (703) 461-2847
E-mail: <mail@boatus.com>
Internet: <www.boatus.com>

Concorde AeroSales
2046 Madison St.
Hollywood, FL 33020 U.S.
Telephone: +1 (954) 929-4200
Fax: +1 (954) 929-4241
E-mail: <info@concordeaerosales.com>
Internet: <www.concordeaerosales.com>

Lifesaving Systems Corp.
220 Elsberry Road
Apollo Beach, FL 33572 U.S.
Telephone: +1 (813) 645-2748
Fax: +1 (813) 645-2768
E-mail: <info@lifesavingsystems.com>
Internet: <www.lifesavingsystems.com>

MSI-Defence Systems
10 Cambridge Road
Granby Industrial Estate,
Weymouth, Dorset DT4 9XA U.K.
Telephone: +1 44 (0) 1305 760 111.
Internet: <www.msi-dsl.com>

Orion Safety Products
Customer Service
Rural Route 6, Box 542
Peru, IN 46970 U.S.
Telephone: +1 (765) 472-4375
Fax: +1 (765) 473-3254
E-mail: <mcustomerservice @orionsignals.com>
Internet: <www.orionsignals.com>

Rescue Technologies Corp.
99-1350 Koaha Place
Aiea, HI 96701 U.S.
Telephone: +1 (808) 483-3255
Fax: +1 (808) 483-3254
E-mail: <rescuetech@lava.net>

Submersible Systems
18072 Gothard St.
Huntington Beach, CA 92648 U.S.
Telephone: +1 (714) 842-6566 or U.S. toll-free (800) 648-3483
Internet: <www.submersiblesystems.com>

West Marine
P.O. Box 50070
Watsonville, CA 95007 U.S.
Telephone: +1 (831) 761-4800
Fax: +1 (831) 761-4020
E-mail: <catintl@westmarine.com>
Internet: <www.westmarine.com> ■

— FSF Library Staff

Regulations and Recommendations

Regulations and Recommendations

Regulations, Judgment Affect Overwater Equipment Decisions

Several U.S. regulations provide specific guidance on emergency/survival equipment that must be carried during overwater operations, but some requirements are vague and give operators wide latitude in choosing equipment.

—FSF EDITORIAL STAFF

Another life raft is stored behind the one shown here. Each has sufficient overload capacity to accommodate all occupants of the Falcon 50.

A corporate aviation department or other noncommercial aircraft operator that flies a large multi-engine airplane (i.e., with a maximum certified takeoff weight of more than 12,500 pounds [5,670 kilograms]) or a turbine-powered (turbofan or turbojet) multi-engine airplane more than 50 nautical miles (93 kilometers) from the nearest shore is required by U.S. Federal Aviation Regulations (FARs) 91.509, "Survival equipment for overwater operations," to carry a life vest or "an approved flotation means" for each occupant of the airplane.

If the airplane is flown more than 30 minutes flying time or more than 100 nautical miles (185 kilometers) from the nearest shore, it is required to have "enough life rafts (equipped with an approved survivor-locator light) of a rated capacity and buoyancy to accommodate the occupants of the airplane."

"Approved" means approved by the U.S. Federal Aviation Administration (FAA). Typically, FAA approves equipment that meets the minimum standards specified in applicable technical standard orders (TSOs) for design, materials and performance (see "For Ditching Survival, Start With Regulations. But Don't Stop There," page 395).

Aviation life rafts that meet TSO standards have a rated capacity and an overload capacity. For example, a life raft with a rated capacity of eight people might have an overload capacity of 12 people.

Part 91.509 requires that the following "survival equipment" be carried during overwater operations more than 30 minutes flying time or more than 100 nautical miles from the nearest shore:

- A life vest with an approved survivor-locator light for each occupant;
- At least one pyrotechnic signaling device for each life raft;
- "One self-buoyant, water-resistant, portable emergency radio signaling device that is capable of transmission on the appropriate emergency frequency or frequencies and not dependent upon the airplane power supply"; and,
- A lifeline (used by occupants to stay on a wing after ditching).

FAA Advisory Circular (AC) 91-38A, *Large and Turbine-powered Multiengine Airplanes, Part 91, Subpart D*, recommends the use of pyrotechnic signaling devices that "have been accepted by an agency of the U.S. government for sea-rescue purposes" and that the portable emergency radio signaling device be an automatic deployable emergency locator transmitter (ADELT) that meets TSO standards (see "Stay Tuned: A Guide to Emergency Radio Beacons," page 139).

RTCA (formerly Radio Technical Commission for Aeronautics) Document DO-183, *Minimum Operational Performance Standards for Emergency Locator Transmitters*, describes an ADELT as an ELT that "is intended to be rigidly attached to the aircraft before the crash and automatically ejected and deployed after the crash force sensor has determined that a crash has occurred." The document says that an ADELT "should float in water and is intended to aid SAR [search-and-rescue] teams in locating the crash site."

A ditching-certified airplane must carry at least two life rafts during overwater operations.

Ditching Certification Requires Backups

Part 91.509 says that the required life rafts, life vests and signaling devices must be installed in "conspicuously marked locations and easily accessible in the event of a ditching without appreciable time for preparatory procedures."

An amendment to Part 91.509, effective Nov. 17, 2003, includes provisions for managers of fractional (shared) aircraft-ownership programs to apply to FAA for deviations from specific survival-equipment requirements (see "A Loophole Big Enough for a Life Raft to Fall Through," page 389).

Although Part 91.509 requires that life vests be equipped with approved survivor-locator lights and that life rafts be equipped with approved "survival locator lights" for overwater flights more than 30 minutes flying time or 100 nautical miles from the nearest shore, the regulation does not require that the life vests and life rafts, themselves, to be approved — that is, certified as meeting applicable TSO standards.

Nevertheless, if the operation involves a transport category airplane that is certified for ditching, another regulation, Part 25.1415, "Ditching equipment," applies (see "Ditching Certification: What Does It Mean?" page 66). The regulation requires that life vests and life rafts carried aboard ditching-certified airplanes be FAA-approved.

Part 25.1415 also says that "unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts [overload capacity] must accommodate all occupants of the airplane in the event of a loss of one raft of the largest rated capacity."

This means that a ditching-certified airplane must carry at least two life rafts during overwater operations, said Aaron Duncan, engineering manager for Garrett Aviation Services in Springfield, Illinois, U.S.[1]

"The regulation says that you have to assume that you are going to lose or destroy one life raft, and it has to be the largest-capacity raft," he said. "So, if I have a four-person life raft, a six-person life raft and an eight-person life raft aboard the airplane, I have to assume that I'll lose the eight-person life raft, and I have to ensure that I have enough overload capacity with the remaining life rafts to accommodate the maximum number of people aboard."

For ditching-certified airplanes, Part 25.1415 also requires the following equipment: a trailing line and a static line (i.e., mooring/inflation line) for each life raft; approved survival equipment attached to each life raft; and an approved survival-type ELT for use in one life raft.

RTCA DO-183 describes a survival-type ELT as an "ELT [that] does not normally activate automatically and is intended to

Continued on page 390

A Loophole Big Enough for a Life Raft to Fall Through

Citing the "proven reliability of turbine engines," the U.S. Federal Aviation Administration (FAA) has amended regulations on emergency/survival equipment, allowing more operators to apply for deviations from requirements to carry specific equipment — including life rafts — during overwater operations.

The amendments, which became effective Nov. 17, 2003, affect airplanes used in fractional (shared) ownership programs operated under U.S. Federal Aviation Regulations Part 91, Subpart K, and airplanes used in commuter operations and on-demand operations under Part 135.

The amendment to Part 91.509 affects requirements to carry life rafts, pyrotechnic signaling devices, emergency radio signaling devices and lifelines. The amendment allows managers of fractional ownership programs to apply to FAA for deviations from these equipment requirements for a "particular overwater operation" or to apply for amendments to their programs' management specifications to require "the carriage of all or any specific items of the equipment."

The amendment to Part 91.509 was generated during the establishment of Subpart K, a new body of Part 91 general operating and flight rules governing fractional ownership programs. During the establishment of Subpart K, Part 135 regulations were reviewed, and the amendment to Part 135.167 was generated.

"Many of the requirements in new Subpart K of Part 91 are based on requirements for on-demand operations in Part 135," FAA said. "In the process of reviewing Part 135 requirements, the [Fractional Ownership Aviation Rulemaking Committee] and the FAA determined that some of the current Part 135 requirements needed to be updated in accordance with new technology and other changes."

The amendment to Part 135.167 affects all the equipment requirements. The amendment allows operators to apply for amendments to their operations specifications requiring "carriage of all or any specific items" listed in Part 135.167 or to apply for deviations from the equipment requirements for specific extended-overwater operations.

FAA said that it received several public comments after the amendments were proposed in July 2001. Among comments opposing the revisions were the following:[1]

- "The change will jeopardize lives because any survivors of a ditching would have no means of surviving in the water until they are rescued."

- "The recent case where an Airbus A330 had a dual-engine flameout over the Atlantic Ocean because of fuel problems is a perfect example of why this equipment should be on every overwater aircraft [see 'The Unthinkable Happens,' page 3]."

- "It would decrease safety to allow flights beyond 50 nautical miles or 30 minutes flight time before requiring safety devices."

- "Thirty minutes over water without safety equipment is too much time. If the [airplane] was on fire or had other reasons for an immediate landing, the lack of a life raft could be fatal."

FAA said that proponents of the amendments "support the revision[s] because the proven reliability of turbine engines shows that there would be no compromise of safety."

When FAA gave notice in September 2003 that it was adopting the amendments, it said that operators who apply for deviations or exceptions to the equipment requirements must have a program to "demonstrate and ensure the reliability of the airplane engines" and comply with "other conditions and limitations … to ensure that safety and survivability are maintained."

FAA said that guidance for approving deviations and exceptions from Part 91.509 equipment requirements and from Part 135.167 equipment requirements will be developed from existing guidance to FAA operations inspectors for approving deviations to Part 121.339, the emergency equipment requirements for overwater operations conducted by air carriers.

The existing guidance includes the *Air Transportation Operations Inspectors Handbook*, which says that air carriers must provide the following information when they apply for a deviation from Part 121.339:[2]

- "Engine-reliability data for the aircraft to be used, including total engine hours, number of in-flight shutdowns and in-flight shutdown rates. This information must include fleetwide data and data pertinent to the operator's aircraft;

- "Aircraft operational capabilities concerning a diversion due to an engine failure. This information must include drift-down profiles, single-engine cruise performance for two[-engine aircraft] and three-engine aircraft, and two-engine cruise performance for four-engine aircraft;

- "The areas of en route operation and/or routes over which provisions of the deviation will apply, including proposed minimum en route altitudes and airports which could be used if a diversion is necessary;

- "Navigation and communication equipment requirements and capabilities for normal flight conditions and for engine-inoperative flight conditions in the proposed areas of en route operation;

- "Existing and/or proposed procedures for diversion contingency planning and training curriculums for flight [crewmembers] and cabin crewmembers concerning ditching without life rafts; [and,]
- "A description of search-and-rescue facilities and capabilities for the proposed areas of en route operations." ■

— FSF Editoral Staff

Notes

1. U.S. Federal Aviation Administration (FAA). "Regulation of Fractional Aircraft Ownership Programs and On-demand Operations." Final rule. *Federal Register*, Part II Volume 68 (Sept. 17, 2003): 54533.
2. FAA. *Air Transportation Operations Inspectors Handbook*. Order 8400.10, Volume 3, Paragraph 87, "Part 121 Operations Without Certain Emergency Equipment."

be removed from the aircraft and used to assist SAR teams in locating survivors of a crash." The document says that a survival-type ELT "can be tethered to a life raft or [to] a survivor."

Part 135 Equipment Must Be 'Approved'

The overwater emergency equipment requirements for Part 135 commuter operators and on-demand operators are similar to those in Part 91.509. Part 135.167, "Emergency equipment: Extended overwater operations," applies to flights of more than 50 nautical miles from the nearest shore in airplanes or in helicopters and to flights of more than 50 nautical miles from an "offshore heliport structure" in helicopters.

Part 135.167 requires the following equipment:

- An approved life vest equipped with an approved survivor-locator light for each occupant of the aircraft; and,
- "Enough approved life rafts of a rated capacity and buoyancy to accommodate the occupants of the aircraft."

Each of the required life rafts must have an approved survivor-locator light and an approved pyrotechnic signaling device. An approved survival-type ELT must be attached to one of the required life rafts. Part 135.167 includes specific requirements for the ELT batteries: They must be replaced or recharged when the transmitter has been used more than one cumulative hour or when the batteries have accumulated 50 percent of their useful life, as established by the battery manufacturer; and the date for the next required replacement/recharging must be marked legibly on the outside of the transmitter.

"The battery useful life (or useful life of charge) requirements … do not apply to batteries (such as water-activated batteries) that are essentially unaffected during probable storage intervals," the regulation says.

An amendment to Part 135.167, effective Nov. 17, 2003, includes provisions for Part 135 operators to apply to FAA for deviations from specific equipment requirements.

Conspicuous and Accessible

Part 91 and Part 135 both require that life rafts be stowed in "conspicuously marked locations" and that they be "easily accessible."

More specific life raft stowage requirements for operators of transport category airplanes are included in Part 25.1411, "[Safety Equipment] General." The regulation says that life rafts must be "stowed near exits through which the rafts can be launched during an unplanned ditching" and in a way that allows protection of the life rafts from inadvertent damage and "rapid detachment and removal [of the life rafts] for use at other than the intended exits."

AC 25-17, *Transport Airplane Cabin Interiors Crashworthiness Handbook*, recommends that tests be conducted to demonstrate that the installation permits rapid detachment and removal of life rafts.

"Two able-bodied adult males directed by a trained crewmember may be used [for the test], if the airplane configuration permits use of that many persons," the AC says.

Jeff Miller, a completions engineer at Duncan Aviation, an airplane-refurbishment facility in Battle Creek, Michigan, U.S., said that after his company refurbishes the interior of a transport category airplane, a life raft removal test is conducted by an FAA designated engineering representative (DER).[2]

"When we are ready to give the airplane back to the customer, the DER will come here and look at our configuration," he said. "To ensure that the life rafts are readily accessible, we will do a mock evacuation. The DER will take off the doors or covers and remove the life rafts to make sure that they don't get snagged on anything. We get right up to the point of heaving the life rafts out the window."

Stowage of life rafts can vary even in the same airplane make and model. There is no standard installation in Gulfstreams, for example.

"Since each cabin layout can differ, the location of the life rafts varies," said Robert Baugniet, director of corporate communications for Gulfstream Aerospace.[3] "They are generally stowed under the divan or in a dedicated storage area near the emergency-escape windows."

The Customer Decides

Several airplane manufacturers said that their customers choose the types of life rafts they want and where they want them installed.

"Life rafts are available as an option for the Hawker 800XP and [will be an option for the] Hawker Horizon," said Tim Travis, manager of executive and corporate communications for Raytheon Aircraft Co.[4] "Location is up to the operator. We do have installations that have already been engineered; however, most life rafts are sold as loose equipment and not as 'installed equipment,' meaning the operator has his choice of location."

Michael Pierce, Citation marketing manager for Cessna Aircraft Co., said that customers usually purchase life rafts outside Cessna and stow them in existing storage compartments.[5]

"The customers purchase whatever type of life raft they want to put in the airplanes," he said. "If they want a dedicated on-board storage compartment for a life raft, they'll give us the size of the life raft as it's stowed, and our completion center will build a cabinet around it, if they want. That's pretty rare; most people will simply stow them in available on-board storage."

When an airplane is taken to a refurbishment facility for installation of a new cabin interior, the airplane owner and the designers/engineers at the facility typically work together on life raft stowage.

"Life rafts are put in the best possible place based on the information that we have," said Jesse Villegas, purchasing agent for Associated Air Center in Dallas, Texas, U.S.[6] "There is no set place for them. The aircraft manufacturer does not dictate where they want the life rafts to be stowed. Usually, our design department or engineering department makes the decision."

Jeff Miller said that if life rafts already are installed in an airplane delivered for refurbishment, Duncan Aviation determines whether the life rafts meet current regulatory requirements and are suitable for the customer's requests for the new interior.

"Typically, if the life rafts are acceptable — if they meet the regulations and are still suitable for the new installation — we reinstall them," he said. "If the old life rafts are not going to work out because of size, we can either get them repacked or buy new ones."

Look Under the Divan

Miller said that life rafts usually are stored under divans (see photo, page 387).

"Divans typically are located near emergency exits," he said. "If the airplane does not have a divan, we put the life rafts in closets or house them in spaces between seats that face away from each other. The regulations say that the life rafts must be accessible, so we put them as close to emergency exits as possible. Anywhere in the cabin pretty much is fair game."

"The aircraft manufacturer does not dictate where they want the life rafts to be stowed."

Duncan Aviation, however, does not install life rafts in aft baggage compartments or in lavatories, Miller said.

Aaron Duncan said that Garrett Aviation does not install life rafts in Class B baggage compartments.[7]

"A Class B baggage compartment is one that is accessible in flight, but it is the type of walk-in baggage compartment that you typically find in business aircraft," he said. "It usually is in the aft end of the aircraft. You walk through the cabin, through the lavatory and open a door to get into it."

Duncan said that his company primarily refurbishes Dassault Falcons, in which life rafts typically are stowed beneath divans.

"With the models we are working on, space is fairly limited, and there are fewer options than in the larger corporate jets," he said. "Dassault does not tell us: 'Here's where the rafts have to go.' But, because the floor plans are fairly limited, most of the airplanes have life rafts in drawers or storage compartments below divans — usually, the single largest space in which we can fit a typical life raft dimension."

If the airplane does not have a divan, life rafts might be installed in a Class A baggage compartment or in a dedicated (specially built) compartment, Duncan said.

"In most mid-size aircraft, like the Hawkers and some of the Falcons, there is an open storage area across from the airstair door," he said. "It's a Class A baggage compartment because it's an open compartment that is immediately accessible to the crew."

If a customer requests a different installation, the company must ensure that the installation meets regulatory requirements.

"Because these are Part 25 aircraft, we are required to ensure that there are adequate stowage provisions for the life rafts," Duncan said. "If a customer requests a specific installation, I have to evaluate whether it is an adequate location — that it is readily accessible, that it would protect the life raft from damage and that it meets all the other Part 25 requirements."

Cabin Bulkheads Provide Stowage

Duncan said that airplane owners who do not regularly conduct overwater operations often opt for temporary stowage of life rafts on cabin bulkheads.

"Operators usually do not want to carry the extra weight [of life rafts] if they don't have to," he said. "So, when they do conduct overwater operations, they use the space between the aft-facing seats and the forward bulkhead or the space between the forward-facing seats and the aft bulkhead to stow life rafts."

Life rafts are secured to the forward bulkhead or to the aft bulkhead with webbing or are enclosed in a specially built cabinet.

"I've seen life rafts go both places," Duncan said. "These aircraft have fairly small cabins, so there is pretty much equal distance from the overwing exit, no matter where you put them."

Duncan said that many airplane owners do not own life rafts; they rent them.

"If an airplane shows up without life rafts and we are changing the interior, we have to ask the owner what type of life rafts are carried aboard the airplane," he said. "Often, we'll get the response that they do not own their own set of life rafts and that they just rent them. We will do some research, select a particular life raft and say, 'OK, we've evaluated the installation for this life raft; it has adequate capacity, and the storage provisions are acceptable.' But it is up to the operator to obtain those life rafts when they are needed under Part 91 or Part 135."

Many airplane owners do not own life rafts; they rent them.

David Miller, director of engineering for Survival Products, a life raft manufacturer based in Hollywood, Florida, U.S., said that customers who rent life rafts from the company typically are familiar with the regulatory requirements.[8]

"They seem to know what they want," he said. "They call and say, 'We need a 10-man raft with Part 135 equipment.' They usually do not come to us and say, 'We have a Falcon 50. What do we need?' If they do, we tell them to check the regulations and find out what they need. We don't have that information."

Have a Backup

Miller recommended that aircraft operators go beyond regulatory requirements to determine what they need to reduce the risk of overwater operations.

"The regulations do not force you to carry equipment unless you're flying under certain rules or flying a certain distance over the water," he said. "What is the difference whether you're 100 miles offshore or 20 miles offshore? When you end up in the water, you're in the water. I never could understand people who take advantage of the rules to save a buck."

Don Draper, inflatable shop manager for Safetech, an overwater survival equipment repair station based in Dallas, said that most people who rent life rafts from Safetech research their needs beforehand.[9] Nevertheless, he has copies of the regulations to use as a reference if a customer requires help.

Draper said that most customers rent the minimum number of life rafts required by regulations. For example, a Part 91 operator that has 12 people aboard the airplane will rent a life raft that can accommodate 12 people. Draper said that redundancy — having a backup — is just as important with overwater survival equipment as it is with other airplane equipment and systems.

"I would like to see these people get more than one life raft," he said. "But they are limited in terms of weight and space in some of these aircraft — and they tend to think of that more than anything else. The life raft is considered an inconvenience. Chances are they are not going to touch any water, but you never know."

Stock a Survival Kit

Part 91 and Part 135 require survival equipment to accompany life rafts. Part 91.509 simply says that a survival kit (also known as a survival equipment pack [SEP] when associated with life rafts) "appropriately equipped for the route to be flown" must be attached to each required life raft.

Some guidance on what might constitute an appropriately equipped survival kit is provided by AC 120-47, *Survival Equipment for Use in Overwater Operations*. The AC says that "some of the items which could be included in the survival kit are: triangular cloths; bandages; eye ointments; water-disinfection tablets; sun-protection balsam; heat-retention foils; burning glass; seasickness tablets; ammonia inhalants; [and] packets with plaster."

David Catey, an FAA national resource specialist for air carrier operations, said that a burning glass is a magnifying lens that can be used to focus sunlight to produce heat and start a fire.[10] He said that a burning glass is not intended to be used in a life raft but, rather, on shore.

Catey said that the survival-kit items listed in AC 120-47 are recommendations; they are not required.

"Part 91 operators are given some latitude to determine what is appropriate," he said "It is really up to the operator to decide what is appropriate."

Some operators, therefore, might construe the absence of specific information in the regulation as carte blanche to carry minimal survival equipment in their aircraft.

Part 135.167 is more specific. The regulation says that each required life raft must be equipped with or contain an appropriately equipped survival kit *or* the following items:

- Canopy (to serve as a sail, a sunshade or a rainwater collector);
- Radar reflector;
- Life raft repair kit;
- Bailing bucket;
- Signaling mirror;
- Police whistle;
- Life raft knife;
- Carbon-dioxide cylinder for emergency inflation;
- Inflation pump;
- Two oars;
- A 75-foot (23-meter) retaining line;
- Magnetic compass;
- Dye marker;
- Flashlight powered by at least two D-cell batteries "or equivalent";
- A two-day supply of emergency food rations providing at least 1,000 calories per day for each person;
- Two pints (one liter) of water or one seawater-desalting kit for "each two persons the raft is rated to carry";
- Fishing kit; and,
- "One book on survival appropriate for the area in which the aircraft is operated."

"It is really up to the operator to decide what is appropriate."

(The Part 135 extended-overwater equipment requirements are almost identical to those in Part 125, which governs noncommercial operation of airplanes with 20 or more passenger seats or a maximum payload capacity of 6,000 pounds [2,722 kilograms] or more.)

David Miller said that most Part 91 operators who buy or rent life rafts from his company choose Part 135 survival kits. David Draper said that many of his company's rental customers ask for Part 121 survival equipment.

"A lot of these guys think that if they get a Part 121 life raft, that's better," Draper said. "But, there is less in the survival kit for a Part 121 life raft [than in a survival kit for a Part 135 life raft]."

Part 121.339, "Emergency equipment for extended over-water operations," includes the same requirement as Part 91.509: "A survival kit, appropriately equipped for the route to be flown, must be attached to each required life raft."

Recommended minimum standards for the contents and packaging of survival kits for life rafts carried by the airlines during overwater operations are included in SAE International Aerospace Recommended Practice (ARP) 1282, Revision A, *Survival Kit — Life Rafts and Slide/Rafts*. The ARP says that the contents of a survival kit should be appropriate for the anticipated time between a ditching and the recovery of survivors.

For an anticipated period of 12 hours between ditching and recovery, the recommended items include: a survival manual; operating instructions for any equipment "whose proper use is not obvious"; signaling devices (mirror, whistle and a high-intensity flashing light); a multi-purpose knife; life raft repair kit; pliers; a bailing device; blunt-nosed scissors; and a waterproof flashlight.

The ARP says that if the anticipated time between ditching and recovery exceeds 12 hours, the operator should consider additional items, including: 30 ounces (one liter) of potable water; two water-storage containers with a capacity of three pints (1.4 liters) each; a device capable of producing from seawater at least two quarts (two liters) of potable water per day; motion-sickness remedy for each person; a radio transceiver; and thermal protection ("heat insulating and/or heat-reflecting devices suitable for retaining body heat").■

The bottom line, in our opinion …

- **Most water-contact accidents, including ditchings, occur close to shore; yet, U.S. regulations don't require life vests aboard a corporate jet or an on-demand/commuter airplane unless it is flown more than 50 nautical miles from the nearest shore.**
- **Life rafts are not required aboard a corporate jet unless it ventures more than 100 nautical miles or 30 minutes' flying time from the nearest shore.**
- **Recent amendments to the regulations allow fractional operators and on-demand/commuter operators to apply for deviations from some of the overwater-survival-equipment requirements.**
- **Operators of ditching-certified airplanes must assume that the life raft with the greatest rated capacity will be lost during a ditching/evacuation and must ensure that there are enough additional life rafts aboard to accommodate all the occupants.**
- **There is no standard storage area for life rafts in most transport category airplanes. The regulations say only that they must be in "conspicuously marked locations and easily accessible."**
- **"What is the difference whether you're 100 miles offshore or 20 miles offshore? When you end up in the water, you're in the water" … and without overwater survival equipment, you're in trouble.**

Notes

1. Duncan, Aaron. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 8, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
2. Miller, Jeff. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
3. Baugniet, Robert. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. July 3, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Travis, Tim. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. May 1, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
5. Pierce, Michael. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. May 22, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
6. Villegas, Jesse. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. April 21, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
7. U.S. Federal Aviation Regulations (FARs) Part 25.857, "Cargo compartment classification," classifies transport category cargo/baggage compartments in terms of fire detection and fire suppression. A Class B baggage compartment is classified, in part, as one for which "there is sufficient access in flight to enable a crewmember to effectively reach any part of the compartment with the contents of a hand fire extinguisher." A Class A baggage compartment is classified as one in which "the presence of a fire would be easily discovered by a crewmember while at his station and … is easily accessible in flight."
8. Miller, David. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 10, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
9. Draper, Don. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 10, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
10. Catey, David. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Oct. 27, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.

For Ditching Survival, Start With Regulations, But Don't Stop There

Complying with regulations and recommendations for life rafts, life vests and cold-water immersion suits will ensure that your water-survival equipment meets minimum requirements. But if you're forced to ditch, "minimum" is not a comforting thought.

— FSF EDITORIAL STAFF

You are 50 miles from land, and your aircraft has disappeared beneath the waves that you're floating on. It's cold, and darkness is imminent. But you're alive! Moreover, you are wearing a life vest, and the crew deployed a life raft that you should be able to reach.

And you remember, gratefully, that your company is scrupulous about going "by the book." That includes its attitude about safety equipment. You know that the life raft and its survival equipment pack (SEP) meet all the applicable regulations.

Nevertheless, there are some issues that your company might not have considered:

- Regulations and recommendations differ among various civil aviation authorities. Not all authorities and specialists in the field agree about what you need to survive;
- That your life raft is built to Technical Standard Order (TSO)-C70a, published by the U.S. Federal Aviation Administration (FAA) and adopted by several other countries, by no means guarantees that you have a life raft that offers maximum protection. TSO'd life rafts are manufactured to good material specifications, but from a design standpoint they can be quite minimal (see FAA Technical Standard Order (TSO)-C70a, *Life Rafts [Reversible and Nonreversible]*, page 396);
- If your flight has been conducted under U.S. Federal Aviation Regulations (FARs) Part 91, the general operating and flight rules, your life raft might not even be manufactured to a TSO — and it could still comply with the FARs;
- Neither Part 91 nor Part 135, the regulations governing commuter and on-demand operators, ensures that you will have an emergency radio beacon (see "Stay Tuned: A Guide to Emergency Radio Beacons," page 139) in the life raft;

Continued on page 402

FAA Technical Standard Order (TSO)-C70a, *Life Rafts (Reversible and Nonreversible)*

Date: April 13, 1984

Department of Transportation
[U.S.] Federal Aviation Administration
Office of Airworthiness
Washington, D.C. [U.S.]

(a) **Applicability.**

(1) **Minimum Performance Standards.** This Technical Standard Order (TSO) prescribes the minimum performance standards that life rafts must meet to be identified with the applicable TSO marking. This TSO has been prepared in accordance with the procedural rules set forth in Subpart O of Federal Aviation Regulations [FARs] Part 21. New models of life rafts that are to be so identified and that are manufactured on or after the date of this TSO must meet the standards set forth in Appendix 1, "Federal Aviation Administration Standard for Life Rafts," of this TSO.

(2) **Environmental Standard.** None.

(3) **Test Methods.** This TSO references Federal Test Method Standard No. 191A dated 7/20/78.

(b) **Marking.** In addition to the marking required in Federal Aviation Regulations [FARs Part] 21.607(d), the part number, serial number, date of manufacture, weight and rated and overload capacities of the life raft must be shown also. The weight of the life raft includes any accessories required in this TSO.

(c) **Data Requirements.** In accordance with [Part] 21.605, each manufacturer shall furnish the Manager, Aircraft Certification Office (ACO), Federal Aviation Administration, having geographical purview of the manufacturer's facilities, one copy each of the following technical data:

(1) Operating instructions.

(2) Packing instructions.

(3) A complete description of the device, including detail drawings, materials identification and specifications, and installation procedures.

(4) Manufacturer's TSO Qualification test reports.

(5) Applicable installation limitations, including stowage area temperatures. The manufacturer shall also provide the purchaser with such limitations.

(6) Maintenance instructions including instructions regarding inspection, repair and stowage of materials.

(7) The functional test specification to be used to test each production article to ensure compliance with this TSO.

(d) **Availability of Referenced Documents.**

(1) Appendix 1, "Federal Aviation Administration Standard for Life Rafts," of this TSO specifies certain test methods that are contained in Federal Test Method Standard No. 191A unless otherwise noted. Federal Test Method Standard No. 191A may be examined at the FAA Headquarters in the Office of Airworthiness, Aircraft Engineering Division (AWS-110), and at all Aircraft Certification Offices, and may be obtained (or purchased) from the General Services Administration, Business Service Center, Region 3, 7th and D Streets, S.W., Washington, D.C. 20407.

(2) Federal Aviation Regulations Part 21, Subpart O and Advisory Circular 20-110, *Index of Aviation Technical Standard Orders*, may be reviewed at the FAA Headquarters in the Office of Airworthiness, Aircraft Engineering Division (AWS-110), and at all regional Aircraft Certification Offices.

— J.A. Pontecorvo
Acting Director of Airworthiness

Appendix 1 — Federal Aviation Administration Standard for Life Rafts

1. **Purpose.** This standard provides the minimum performance standards for life rafts.

2. **Scope.** This standard covers the following types of life rafts:

- **Type I** — For use in any category aircraft.
- **Type II** — For use in nontransport-category aircraft.

3. **Materials and Workmanship.**

3.1 **Nonmetallic Materials.**

3.1.1 The finished device must be clean and free from any defects that might affect its function.

3.1.2 Coated fabrics and other items, such as webbing, subject to deterioration must have been manufactured not more than 18 months prior to the date of delivery of the finished product.

3.1.3 The materials must not support fungus growth.

3.1.4 **Coated fabrics — General.** Coated fabrics, including seams, subject to deterioration used in the manufacture of the devices must possess at least 90 percent of their original physical properties after these fabrics have been subjected to the accelerated-aging test specified in paragraph 6.1 of this standard. Material used in the construction of flotation chambers and decks must be capable of withstanding the detrimental effects of exposure to fuels, oils and hydraulic fluids.

3.1.4.1 **Strength.** Coated fabrics used for these applications must conform to the following minimum strengths after aging:

- **Tensile Strength (Grab Test):**
  - Warp 190 pounds/inch;
  - Fill 190 pounds/inch; [and,]
- **Tear Strength:**
  - Trapezoid Test: 13 [pounds/inch] x 13 pounds/inch (minimum); or
  - Tongue Test: 13 [pounds/inch] x 13 pounds/inch (minimum).

3.1.4.2 **Adhesion.** In addition to the requirements of 3.1.4.1, coated fabrics must meet the following minimum strengths after aging:

- **Ply Adhesion** — 5 pounds/inch width at 70 [degrees] ± 2 degrees F [Fahrenheit] at a pull rate of 2.0 [inches/minute] to 2.5 inches/minute; [and,]
- **Coat Adhesion** — 5 pounds/inch width at 70 [degrees] ± 2 degrees F at 2.0 [inches/minute] to 2.5 inches/minute.

3.1.4.3 **Permeability.** For coated fabrics used in the manufacture of inflation chambers, the maximum permeability to helium (Permeability Test Method) may not exceed 10 liters per square meter in 24 hours at 77 degrees F, or its equivalent using hydrogen. The permeameter must be calibrated for the gas used. In lieu of this permeability test, an alternate test may be used provided the alternate test has been approved as an equivalent to this permeability test by the manager of the FAA office to which this TSO data is to be submitted, as required in Paragraph (c), Data Requirements.

3.1.5 **Seam Strength and Adhesives.** Cemented or heat-sealable seams used in the manufacture of the device must meet the following minimum strength requirements:

- **Shear Strength (Seam Shear Test Method)**
  - 175 pounds/inch width at 75 degrees F;
  - 40 pounds/inch width at 140 degrees F; [and,]
- **Peel Strength (Peel Test Method):**
  - 5 pounds/inch width at 70 degrees F.

3.1.6 **Seam Tape.** If tape is used for seam reinforcement or abrasion protection of seams or both, the tape must have a minimum breaking strength (Grab Test Method) of 40 pounds/inch width in both the warp and fill directions. When applied to the seam area, the adhesion-strength characteristics must meet the seam-strength requirements in paragraph 3.1.5.

3.1.7 **Canopy.** Fabrics used for this purpose must be waterproof and resistant to sun penetration, must not affect the potability of collected water and must meet the following minimum requirements in the applicable tests prescribed in paragraph 6.1 of this standard, except that in lieu of meeting the tensile-strength requirements, a fabricated canopy may be demonstrated to withstand 35-knot winds and 52-knot gusts:

- **Tensile Strength (Grab Test):**
  - Warp 75 pounds/inch; [and,]
  - Fill 75 pounds/inch;
- **Tear Strength:**
  - Trapezoid Test: 4 [pounds/inch] x 4 pounds/inch; or
  - Tongue Test: 4 [pounds/inch] x 4 pounds/inch; [and,]
- **Coat Adhesion of Coated Fabrics:**
  - 3.5 pounds/inch width at 70 [degrees] ± 2 degrees F at a separation rate of 2.0 [inches/minute] to 2.5 inches/minute.

3.1.8 **Flammability.** The device (including carrying case or stowage container) must be constructed of materials which meet [Part] 25.853 in effect on May 1, 1972, as follows: Type I rafts must meet [Part] 25.853(b) and Type II rafts must meet [Part] 25.853 (b-3).

3.2 **Metallic Parts.** All metallic parts must be made of corrosion-resistant material or must be suitably protected against corrosion.

3.3 **Protection.** All inflation chambers and load-carrying fabrics must be protected in such a manner that nonfabric parts do not cause chafing or abrasion of the material in either the packed or the inflated condition.

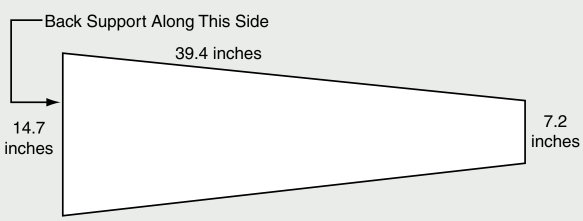
4. **Design and Construction.**

4.1 **Capacity.** The rated and overload capacities of a life raft must be based on not less than the following usable sitting areas on the deck of the life raft:

- Rated Capacity — 3.6 $feet^2$ per person
- Overload Capacity — 2.4 $feet^2$ per person

4.1.1 **Capacity — Alternate Rating Methods.** In lieu of the rated capacity as determined by paragraph 4.1 of this standard, one of the following methods may be used:

4.1.1.1 The rated capacity of a Type I or Type II life raft may be determined by the number of occupant seating spaces which can be accommodated within the occupiable area exclusive of the perimeter structure (such as buoyancy tubes) without overlapping of the occupant seating spaces and with the occupant seating spaces located to provide each occupant with a back support of not less than eight inches high. The occupant seating space may not be less than the following size:



4.1.1.2 The rated capacity of a Type I or Type II life raft may be determined on the basis of a controlled-pool or freshwater demonstration which includes conditions prescribed under Paragraph 6.2.3 of this standard and the following:

4.1.1.2.1 The sitting area on the life raft deck may not be less than three square feet per person.

4.1.1.2.2 The life raft must have a back support for each occupant of not less than 14.7 inches wide and eight inches high.

4.1.1.2.3 At least 30 percent but no more than 50 percent of the participants must be female.

4.1.1.2.4 Except as provided below, all participants must select their sitting space without placement assistance. Instructions, either identified on the raft or announced prior to the demonstration, may be used informing that each participant should have a back support. A raft commander, acting in the capacity of a crewmember, may direct occupant seating to the extent necessary to achieve reasonable weight distribution within the raft.

4.1.1.2.5 All participants must not have practiced, rehearsed or have had the demonstration procedures described to them within the past six months.

4.2 **Buoyancy.** An average occupant weight of not less than 170 pounds must be used in all applicable calculations and tests specified herein. In tests, ballast in the form of sand bags or equivalent may be used to achieve the 170-pound average, provided the appropriate weight distribution within the raft is maintained.

4.2.1 **Type I Life Raft.** Buoyancy must be provided by two independent buoyancy tubes each of which, including the raft floor, must be capable of supporting the rated and overload capacities in fresh water if the other tube is deflated. The life raft loaded to its rated capacity must have a freeboard of at least 12 inches with both buoyancy tubes at minimum operating pressure. The life raft loaded to its rated capacity with the critical tube deflated and the remaining tube at minimum operating pressure must have a freeboard of at least six inches. The life raft loaded to its overload capacity with the critical tube deflated must have a measurable freeboard.

4.2.2 **Type II Life Raft.** When single-tube construction is used to provide the buoyancy, internal bulkheads must divide the flotation tube into at least two separate chambers such that the life raft will be capable of supporting the rated number of occupants out of fresh water in the event that one chamber is deflated. The complete life raft loaded to its rated capacity must have a freeboard of at least six inches.

4.3 **Inflation.** The inflation system must be arranged so that failure of one inflatable chamber or manifold will not result in loss of gas from the other chambers. The inflation equipment must be located so as not to interfere with boarding operations. Components of the inflation system must meet Department of Transportation Specification 3AA (49 CFR 178.37) or Specification 3HT (49 CFR 178.44) in effect May 30, 1976, as applicable, or an equivalent approved by the manager of the FAA office to which this TSO data is to be submitted, as required in paragraph (c), Data Requirements. The inflation system must be constructed to minimize leakage due to back pressure after inflation. If an air aspirator system is used, the system must be constructed either to prevent the ingestion of foreign objects or to prevent failure or malfunction as a result of ingestion of small foreign objects. For Type I life rafts, there must be an independent inflation source for each primary flotation tube, except that there may be a single inflation source for all flotation tubes if data substantiating the reliability of the single inflation source is approved by the manager of the FAA office to which this TSO data is to be submitted, as required in Paragraph (c), Data Requirements.

4.4 **Life Raft Canopy.** A canopy must be packed with or attached to the raft. The erected canopy must be capable of withstanding 35-knot winds and 52-knot gusts in open water. The canopy must provide adequate headroom and must have provision for openings 180 degrees apart. Means must be provided to make the openings weathertight. If the canopy is not integral with the raft, it must be capable of being erected by occupants following conspicuously posted, simple instructions. It must be capable of being erected by one occupant of an otherwise empty raft and by occupants of a raft filled to rated capacity. For a reversible raft, attachment provisions must be installed to permit the canopy to be installed on either side of the raft.

4.5 **Capsize Resistance.** There must be water pockets or other means to provide capsize resistance for an empty or lightly loaded life raft.

4.6 **Boarding Aids.** For Type I life rafts, boarding aids must be provided at two opposing positions on the raft. One boarding aid is sufficient for a Type II life raft. Boarding aids must permit unassisted entry from the water into the unoccupied raft and must not at any time impair either the rigidity or the inflation characteristics of the raft. Puncturing of inflatable boarding aids must not affect the buoyancy of the raft buoyancy chambers. Boarding handles and/or stirrups used in conjunction with the boarding aids must withstand a pull of 500 pounds.

4.7 **Righting Aid(s).** Means must be provided to right a nonreversible life raft if it inflates in an inverted position. The means provided for righting must be such that they may be used by one person in the water.

4.8 **Lifeline.** A nonrotting lifeline of contrasting color and at least 3/8-inch diameter or 3/4-inch width must encircle the life raft on the outside periphery so that it can be easily grasped by persons in the water. The lifeline and its attachment must be capable of withstanding a minimum load of 500 pounds and must not interfere with the life raft inflation.

4.9 **Grasp Line.** A grasp line, meeting the size and strength requirements for the lifeline, must be provided with sufficient slack for use by life raft occupants to steady themselves when seated on the life raft deck with their backs to the main flotation tube(s).

4.10 **Color.** The color of the life raft's surfaces, including the canopy surface, visible from the air must be an International Orange-Yellow or an equivalent high-visibility color.

4.11 **Placards.** Suitable placarding must be provided in contrasting colors in waterproof paint which is not detrimental to the fabric, that denotes use and location of the inflation systems, raft equipment, boarding aids and righting aids. For reversible rafts, placement of the placarding must take into account usage of either side of the raft. The letters used for such placarding must be at least two inches high except that details and miscellaneous instructions may be of smaller lettering. Applicable placarding must take into account persons boarding or righting the raft from the water.

4.12 **Lights.** One or more survivor-locator lights must be provided that are approved under TSO-C85. The lights must be automatically activated upon raft inflation in the water, and visible from any direction by persons in the water.

4.13 **Raft Sea Performance.** The raft must meet the seaworthiness requirements in 6.2.3.2 and must be capable with its equipment of withstanding a saltwater marine environment for a period of at least 15 days.

5. **Life Raft Equipment.** All lines must be suitably stowed and secured to prevent entanglement during launching/inflation of a life raft.

5.1 **Mooring Line.** A nonrotting mooring line at least 20 feet in length must be attached at one end of the raft, with the remainder of the line held flaked to the carrying case (see 5.2). The mooring line must be capable of keeping the raft, loaded to maximum rated capacity, attached to a floating aircraft, and not endanger the raft or cause the raft to spill occupants if the aircraft sinks. The line may be equipped with a mechanical release linkage. The breaking strength of the line must be at least 500 pounds, or 40 times the rated capacity of the raft, whichever is greater, but need not exceed 1,000 pounds.

5.2 **Life Raft Launching Equipment.** A parachute ripcord grip and retaining pocket must form the primary inflation control. The ripcord grip or the attached static mooring line must be provided with means for attachment to the aircraft. If the ripcord grip is designed to attach to the aircraft, its strength may not be less than that of the static mooring line. The position of the ripcord grip must be standardized. When facing the release end of the carrying case, the centerline of the ripcord-grip-retaining pocket must lie at 45 degrees in the right-upper quadrant of the end section. The outermost extremity of the ripcord grip may not extend beyond the outer margin of the carrying case. The line attached to the ripcord grip must serve both to retain the life raft and to actuate the gas release(s). The tension required to withdraw the static mooring line and to actuate the gas release mechanism(s) must be between 20 [pounds] and 30 pounds. The strength of the gas release mechanism(s), its fittings and its attachments may not be less than 100 pounds.

5.3 **Sea Anchor.** A sea anchor, or anchors, or other equivalent means must be provided to maintain the raft, with rated capacity and canopy installed, on a substantially constant heading relative to the wind and have the ability to reduce the drift to two knots in 17[-knot] to 27-knot winds. Unless analysis and/or test data substantiating the adequacy of a lower breaking strength is approved by the manager of the FAA office to which this TSO data is to be submitted as required in paragraph (c), Data Requirements, the line securing a sea anchor to the raft must have a breaking strength of 500 pounds or 40 pounds times the rated capacity of the raft, whichever is greater. The attachment of the line to the raft must be capable of withstanding a load of 1.5 times the line rated strength without damaging the raft. The line must be at least 25 feet in length and must be protected to prevent it from being cut inadvertently by raft occupants.

5.4 **Heaving-Trailing Line.** At least one floating heaving-trailing line not less than 75 feet in length for Type I rafts and not less than 35 feet in length for Type II rafts, and at least 250 pounds strength, must be located on the main flotation tube near the sea-anchor attachment. The attach point of the line must withstand a pull of not less than 1.5 times the line rated strength without damage to the raft. A heaving-trailing line must be accessible in any inflated position of a reversible life raft.

5.5 **Emergency Inflation.** Means readily accessible to occupants of the raft, and having a displacement of at least 32 cubic inches per full stroke, must be provided to manually inflate and maintain chambers at minimum operating pressure. Manual inflation valves, with a nonreturn opening adequate for the size and capacity of the inflation means, must be located to permit inflation of all chambers. The location must take into consideration occupancy of each side of [a] reversible raft. The inflation means and valves must have provisions to prevent inadvertent removal and loss when either stowed or in use.

5.6 **Accessory-case Tiedowns.** Provisions must be made for tiedowns to hold any accessory case. Each accessory case tiedown must withstand a pull of 250 pounds.

5.7 **Carrying Case.** A carrying case which meets the flammability requirements of this standard and which properly fits the packed life raft must be provided. Carrying case materials must be of a highly visible color, be fungus-proof and be resistant to aircraft fuels and other fluids. The carrying case must provide chafe protection to the life raft. The carrying case must be provided with easily distinguishable handles so that it may be carried by one person, carried by two persons in tandem or dragged by either end; none of these carrying operations must tend to pull the carrying case open. Each handle must be easily grasped and its strength must be at least four times the total weight of the life raft and case. Conventional zippers may not be employed for closure. Location of and instructions for use of the inflation handle must be clearly identified and marked on the carrying-case surface.

5.8 **Knife.** A hook-type knife secured by a retaining line must be sheathed and attached to the liferaft adjacent to the point of mooring line attachment.

6. **Tests.**

6.1 **Material Tests.** The material tests required in paragraph 3.0 of this standard must be determined in accordance with the following test method or other approved equivalent methods:

Test Method

Federal Test Method Standard No. 191A Dated July 20, 1978

Tests Required		Notes
Accelerated Age	Method 5850	Per Note (1)
Tensile Strength (Grab Test)	Method 5100	
Tear Strength (Trapezoid Test)	Method 5136 (4)	
Tear Strength (Tongue Test)	Method 5134 (Alternate to Trapezoid Test: See 3.1.4.1)	
Ply Adhesion	Method 5960	
Coat Adhesion	Method 5970	
Permeability	Method 5460 (4)	
Seam-shear Strength		Per Note (2)
Seam-peel Strength	Method 5960	Per Note (3)

Notes:

(1) Samples for the accelerated aging tests must be exposed to a temperature of 158 [degrees] ± 5 degrees Fahrenheit for not less than 168 hours. After exposure, the samples must be allowed to cool to 70 [degrees] ± 2 degrees Fahrenheit for neither less than 16 hours nor more than 96 hours before determining their physical properties in accordance with 3.1 of this standard.

(2) Each sample shall consist of two strips two inches maximum width by five inches maximum length bonded together with an overlap [0.75 inch] maximum. The free ends must be placed in the testing machine described in Method 5100 and separated at a rate of 12 [inches] ± [0.5 inch] per minute. The average value of two samples must be reported. Samples may be multilayered as required to provide adequate strength to ensure against premature material failure.

(3) Separation rate must be 2.0 [inches] to 2.5 inches per minute.

(4) Federal Test Method Standard No. 191 in effect Dec. 31, 1968.

6.2 **Life Raft Tests.**

6.2.1 **Pressure Retention.** Under static conditions and when inflated and stabilized at the nominal operating pressure, the pressure in each inflatable chamber must not fall below the minimum operating pressure in less than 24 hours. The minimum operating pressure is the pressure required to meet the minimum design-buoyancy requirements of paragraph 4.2 of this standard.

6.2.2 **Overpressure Tests.**

6.2.2.1 The device must be shown by test to withstand a pressure at least 1.5 times the maximum operating pressure for at least five minutes without sustaining damage.

6.2.2.2 At least one specimen of the inflatable-device model must be shown by test to withstand a pressure at least two times the maximum operating pressure without failure. Devices so tested must be clearly identified.

6.2.3 **Functional Tests.** Each life raft model must pass the following tests:

6.2.3.1 **Water tests.** In either a controlled pool or fresh water, the life raft capacity and buoyancy must be demonstrated as follows:

6.2.3.1.1 Both rated and overload capacities established in accordance with the requirements of paragraph 4.1 of this standard must be demonstrated with inflation tubes at minimum operating pressure and with the critical buoyancy chambers deflated. The resultant freeboard in each case must meet the requirements of paragraph 4.2 of this standard.

6.2.3.1.2 Persons used in the demonstration must have an average weight of not less than 170 pounds. Ballast in the form of sand bags or equivalent may be used to achieve proper loading provided the appropriate weight distribution within the slide/raft is maintained.

6.2.3.1.3 Persons used in the demonstration must wear life [vests] with at least one chamber inflated.

6.2.3.1.4 The required life raft equipment, including one emergency locator transmitter or a weight simulating a transmitter, must be aboard the life raft.

6.2.3.1.5 It must be demonstrated that the life raft is self-righting, or can be righted by one person in water, or while inverted can be boarded and provide flotation for the normal rated capacity.

6.2.3.1.6 It must be demonstrated that the boarding aids are adequate for the purpose intended and that it is possible for an adult wearing an inflated life [vest] to board the life raft unassisted.

6.2.3.2 **Sea Trials.** The life raft must be demonstrated by tests or analysis, or a combination of both, to be seaworthy in an open sea condition of 17[-knot] to 27-knot winds and waves of six [feet] to 10 feet. In tests, ballast in the form of sand bags or equivalent may be used to achieve proper loading provided the appropriate weight distribution within the raft is maintained. If analysis is used, the analysis must be approved by the manager of the FAA office to which the TSO data is to be submitted as required in paragraph (c), Data Requirements. For this seaworthiness demonstration, the following apply:

6.2.3.2.1 The life raft must be deployed to simulate deployment from an aircraft under the most adverse wind direction and wave condition. If the life raft is an aspirated inflated type, it must be demonstrated that water ingested during inflation will not cause the raft to fail to meet the requirement for buoyancy under rated capacity in 4.2.

6.2.3.2.2 All required equipment must be aboard and the proper functioning of each item of equipment must be demonstrated.

6.2.3.2.3 The canopy must be erected for a sufficient time to assess its resistance to tearing and the protection it affords. The method of erection must be shown to be accomplished by one occupant of an otherwise empty life raft and by occupants of a life raft filled to rated capacity.

6.2.3.2.4 The stability of the life raft must be demonstrated when occupied at normal rated capacity and at 50 percent rated capacity.

6.2.3.3 **Life Raft Drop Test.** A complete life raft package must be dropped or thrown from a height of five feet onto a hard surface floor after which it must be inflated and meet the pressure-retention requirements of paragraph 6.2.1 of this standard.

6.2.3.4 **Portability Test.** If the life raft is to be manually deployed, it must be demonstrated that the complete life raft package can be moved from a typical stowage installation by no more than two persons and then deployed at another suitable exit.

6.2.3.5 **Carrying Case.** It must be demonstrated at least 10 times that the carrying case will open satisfactorily and cause no delay in the deployment and inflation of the life raft.

6.2.3.6 **Gas-cylinder Releases.** It must be demonstrated that pulling the ripcord grip from any position will actuate the primary gas release(s).

6.2.5 **Temperature Exposure and Inflation.** The manufacturer shall determine the minimum temperature at which the complete life raft assembly, with its inflation bottles, will be "rounded out" (i.e., attain its design shape and approximate dimensions) so that the life raft will be able to receive and to support the first occupant within one minute after the start of inflation. Thereafter, the rate of inflation must progress in such a manner and rate as to ensure a serviceable and rigid life raft for boarding by the remainder of the occupants. Similarly, a maximum environmental temperature to which the life raft assembly may be exposed and still remain in a seaworthy condition upon inflation must be determined. The temperature limitations must be submitted to the FAA and life raft purchaser in accordance with the data requirements of this TSO.

6.2.5.1 **Test Procedure.** The packed life raft assembly with its inflation bottles installed must be exposed to each of the above temperatures for not less than 24 hours and must be inflated within five minutes after removal from such temperatures. The life raft must be allowed to return to a temperature of approximately 70 [degrees] ± 5 degrees Fahrenheit before being deflated, repacked and subjected to a second exposure. After the above tests have been completed, the life raft must be able to pass tests required by paragraphs 6.2.1 and 6.2.2 of this standard. ■

- If your life raft, or the SEP, has not been maintained properly, its ability to help you survive could be compromised (see "Physical Fitness for Life Rafts and Life Vests," page 337); and,
- There have been documented instances in which a repair station carried out improper maintenance practices that could have put life raft occupants at greater risk following a ditching (see "Physical Fitness for Life Rafts and Life Vests").

Regulations specify what survival equipment must be carried on what categories of flights. (For U.S. regulations, see Table 1, page 403, and Table 2, page 404; for non-U.S. regulations, see Table 2.)

TSOs Set Minimum Performance Standards for Equipment

Civil aviation authorities publish TSOs, which have been defined as minimum performance standards for specified materials, parts, processes and appliances.[1]

TSOs exist for life rafts, life vests and other flotation devices, survivor-locator lights and emergency locator transmitters (ELTs; emergency radio beacons). (See page 452 for TSO-C13f for life vests; page 459 for TSO-C72c for individual flotation devices; and page 462 for TSO-C85a for survivor-locator lights.)

In addition to regulations, recommendations have been issued on topics such as crewmember survival training and preparation for ditching. Authorities have issued a variety of ditching-related documents. Table 2 summarizes some English-language regulations and recommendations.

Civil aviation authorities generally do not certify emergency equipment, as they do aircraft types and modifications. There are too many products, some of which are replaced quickly with newer versions, for a formal certification process to handle conveniently. In addition, assessing them requires specialized, non-aviation-related knowledge. Instead, the TSO provides a template for a manufacturer's designs. To be permitted to label a product as conforming to the applicable TSO, the manufacturer must demonstrate to the civil aviation authority that the product meets the standards specified in that TSO.

TSOs often are developed with the help of industry groups such as SAE International (formerly the Society of Automotive Engineers) and RTCA (formerly the Radio Technical Commission for Aeronautics), which publish technical standards based on a consensus of specialists in the relevant field. Provisions in such standards are requirements, however, only insofar as civil aviation authorities adopt them.

"The rationale for TSOs is that FAA needs to focus its limited resources on certifying aircraft rather than equipment that is relatively aircraft-independent — suitable for many aircraft types — and typically not critical to flight safety," said Hal Jensen, aerospace engineer with the FAA Aircraft Certification Service. "The initial stimulus to create a TSO often comes from the air carriers or equipment manufacturers, but sometimes NTSB [the U.S. National Transportation Safety Board] or FAA personnel in the field suggest that one is needed. FAA generally has a representative on the committee established to draft an industry standard. When a committee such as RTCA or SAE publishes its standard, we use it to the greatest possible extent as appropriate for our TSO."[2]

TSO'd Life Rafts Vary Considerably

Although TSO-C70a is detailed in some respects, life rafts with equal rated

Continued on page 450

Table 1
Emergency and Survival Equipment Required, Overwater Operations, U.S. Federal Aviation Regulations (FARs)

	Overwater Operations					
	<50 Nautical Miles From Nearest Shore (Part 91: Overwater and Beyond Gliding Distance From Shore)		Extended Overwater Operations			
			>50 to 100 Nautical Miles From Nearest Shore		>100 Nautical Miles or More Than 30 Minutes Flying Time From Nearest Shore	
Operating Under FARs …	**Required Equipment**	**Required by FARs Part …**	**Required Equipment**	**Required by FARs Part …**	**Required Equipment**	**Required by FARs Part …**
Part 91 (For hire)	Approved flotation gear Pyrotechnic signaling device(s)	91.205(b)(12)	Life vests[1] Pyrotechnic signaling device(s)	91.509(a)[2] 91.205(b)(12)	Life vests[3] Life raft(s) Pyrotechnic signaling device(s) Emergency locator transmitter (ELT) Lifeline Survival equipment pack (SEP)	91.509(b)(1)[2] 91.509(b)(2)[2] 91.509(b)(3)[2] 91.509(b)(4)[2] 91.509(b)(5)[2] 91.509(d)[2]
Part 91 (Not for hire)						
Part 135	Approved flotation gear Pyrotechnic signaling device(s)	91.205(b)(12)	Life vests Life raft SEP[4] Survival-type ELT	135.167(a)(1)[3] 135.167(a)(2) 135.167(b)(3) 135.167(c)	Life vests Life raft(s) SEP[5] Survival-type ELT	135.167(a)(1)3 135.167(a)(2) 136.157(b)(3) 135.167(c)
Part 121	Life vests or approved flotation means	121.340(a)	Life vests Life rafts Pyrotechnic signaling device(s) Survival-type ELT SEP[4]	121.339(a)(1) 121.339(a)(2) 121.339(a)(3) 121.339(a)(4) 121.339(c)	Life vests Life rafts Pyrotechnic signaling device(s) Survival-type ELT SEP[4]	121.339(a)(1) 121.339(a)(2) 121.339(a)(3) 121.339(a)(4) 121.339(c))
Airplanes Certificated for Ditching Under Part 25.801	Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss of one raft of the largest rated capacity. Each life raft must have a heaving/trailing line and a mooring/inflation line to hold the life raft near to the airplane but to release it if the airplane becomes totally submerged. Approved survival equipment attached to each life raft Survival-type ELT for use in one life raft					25.1415(b)(1) 25.1415(b)(2) 25.1415(c) 25.1415(d)
Airplanes Not Certificated for Ditching Under Part 25.801	Airplanes not having approved life vests must have an approved flotation means for each occupant, within easy reach of each seated occupant and readily removable from the airplane.					25.1415(e)
Normal-category Rotorcraft Certificated for Ditching Under Part 27.801	Life raft Life vests Signaling device					27.1415 27.1415 27.1415
Transport Category Rotorcraft Certificated for Ditching Under Part 29.801	At least two life rafts Approved survival equipment attached to each life raft Approved survival-type ELT for use in one life raft					29.1415 29.1415 29.1415

Note: *Shore* is defined as the land adjacent to the water that is above the high water mark, excluding land areas that are intermittently under water.

[1] For each occupant, a TSO-C13f life vest (see page 452) or a TSO-C72c life vest or other approved flotation means (see page 459).

[2] Applies to large and turbine-powered multi-engine airplanes.

[3] Requires, for each occupant, a TSO-C13f life vest with a TSO-C85a (see page 462) approved survivor-locator light.

[4] SEP "appropriately equipped for the route to be flown."

[5] Either a SEP "appropriately equipped for the route to be flown" or 18 specific items: one canopy (for sail, sun shade or rain catcher); one radar reflector; one life raft–repair kit; one bailing bucket; one signaling mirror; one police whistle; one raft knife; one CO_2 [carbon dioxide] bottle for emergency inflation; one inflation pump; two oars; one 75-foot retaining line; one magnetic compass; one dye marker; one flashlight having at least two D-cell batteries or equivalent; a two-day supply of emergency food rations supplying at least 1,000 calories per day for each person; for each two persons the raft is rated to carry, two pints of water or one seawater-desalting kit; one fishing kit; and one book on survival appropriate for the area in which the aircraft is operated.

Source: U.S. Federal Aviation Administration

Table 2
Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures

This table of regulatory and advisory documents concerning safety equipment, training and other aspects of overwater flight has been assembled from several sources. To the extent feasible, excerpts have been quoted directly from the documents. Care has been taken to ensure that the regulations and advisories included were current at the editorial deadline, but such documents are continually evolving. Refer to the appropriate civil aviation authority for the latest edition of any document.

The material is arranged as follows:

International Civil Aviation Organization

Document: Annex 6, Part I: International Commercial Air Transport — [Airplanes]

Subject: Requirements for international commercial air transport airplanes flying over water more than 93 kilometers (50 nautical miles) from the shore, on long-range overwater flights or under certain other conditions

Content: Seaplanes are required to carry the following:

- "One life [vest] or equivalent individual flotation device for each person on board, stowed in a position easily accessible from the seat or berth;
- "Equipment for making the sound signals prescribed in the International Regulations for Preventing Collisions at Sea, where applicable; [and,]
- "One sea anchor (drogue), when necessary to assist in maneuvering."

Landplanes are required to carry the following:

- "One life [vest] or equivalent individual flotation device for each person on board, stowed in a position easily accessible from the seat or berth of the person for whose use it is provided."

On routes on which the airplane may be over water at more than a distance corresponding to 120 minutes at cruising speed or 740 kilometers (400 nautical miles), whichever is less, away from land suitable for emergency landing, or for some airplanes 30 minutes or 185 kilometers (100 nautical miles), the aircraft must carry the following:

- "Lifesaving rafts in sufficient numbers to carry all persons on board, stowed so as to facilitate their ready use in an emergency, provided with such lifesaving equipment including means of sustaining life as is appropriate to the flight to be undertaken; [and,]
- "Equipment for making the pyrotechnical distress signals described in Annex 2."

Other provisions include the following:

- "Each life [vest] and equivalent individual flotation device … shall be equipped with a means of electric illumination for the purpose of facilitating the location of persons, except where the requirement … is met by the provision of individual flotation devices other than life [vests];
- "Until 1 January 2005 all [airplanes] operated on long-range overwater flights … shall be equipped with at least two ELTs [emergency locator transmitters];
- "All [airplanes] for which the individual certificate of airworthiness is first issued after 1 January 2002, operated on long-range overwater flights … shall be equipped with at least two ELTs, one of which shall be automatic;
- "From 1 January 2005, all [airplanes] operated in long-range overwater flights … shall be equipped with at least two ELTs, one of which shall be automatic; [and,]
- "Recommendation — All [airplanes] should carry an automatic ELT."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: Annex 6, Part II: International General Aviation — [Airplanes]

Subject: Requirements for international general aviation airplanes flying over water more than 93 kilometers (50 nautical miles) from the shore, on long-range overwater flights or under certain other conditions

Content: Seaplanes are required to carry the following:

- "One life [vest] or equivalent individual flotation device for each person on board, stowed in a position easily accessible from the seat or berth;
- "Equipment for making the sound signals prescribed in the International Regulations for Preventing Collisions at Sea, where applicable;
- "One anchor; [and,]
- "One sea anchor (drogue), when necessary to assist in maneuvering."

Landplanes are required to carry the following:

- "One life [vest] or equivalent individual flotation device for each person on board, stowed in a position easily accessible from the seat or berth of the person for whose use it is provided."

Landplanes, when over water and more than 185 kilometers (100 nautical miles) from shore, for single-engine airplanes more than 370 kilometers (200 nautical miles) from shore, for multi-engine airplanes capable of one-engine-inoperative flight, away from land suitable for making an emergency landing, are required to carry the following:

- "Lifesaving rafts in sufficient numbers to carry all persons on board, stowed so as to facilitate their ready use in an emergency, provided with such lifesaving equipment including means of sustaining life as is appropriate to the flight to be undertaken; [and,]
- "Equipment for making the pyrotechnical distress signals described in Annex 2."

Provisions for ELTs are similar to those in Part I, except that only one ELT is required.

- "Recommendation — All [airplanes] should carry an automatic ELT."

Document: Annex 6, Part III: International Operations — Helicopters

Subject: Requirements for Performance Class 1* and Performance Class 2** helicopters flying over water at a distance from land corresponding to more than 10 minutes at normal cruise speed; Performance Class 3*** helicopters "flying over water beyond autorotational or safe forced-landing distance from land"

Content: Performance Class 1 and Performance Class 2 helicopters are required to carry the following:

- "One life [vest] or equivalent individual flotation device for each person on board, stowed in a position easily accessible from the seat or berth of the person for whose use it is provided;
- "Lifesaving rafts in sufficient numbers to carry all persons on board, stowed so as to facilitate their ready use in an emergency, provided with such lifesaving equipment including means of sustaining life as is appropriate to the flight to be undertaken; [and,]
- "Equipment for making the pyrotechnical distress signals described in Annex 2."
- Performance Class 3 helicopters "when operating beyond autorotational distance from land but within a distance from land specified by the appropriate authority of the responsible State shall be equipped with one life [vest] or equivalent individual flotation device for each person on board, stowed in a position easily accessible from the seat or berth of the person for whose use it is provided." Otherwise, Performance Class 3 helicopters must carry the same equipment as Performance Class 1 and Performance Class 2 helicopters;
- At least one automatic ELT is required on most overwater helicopter flights; [and,]
- "Recommendation — All helicopters should carry an automatic ELT."

***Performance Class 1:** A helicopter that, "in case of a critical power-unit failure … is able to land on the rejected takeoff area or safely continue the flight to an appropriate landing area, depending on when the failure occurs."

****Performance Class 2:** A helicopter that, "in case of critical power-unit failure … is able to safely continue the flight, except when the failure occurs prior to a defined point after takeoff or after a defined point before landing, in which cases a forced landing may be required."

*** **Performance Class 3:** "A helicopter with performance such that, in case of power-unit failure at any point in the flight profile, a forced landing must be performed."

Document: Annex 8: Airworthiness of Aircraft

Subject: Airplanes certificated for ditching

Content: "Provisions shall be made in the design to give maximum practicable assurance that safe evacuation from the [airplane] of passengers and crew can be executed in the case of ditching."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

European Joint Aviation Authorities

Document: JAR-OPS 1.060 [Joint Airworthiness Requirements —Operations]

Subject: Ditching requirements

Content: "An operator shall not operate an [airplane] with an approved passenger seating of more than 30 passengers on overwater flights at a distance from land suitable for making an emergency landing, greater than 120 minutes at cruising speed, or 400 nautical miles, whichever is the lesser, unless the [airplane] complies with the ditching requirements prescribed in the applicable airworthiness code."

Document: JAR-OPS 1.820

Subject: Emergency locator transmitters (ELTs) in airplanes

Content:

"(a) An operator shall not operate an [airplane] first issued with an individual certificate of airworthiness on or after Jan. 1, 2002, unless it is equipped with an automatic Emergency Locator Transmitter (ELT) capable of transmitting on 121.5 MHz [megahertz] and 406 MHz;

"(b) An operator shall not operate on or after Jan. 1, 2002, an [airplane] first issued with an individual certificate of airworthiness before Jan. 1, 2002, unless it is equipped with any type of ELT capable of transmitting on 121.5 MHz and 406 MHz, except that [airplanes] equipped on or before April 1, 2000, with an automatic ELT transmitting on 121.5 MHz but not on 406 MHz may continue in service until Dec. 31, 2004; [and,]

"(c) An operator shall ensure that all ELTs that are capable of transmitting on 406 MHz shall be coded in accordance with ICAO Annex 10 and registered with the national agency responsible for initiating search and rescue or another nominated agency."

Document: JAR-OPS 1.825

Subject: Life vests in airplanes

Content:

"(a) Land [airplanes]. An operator shall not operate a land [airplane]:

"(1) When flying over water and at a distance of more than 50 nautical miles from shore; or

"(2) When taking off or landing at an [airport] where the takeoff or approach path is so disposed over water that in the event of a mishap there would be a likelihood of a ditching, unless it is equipped with life [vests] equipped with a survivor-locator light, for each person on board. Each life [vest] must be stowed in a position easily accessible from the seat or berth of the person for whose use it is provided. Life [vests] for infants may be substituted by other approved flotation devices equipped with a survivor-locator light; [and,]

"(b) Seaplanes and amphibians. An operator shall not operate a seaplane or an amphibian on water unless it is equipped with life [vests] equipped with a survivor-locator light, for each person on board. Each life [vest] must be stowed in a position easily accessible from the seat or berth of the person for whose use it is provided. Life [vests] for infants may be substituted by other approved flotation devices equipped with a survivor-locator light."

Document: JAR-OPS 1.830

Subject: Life rafts in extended overwater airplane flights

Content:

"(a) On overwater flights, an operator shall not operate an [airplane] at a distance away from land, which is suitable for making an emergency landing, greater than that corresponding to:

"(1) 120 minutes at cruising speed or 400 nautical miles, whichever is the lesser, for [airplanes] capable of continuing the flight to an [airport] with the critical power unit(s) becoming inoperative at any point along the route or planned diversions; or

"(2) 30 minutes at cruising speed or 100 nautical miles, whichever is the lesser, for all other [airplanes], unless the equipment specified in sub-paragraphs (b) and (c) below is carried;

"(b) Sufficient life rafts to carry all persons on board. Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the [airplane] in the event of the loss of one raft of the largest rated capacity. The life rafts shall be equipped with:

"(1) A survivor-locator light; and,

"(2) Lifesaving equipment including means of sustaining life as appropriate to the flight to be undertaken (see AMC OPS 1.830(b)(2)*); and,

"(c) At least two survival emergency locator transmitters (ELTs) capable of transmitting on the distress frequencies prescribed in ICAO Annex 10, Volume V, Chapter 2. (See AMC OPS 1.380(c).**)"

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

* AMC (Acceptable Means of Compliance) OPS 1.830(b)(2) says that the following should be "readily available with each life raft": means for maintaining buoyancy; a sea anchor; lifelines and means of attaching one life raft to another; paddles for life rafts with a capacity of six or fewer; means of protecting the occupants from the elements; a water-resistant torch [flashlight]; signaling equipment to make the pyrotechnical distress signals described in ICAO Annex 2; 100 grams of glucose tablet for each four, or fraction of four, persons that the life raft is designed to carry; at least two liters of drinkable water provided in durable containers or means of making seawater drinkable or a combination of both; and first aid equipment. AMC OPS 1.830(b)(2) says that as far as is practicable, the items "should be contained in a pack."

** AMC OPS 1.830(c): "1. A survival ELT (ELT[S]) is intended to be removed from the [airplane] and activated by survivors of a crash. An ELT(S) should be stowed so as to facilitate its ready removal and use in an emergency. An ELT(S) may be activated manually or automatically (e.g., by water activation). It should be designed to be tethered to a life raft or a survivor." 2. An automatic portable ELT (ELT[AP]), as installed in accordance with JAR-OPS 1.820, may be used to replace one ELT(S) provided that it meets the ELT(S) requirements. A water-activated ELT(S) as described above is not an ELT(AP)."

Document: JAR-OPS 1.835

Subject: Survival equipment in airplane flight where search and rescue would be especially difficult

Content: "An operator shall not operate an [airplane] across areas in which search and rescue would be especially difficult unless it is equipped with the following:

"(a) Signaling equipment to make the pyrotechnical distress signals described in ICAO Annex 2;

"(b) At least one ELT capable of transmitting on the distress frequencies prescribed in ICAO Annex 10, Volume V, Chapter 2 (see AMC OPS 1.830(c)); and,

"(c) Additional survival equipment for the route to be flown, taking account of the number of persons on board … ."

Document: JAR-OPS 1.965

Subject: Recurrent training and checking (flight crew)

Content: Includes, among other provisions, the following:

"(d) Emergency and safety equipment training and checking. An operator shall ensure that each flight crewmember undergoes training and checking on the location and use of all emergency and safety equipment carried. The period of validity of an emergency and safety equipment check shall be 12 calendar months in addition to the remainder of the month of issue. If issued within the final three calendar months of validity of a previous emergency and safety check, the period of validity shall extend from the date of issue until 12 calendar months from the expiry date of that previous emergency and safety equipment check."

Document: Appendix 1 to JAR-OPS 1.965

Subject: Recurrent training and checking (flight crew)

Content: Includes, among other provisions, the following:

"(a) Recurrent training — Recurrent training shall comprise: …

"(3) Emergency and safety equipment training

"(i) Emergency and safety equipment training may be combined with emergency and safety equipment checking and shall be conducted in an [airplane] or a suitable alternative training device.

"(ii) Every year the emergency and safety equipment training program must include the following:

"(A) Actual donning of a life [vest] where fitted;

"(B) Actual donning of protective breathing equipment where fitted;

"(C) Actual handling of fire extinguishers;

"(D) Instruction on the location and use of all emergency and safety equipment carried on the [airplane];

"(E) Instruction on the location and use of all types of exits; and,

"(F) Security procedures."

Document: AMC [Acceptable Means of Compliance] OPS 1.965(d)

Subject: Emergency and safety equipment training conducted under JAR-OPS 1.965(d)

Content:

"1. The successful resolution of [airplane] emergencies requires interaction between flight crew and cabin crew, and emphasis should be placed on the importance of effective coordination and two-way communication between all crew members in various emergency situations;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

"2. Emergency and safety equipment training should include joint practice in [airplane] evacuations so that all who are involved are aware of the duties other crewmembers should perform. When such practice is not possible, combined flight crew and cabin crew training should include joint discussion of emergency scenarios; [and,]

"3. Emergency and safety equipment should, as far as is practicable, take place in conjunction with cabin crew undergoing similar training with emphasis on coordinated procedures and two-way communication between the flight deck and the cabin."

Document: Appendix 1 to JAR-OPS 1.1005

Subject: Initial training (cabin crew)

Content: Includes, among other provisions, the following:

"(c) *Water survival training*. An operator shall ensure that water survival training includes the actual donning and use of personal flotation equipment in water by each cabin crewmember. Before first operating on an [airplane] fitted with life rafts or other similar equipment, training must be given on the use of this equipment, as well as actual practice in water.

"(d) *Survival training*. An operator shall ensure that survival training is appropriate to the areas of operation (e.g., polar, desert, jungle or sea)."

Document: Appendix 1 to JAR-OPS 1.1015

Subject: Recurrent training (cabin crew)

Content: Includes, among other provisions, the following:

"(c) An operator shall ensure that, at intervals not exceeding three years, recurrent training also includes: …

"(4) Use of pyrotechnics (actual or representative devices); and,

"(5) Demonstration of the use of the life raft, or slide raft, where fitted."

Document: JAR-OPS 3.825

Subject: Life vests in helicopter operations

Content:

"(a) An operator shall not operate a helicopter for any operations on water or on a flight over water:

"(1) When operating in Performance Class 3 [see ICAO Annex 6, Part III] beyond autorotational distance from land; or

"(2) When operating in Performance Class 1 or 2 [see ICAO Annex 6, Part III] at a distance from land corresponding to more than 10 minutes flying time at normal cruise speed; or

"(When operating in Performance Class 2 or 3 when taking off or landing at a heliport where the takeoff or approach path is over water, unless it is equipped with life [vests] equipped with a survivor-locator light, for each person on board, stowed in an easily accessible position, with safety belt or harness fastened, from the seat or berth of the person for whose use it is provided and an individual infant flotation device, equipped with a survivor-locator light, for use by each infant on board."

Document: JAR-OPS 3.827

Subject: Crew cold-water immersion suits in helicopter operations

Content:

"(a) An operator shall not operate a helicopter in Performance Class 1 or 2 on a flight over water at a distance from land corresponding to more than 10 minutes flying time at normal cruising speed from land on a flight in support of or in connection with the offshore exploitation of mineral resources (including gas) when the weather report or forecasts available to the commander indicate that the sea temperature will be less than plus 10 degrees C [50 degrees F] during the flight or when the estimated rescue time exceeds the calculated survival time unless each member of the crew is wearing [an immersion] suit; [and,]

"(b) An operator shall not operate a helicopter in Performance Class 3 on a flight over water beyond autorotational or safe forced-landing distance from land when the weather report or forecasts available to the commander indicate that the sea temperature will be less than plus 10 degrees C during the flight, unless each member of the crew is wearing [an immersion] suit."

Document: JAR-OPS 3.830

Subject: Life rafts and emergency locator transmitters (ELTs) in extended overwater flights by helicopters

Content:

"(a) An operator shall not operate a helicopter on a flight over water at a distance from land corresponding to more than 10 minutes flying time at normal cruising speed when operating in Performance Class 1 or 2, or three minutes flying time at normal cruising speed when operating in Performance Class 3 unless it carries:

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(1) In the case of a helicopter carrying less than 12 persons, a minimum of one life raft with a rated capacity of not less than the maximum number of persons on board;

"(2) In the case of a helicopter carrying more than 11 persons, a minimum of two life rafts sufficient together to accommodate all persons capable of being carried on board. Should one life raft of the largest rated capacity be lost, the overload capacity of the remaining life raft(s) shall be sufficient to accommodate all persons on the helicopter (see AMC OPS 3 3.830(a)(2));

"(3) At least one survival emergency locator transmitter (ELT) for each life raft carried (but not more than a total of two ELTs are required), capable of transmitting on the distress frequencies prescribed in ICAO Annex 10. (See AMC OPS 3.830(a)(3))*;

"(4) Emergency-exit illumination; and,

"(5) Lifesaving equipment, including means of sustaining life as appropriate to the flight to be undertaken."

* AMC OPS 3.830(a)(3) says, "A survival ELT (ELT[S]) is intended to be removed from the helicopter and activated by survivors of a crash. An ELT(S) should be stowed so as to facilitate its ready removal and use in an emergency. An ELT(S) may be activated manually or automatically (e.g., by water activation). It should be designed to be tethered to a life raft or a survivor."

Document: AMC [Acceptable Means of Compliance] OPS 3.830(a)(2)

Subject: Specifications for life rafts required under JAR-OPS 3.830

Content:

"1. Each life raft required by JAR-OPS 3.830 shall conform to the following specifications:

"a. They shall be of an approved design and stowed so as to facilitate their ready use in an emergency;

"b. They shall be radar-conspicuous to standard airborne radar equipment;

"c. When carrying more than one life raft on board, at least 50 percent shall be jettisonable by the crew while seated at their normal station, where necessary by remote control; [and,]

"d. Those life rafts which are not jettisonable by remote control or by the crew shall be of such weight as to permit handling by one person. Forty kilograms [88 pounds] shall be considered a maximum weight;

"2. Each life raft required by JAR-OPS 3.830 shall contain at least the following:

"a. One approved survivor-locator light;

"b. One approved visual signaling device;

"c. One canopy (for use as a sail, sun shade or rain catcher);

"d. One radar reflector;

"e. One 20-meter [66-foot] retaining line designed to hold the life raft near the helicopter but to release it if the helicopter becomes totally submerged;

"f. One sea anchor;

"g. One survival kit, appropriately equipped for the route to be flown, which shall contain at least the following:

"i. One life raft repair kit; ii. One bailing bucket; iii. One signaling mirror; iv. One police whistle; v. One buoyant raft knife; vi. One supplementary means of inflation; vii. Seasickness tablets; viii. One first aid kit; ix. One portable means of illumination; x. One half liter [0.13 U.S. gallon]; [and] xi. One comprehensive illustrated survival booklet in an appropriate language; [and,]

"3. Batteries used in the ELTs should be replaced (or recharged, if the battery is rechargeable) when the equipment has been in use for more than one cumulative hour, and also when 50 percent of their useful life (or for rechargeable [batteries], 50 percent of their useful life of charge), as established by the equipment manufacturer, has expired. The new expiration date for the replacement (or recharged) battery must be legibly marked on the outside of the equipment. The battery useful life (or useful life of charge) requirements of this paragraph do not apply to batteries (such as water-activated batteries) that are essentially unaffected during probable storage intervals."

Document: JAR-OPS 3.835

Subject: Survival equipment in helicopters

Content: "An operator shall not operate a helicopter in areas where search and rescue would be especially difficult unless it is equipped with the following:

"(a) Signaling equipment to make the pyrotechnical distress signals described in ICAO Annex 2;

"(b) At least one [ELT] capable of transmitting on the distress frequencies prescribed in ICAO Annex 10 (see AMC OPS 3.830(a)(3)); and,

"(c) Additional survival equipment for the route to be flown, taking account of the number of persons on board."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

Document: JAR-OPS 3.837

Subject: Helicopters operating to or from helidecks in a hostile sea area

Content:

"(a) An operator shall not operate a helicopter on a flight to or from a helideck located in a hostile sea area at a distance from land corresponding to more than 10 minutes flying time at normal cruising speed on a flight in support of, or in connection with, the offshore exploitation of mineral resources (including gas) unless:

"(1) When the weather report or forecasts available to the commander indicate that the sea temperature will be less than plus 10 degrees C [50 degrees F] during the flight, or when the flight is planned to be conducted at night, all persons on board are wearing [a cold-water immersion] suit (see IEM OPS 3.827)*;

"(2) All life rafts carried in accordance with JAR-OPS 3.830 are installed so as to be usable in the sea conditions in which the helicopter's ditching, flotation and trim characteristics were evaluated in order to comply with the ditching requirements for certification (see IEM OPS 3.837(a)(2));

"(3) The helicopter is equipped with an emergency-lighting system having an independent power supply to provide a source of general cabin illumination to facilitate the evacuation of the helicopter;

"(4) All emergency exits, including crew emergency exits, and its means of opening are conspicuously marked for the guidance of occupants using the exits in daylight or in the dark. Such markings are designed to remain visible if the helicopter is capsized and the cabin is submerged;

"(5) All non-jettisonable doors which are designated as ditching emergency exits have a means of securing them in the open position so they do not interfere with occupants' egress in all sea conditions up to the maximum required to be evaluated for ditching and flotation;

"(6) All doors, windows or other openings in the passenger compartment authorized by the Authority as suitable for the purpose of underwater escape, are equipped so as to be operable in an emergency; [and,]

"(7) Life [vests] are worn at all times; unless the passenger or crewmember is wearing an integrated [immersion] suit that meets the combined requirement of the [immersion] suit and life [vest] which is acceptable to the Authority."

* IEM [Interpretative/Explanatory Material] OPS 3.827 provides formulas for calculating survival times in the water under various conditions.

Document: IEM (Interpretative/Explanatory Material) OPS 3.387

Subject: Additional requirements for helicopters operating to helidecks located in a hostile sea area

Content:

"1. Operators should be aware that projections on the exterior surface of the helicopter, which are located in a zone delineated by boundaries which are 1.22 meters (four feet) above and 0.61 meters (two feet) below the established static water line could cause damage to a deployed life raft. Examples of projections which need to be considered are aerials, overboard vents, unprotected split-pin tails, guttering and any projection sharper than a three-dimensional right-angled corner;

"2. While the boundaries specified in paragraph 1 above are intended as a guide, the total area which should be considered should also take into account the likely behavior of the life raft after deployment in all sea states up to the maximum in which the helicopter is capable of remaining upright;

"3. Operators and maintenance organizations are reminded that wherever a modification or alteration is made to a helicopter within the boundaries specified, the need to prevent the modification or alteration causing damage to a deployed life raft should be taken into account in the design;

"4. Particular care should also be taken during routine maintenance to ensure that additional hazards are not introduced by, for example, leaving inspection panels with sharp corners proud of [extending from] the surrounding fuselage surface, or allowing door sills to deteriorate to a point where sharp edges become a hazard; [and,]

"5. The same considerations apply in respect of emergency flotation equipment."

Document: JAR-OPS 3.840

Subject: Miscellaneous equipment for helicopters operating on water

Content:

"(a) An operator shall not operate on water a helicopter certificated for operating on water unless it is equipped with:

"(1) A sea anchor and other equipment necessary to facilitate mooring, anchoring or maneuvering the aircraft on water, appropriate to its size, weight and handling characteristics; and,

"(2) Equipment for making the sound signals prescribed in the International Regulations for Preventing Collisions at Sea, where applicable."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: JAR-OPS 3.843

Subject: Ditching certification for helicopters on overwater flights

Content:

"(a) An operator shall not operate a helicopter in Performance Class 1 or 2 [see ICAO Annex 6, Part III] on a flight over water in a hostile environment at a distance from land corresponding to more than 10 minutes flying time at normal cruise speed unless that helicopter is so designed for landing on water or is certificated in accordance with ditching provisions;

"(b) An operator shall not operate a helicopter in Performance Class 1 or 2 on a flight over water in a non-hostile environment at a distance from land corresponding to more than 10 minutes flying time at normal cruise speed unless that helicopter is so designed for landing on water; or is certificated in accordance with ditching provisions; or is fitted with emergency flotation equipment;

"(c) An operator shall not operate a helicopter in Performance Class 2, when taking off or landing over water, unless that helicopter is so designed for landing on water; or is certificated in accordance with ditching provisions; or is fitted with emergency flotation equipment. (See IEM OPS 3.843(c)*). Except where for the purpose of minimizing exposure, the landing or takeoff at a HEMS [Helicopter Emergency Medical Service] operating site located in a congested environment is conducted over water — unless otherwise required by the Authority; [and,]

"(d) An operator shall not operate a helicopter in Performance Class 3 [see ICAO Annex 6, Part III] on a flight over water beyond safe forced-landing distance from land unless that helicopter is so designed for landing on water; or is certificated in accordance with ditching provisions; or is fitted with emergency flotation equipment."

* IEM OPS 3.843(c) says, "When helicopters are operated in Performance Class 2 and are taking off or landing over water, they are exposed to a critical-power-unit failure. They should therefore be designed for landing on water, certificated in accordance with ditching provisions or have the appropriate floats fitted (for a nonhostile environment)."

Document: JAR [Joint Airworthiness Requirement] 25.801

Subject: Certification with ditching provisions for airplanes

Content: Equivalent to U.S. Federal Aviation Regulations (FARs) Part 25.801

Document: JAR 25.1411

Subject: Safety equipment for large airplane

Content: Includes the following subparagraphs:

"(d) *Life rafts*

"(1) The stowage provisions for the life rafts described in JAR 25.1415 must accommodate enough rafts for the maximum number of occupants for which certification for ditching is requested;

"(2) Life rafts must be stowed near exits through which the rafts can be launched during an unplanned ditching;

"(3) Rafts automatically or remotely released outside the [airplane] must be attached to the [airplane] by means of the static line prescribed in JAR 25.1415; [and,]

"(4) The stowage provisions for each portable life raft must allow rapid detachment and removal of the raft for use at other than the intended exits;

"(e) *Long-range signaling device.* The stowage provisions for the long-range signaling device required by JAR 25.1415 must be near an exit available during an unplanned ditching;

"(f) *Life [vest] stowage provisions.* The stowage provisions for life [vests] described in JAR 25.1415 must accommodate one life [vest] for each occupant for which certification for ditching is requested. Each life [vest] must be within easy reach of each seated occupant; [and,]

"(g) *Life-line stowage provisions.* If certification for ditching under JAR 25.801 is requested, there must be provisions to store the life lines. These provisions must —

"(1) Allow one life line to be attached to each side of the fuselage; [and,]

"(2) Be arranged to allow the life lines to be used to enable the occupants to stay on the wing after ditching. This requirement is not applicable to [airplanes] having no overwing ditching exits."

Document: JAR 25.1415

Subject: Ditching equipment to be used in airplanes to be certificated for ditching under JAR 25.801

Content: Equivalent to FARs Part 25.1415, except for the following sections worded slightly differently:

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(a) Ditching equipment used in [airplanes] to be certified under JAR 25.801, and required by the National Operating Rules, must meet the requirements of this paragraph:

"(c) Approved survival equipment must be attached to, or stored adjacent to, each life raft;

"(d) Survival-type emergency locator transmitters for use in life rafts must meet the applicable requirements of the relevant JTSO [joint technical standard order] or an acceptable equivalent; [and,]

"(e) For [airplanes] not having approved life [vests], … ."

Document: JAR 25.1561

Subject: Marking of safety equipment for large airplanes

Content: Equivalent to FARs Part 25.1561

Document: JAR 27.801

Subject: Certification with ditching provisions for small rotorcraft

Content: Equivalent to FARs Part 27.801

Document: JAR 27.1411

Subject: Safety equipment for normal-category rotorcraft

Content: Equivalent to FARs Part 27.1411

Document: JAR 27.1415

Subject: Ditching equipment used in airplanes to be certificated for ditching under JAR 27.801

Content: Equivalent to FARs Part 27.1415

Document: JAR 27.1561

Subject: Marking of safety equipment for small rotorcraft

Content: Equivalent to FARs Part 27.1561

Document: JAR 29.807(d)

Subject: Ditching emergency exits for passengers

Content: Equivalent to FARs Part 29.807(d)

Document: JAR 29.801

Subject: Certification of large rotorcraft

Content: Equivalent to FARs Part 29.801

Document: JAR 29.807(d)

Subject: Ditching emergency exits for passengers

Content: Equivalent to FARs Part 29.807(d)

Document: JAR 29.1411

Subject: Safety equipment for transport-category rotorcraft

Content: Equivalent to FARs Part 29.1411

Document: JAR 29.1415

Subject: Ditching equipment for large rotorcraft

Content: Equivalent to FARs Part 29.1415

Document: JAR 29.1561

Subject: Marking of safety equipment for large rotorcraft

Content: Equivalent to FARs Part 29.1561(a) and (b)

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: Joint Technical Standard Order (JTSO)-C69c

Subject: Emergency evacuation slides, ramps and slide/raft combinations

Content: Equivalent to FAA TSO-C69c

Document: JTSO-C72c

Subject: Individual flotation devices

Content: Equivalent to FAA TSO-C72c

Document: JTSO-C85a

Subject: Survivor-locator lights

Content: Equivalent to FAA TSO-C85a

Document: JTSO-2C91a

Subject: Emergency locator transmitter (ELT)

Content: Incorporates by reference RTCA (formerly known as Radio Technical Commission for Aeronautics) DO-183, Section 2.0. This JTSO supplements DO-183's paragraph concerning modulation characteristics with the following:

- "To aid SAR [search-and-rescue] satellite detection, the ELT shall have clearly defined sideband components which are symmetric about the output signal spectrum and distinct from the carrier component at both the 121.5 and 243 MHz frequencies. The ELT spectrum at 121.5 MHz shall have at least 30 percent of its energy distribution within a bandwidth of ±30 Hz about a fixed reference frequency corresponding to the carrier component over the audio/sweep modulation cycle. At 243 MHz 30 percent of the energy distribution shall fall within a bandwidth of ±60 Hz; [and,]
- "All materials used, except small parts … that would not contribute significantly to the propagation of a fire, must be self-extinguishing when tested in accordance with applicable requirements of JAR 25.1359(d) and Appendix F."

The environmental standard incorporated by reference is European Organisation for Civil Aviation Electronics (EUROCAE)/RTCA document ED-14C/DO-160C, "Environmental Conditions and Test Procedures for Airborne Equipment."

- "If the equipment design implementation includes a digital computer, the computer software must be verified and validated in an acceptable manner." One acceptable means is outlined in EUROCAE/RTCA document ED-12A/DO-178A, "Software Considerations in Airborne Systems and Equipment Certification."

Document: JTSO-2C126

Subject: 406-megahertz (MHz) emergency locator transmitter (ELT)

Content: Incorporates by reference European Organisation for Civil Aviation Electronics (EUROCAE) document ED-62, "MOPS for Aircraft Emergency Locator Transmitters (121.5/243 MHz and 406 MHz)."

The environmental standard incorporated by reference is EUROCAE/Radio Technical Commission for Aeronautics (RTCA) document ED-14C/DO-160C, "Environmental Conditions and Test Procedures for Airborne Equipment."

If the equipment design implementation includes a digital computer, the software must be developed in accordance with EUROCAE/RTCA document ED-12B/DO-178B, "Software Considerations in Airborne Systems and Equipment Certification."

European Aviation Safety Agency

Document: European Technical Standard Order (ETSO)-C69c

Subject: Emergency evacuation slides, ramps, ramp/slides and slide/rafts

Content: Equivalent to U.S. Federal Aviation Administration (FAA) TSO-C69c

---

Document: ETSO-C72c

Subject: Individual flotation devices

Content: Equivalent to FAA TSO-C72c

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: ETSO-C85a

Subject: Survivor-locator lights

Content: Equivalent to FAA TSO-C85a

Document: ETSO-2C91a

Subject: Emergency locator transmitter (ELT) equipment

Content: Equivalent to European Joint Aviation Authorities (JAA) JTSO-2C91a

---

Document: ETSO-2C126

Subject: 406-megahertz (MHz) emergency locator transmitter (ELT)

Content: Equivalent to JTSO-2C126

U.K. Civil Aviation Authority

Document: Specification no. 2

Subject: Life rafts submitted for approval in accordance with the provisions of the Air Navigation Order

Content: Prescribes the minimum standards for life rafts. Expected to be replaced by forthcoming European Technical Standard Order (ETSO) harmonized with FAA TSO-C70a.

Specification no. 2 is no longer enforceable by the CAA, although the new European Aviation Safety Agency (EASA) may, if it chooses, continue to require compliance with it until the new ETSOs are approved.

Document: Appendix to Specification no. 2

Subject: Life rafts designed specifically for helicopter use

Content: Modifies Specification no. 2 for helicopters supporting offshore energy-exploitation operations. Expected to be replaced by forthcoming ETSOs.

Specification no. 2 is no longer enforceable by the CAA, although the new European Aviation Safety Agency (EASA) may, if it chooses, continue to require compliance with it until the new ETSOs are approved.

Document: British Civil Airworthiness Requirements (BCAR) Chapter A4-8

Subject: Aircraft equipment and accessories for which CAA has the primary responsibility for type approval of the product

Content: Sets out procedures whereby aircraft equipment and accessories may be approved, accepted and certified as suitable for installation in aircraft for which a U.K. Certificate of Airworthiness is desired.

Document: BCAR Chapter B4-8

Subject: Aircraft equipment and accessories for which CAA does not have the primary responsibility for type approval of the product

Content: Sets out procedures whereby aircraft equipment and accessories may be approved, accepted and certified as suitable for installation in aircraft for which a U.K. Certificate of Airworthiness is desired.

Transport Canada

Document: ***Airworthiness Manual, 537.103***

Subject: Technical Standard Orders

Content: Adopts FAA Technical Standard Orders (TSOs) that include TSO-C13f, *Life Preservers*; TSO-C69b, *Emergency Evacuation Slides, Ramps and Slide/ramp Combinations*; TSO-C70a, *Life Rafts (Reversible and Nonreversible)*; TSO-C72c, *Individual Flotation Devices*; TSO-C85a, *Survivor-locator Lights*; TSO-C91a, *Emergency Locator Transmitter* (ELT); and TSO-C126, *406-MHz Emergency Locator Transmitter (ELT)*.

Document: Canadian Aviation Regulations (CARs) 537.205

Subject: Helicopter-passenger [cold-water immersion suit] systems

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

Content: Defined as "a personal immersion-suit system that reduces thermal shock upon entry into cold water, delays onset of hypothermia during immersion in cold water and provides some flotation to minimize risk of drowning, while not impairing the wearer's ability to evacuate from a ditched helicopter."

References Canadian General Standards Board standard CAN/CGSB-65.17-99.

Document: CARs 537.207

Subject: Emergency locator transmitters

Content: References FAA TSO-C91, TSO-C91a and TSO-C126.

Document: CARs 602.62

Subject: Life vests and flotation devices

Content: Includes the following provisions:

- "No person shall conduct a takeoff or a landing on water in an aircraft or operate an aircraft over water beyond a point where the aircraft could reach shore in the event of an engine failure, unless a life [vest], individual flotation device or personal flotation device is carried for each person on board;
- "No person shall operate a land [airplane], gyroplane, helicopter or airship at more than 50 nautical miles [93 kilometers] from shore unless a life [vest] is carried for each person on board; [and,]
- "For aircraft other than balloons, every life [vest], individual flotation device and personal flotation device referred to in this section shall be stowed in a position that is easily accessible to the person for whose use it is provided, when that person is seated."

Document: CARs 602.63

Subject: Life rafts and survival equipment — flights over water

Content: Includes the following provisions:

"(1) No person shall operate over water a single-engined [airplane], or a multi-engined [airplane] that is unable to maintain flight with any engine failed, at more than 100 nautical miles [185 kilometers], or the distance that can be covered in 30 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board;

"(2) Subject to subsection (3), no person shall operate over water a multi-engined [airplane] that is able to maintain flight with any engine failed at more than 200 nautical miles [370 kilometers], or the distance that can be covered in 60 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board;

"(3) A person may operate over water a transport category aircraft that is an [airplane], at up to 400 nautical miles [741 kilometers], or the distance that can be covered in 120 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site without the life rafts referred to in subsection (2) being carried on board;

"(4) No person shall operate over water a single-engined helicopter, or a multi-engined helicopter that is unable to maintain flight with any engine failed, at more than 25 nautical miles [46 kilometers], or the distance that can be covered in 15 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board;

"(5) No person shall operate over water a multi-engined helicopter that is able to maintain flight with any engine failed at more than 50 nautical miles [93 kilometers], or the distance that can be covered in 30 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board;

"(6) The life rafts referred to in this section shall be

"(a) stowed so that they are easily accessible for use in the event of a ditching;

"(b) installed in conspicuously marked locations near an exit; and,

"(c) equipped with an attached survival kit, sufficient for the survival on water of each person on board the aircraft, given the geographical area, the season of the year and anticipated seasonal climatic variations, that provides a means for

"(i) providing shelter;

"(ii) providing or purifying water; and,

"(iii) visually signaling distress;

"(7) Where a helicopter is required to carry life rafts pursuant to subsection (4) or (5), no person shall operate the helicopter over water having a temperature of less than 10 degrees C [50 degrees F] unless

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(a) a helicopter-passenger [cold-water immersion] suit system is provided for the use of each person on board; and,

"(b) the pilot-in-command directs each person on board to wear the helicopter-passenger [immersion] suit system; [and,]

"(8) Every person who has been directed to wear a helicopter-passenger [immersion] suit system pursuant to paragraph (7)(b) shall wear that suit system."

Document: CARs 725.95

Subject: Survival equipment on life rafts

Content: "Where life rafts are required to be carried in accordance with Section 602.63 of the Canadian Aviation Regulations, they shall be equipped with an attached survival kit containing at least the following:

"(a) a pyrotechnic signaling device;

"(b) a radar reflector;

"(c) a life raft repair kit;

"(d) a bailing bucket and sponge;

"(e) a signaling mirror;

"(f) a whistle;

"(g) a raft knife;

"(h) an inflation pump;

"(i) dye marker;

"(j) a waterproof flashlight;

"(k) a two-day supply of water, calculated using the overload capacity of the raft, consisting of one pint of water per day for each person or a means of desalting or distilling salt water sufficient to provide an equivalent amount;

"(l) a fishing kit;

"(m) a book on sea survival; and,

"(n) a first aid kit containing antiseptic swabs, burn dressing compresses, bandages and anti-motion-sickness pills."

Document: Canadian General Standards Board (CGSB) CAN/CGSB-65.17-99

Subject: Helicopter-passenger cold-water immersion suits

Content: The standard applies to immersion-suit systems that reduce thermal shock on entry into cold water; delay the onset of hypothermia during immersion in cold water; provide acceptable flotation and minimize the risk of drowning; and do not impair the wearer's ability to evacuate from a ditched helicopter.

Civil Aviation Safety Authority–Australia

Document: Civil Aviation Regulations (CARs) 252A

Subject: Commercial operations, emergency locator transmitters (ELTs)

Content: Includes, among other provisions, the following:

"(1) On and after 31 July 1997, the pilot-in-command of an Australian aircraft that is not an exempted aircraft, may begin a flight only if the aircraft:

"(a) Is fitted with an approved ELT:

"(i) That is in working order; and,

"(ii) Whose switch is set to the position marked 'armed,' if that switch has a position so marked; or

"(b) Carries, in a place readily accessible to the operating crew, an approved portable ELT that is in working order; …

"(4) For the purposes of this regulation, and subject to subregulation (6), an ELT is taken to be an approved ELT in relation to an aircraft if, and only if, it is automatically activated on impact and meets any of the following requirements:

"(a) It is of a type that is authorized by the FAA [U.S. Federal Aviation Administration] in accordance with TSO [Technical Standard Order]-C91a or TSO-C126; or

"(b) CASA [Civil Aviation Safety Authority Australia] is satisfied that it meets the requirements of TSO-C91a or TSO-C126;

"(c) It was fitted to the aircraft before 5 December 1996 and meets either of the following requirements:

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(i) It is of a type that is authorized by the FAA in accordance with TSO-C91;

"(ii) CASA is satisfied that it meets the requirements of TSO-C91;

"(5) For the purposes of this regulation, and subject to subregulation (6), an ELT (whether or not automatically activated on impact) is taken to be an approved portable ELT if, and only if:

"(a) It is a portable emergency position-indicating radio beacon of a type that meets the requirements of MS* 241, MS 309, AS/NZS** 4330:1995 or AS/NZS 4280:1995; or

"(b) It is a portable ELT of a type that meets the requirements of TSO-C91, TSO-C91a or TSO-C126; [and,]

"(6) For the purposes of this regulation, an ELT is not taken to be an approved ELT or an approved portable ELT if it is fitted with a lithium-sulfur dioxide battery that does not meet the requirements of TSO-C97. … "

* MS = Ministerial Standard issued under section 9 of the Radiocommunications (Transitional Provisions and Consequential Amendments) Act of 1992.

** AS/NZS = Australian/New Zealand Standard published jointly by Standards Australia or Standards New Zealand.

Document: CARs 253

Subject: Commercial operations, emergency and lifesaving equipment

Content: Includes, among other provisions, the following:

"(1) An operator shall not assign a person to act as a crewmember of an aircraft, and a person shall not act as a crewmember of an aircraft, unless the person is competent in the use of the emergency and lifesaving equipment carried in the aircraft;

"(2) An operator shall ensure that crewmembers are periodically tested as to competency in the use of the emergency and lifesaving equipment carried in the aircraft to which they are assigned;

"(3) The operator of an aircraft which is used in overwater flights shall ensure that each crewmember is instructed in 'ditching' and 'abandon ship' procedures insofar as is practicable and that he or she is periodically tested as to his or her knowledge of those procedures; [and,]

"(4) The operator of an aircraft shall detail a crewmember to ensure that passengers are made familiar with the location of emergency exits in the aircraft in which they are traveling and the location and use of emergency equipment carried in the aircraft. … "

Document: CARs 258

Subject: Flights over water

Content:

"(1) The pilot-in-command of the aircraft must not fly over water at a distance from land greater than the distance from which the aircraft could reach land if the engine, or in the case of a multi-engined aircraft, the critical engine (being the engine the non-operation of which when the other engines are in operation gives the highest minimum speed at which the aircraft can be controlled) were inoperative. … "

Document: CARs 169

Subject: Prevention of collisions at sea

Content:

"(1) The pilot-in-command of an aircraft in flight, or in the process of maneuvering near the surface of the water, must, as far as possible:

"(a) Keep clear of all vessels; and,

"(b) Not impede their navigation; …

"(2) Subject to this regulation, the pilot-in-command of an aircraft on the water must comply with the International Regulations for Preventing Collisions at Sea as set out in Schedule 3 to the *Navigation Act 1912*; …

"(3) In conforming with the International Regulations for Preventing Collisions at Sea, the pilot-in-command of an aircraft must give due regard to the fact that in narrow channels stem vessels cannot maneuver to avoid collision, and must, as far as possible:

"(a) Keep clear of such vessels; and,

"(b) Not impede their navigation; …

"(4) Notwithstanding anything contained in the International Regulations for Preventing Collisions at Sea, the pilot-in-command of an aircraft must observe the following rules with respect to other aircraft and vessels:

"(a) When aircraft, or an aircraft and a vessel are approaching one another and there is a risk of a collision, the aircraft shall proceed with careful regard to existing circumstances and conditions, including the limitations of the respective craft;

"(b) An aircraft which is converging with another aircraft or a vessel on its right shall give way so as to keep well clear of that aircraft or vessel;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(c) An aircraft approaching another aircraft or a vessel head-on, or approximately head-on, shall alter its heading to the right so as to keep well clear of that aircraft or vessel; [and,]

"(d) An aircraft or vessel which is being overtaken has the right of way, and the one overtaking shall alter its heading to keep well clear of the aircraft or vessel being overtaken; … [and,]

"(5) At a water [airport] which is a controlled [airport], the following additional rules shall apply:

"(a) The pilot-in-command of an aircraft must not take off or alight if the alighting area:

"(i) Has not been swept; or

"(ii) Is not clear of floating debris dangerous to the navigation of the aircraft; [and,]

"(b) The pilot-in-command of an aircraft shall ensure that operations are conducted on the swept part of a water [airport] by commencing his or her takeoff or landing run from such a position that the control launch is on his or her left at no greater distance than 75 yards [69 meters]. … "

Document: CARs 551.104

Subject: ELTs

Content: Airworthiness standards for installation approval of ELTs required by CARS 605.38.

Document: CARs 551.401

Subject: Lifesaving equipment over water — Life vests

Content: Standards of airworthiness for life vests required by CARs 602.62.

Document: CARs 551.402

Subject: Lifesaving equipment over water — Individual flotation devices

Content: Standards of airworthiness for individual flotation devices required by CARs 602.62.

Document: CARs 551.403

Subject: Lifesaving equipment over water — Personal flotation devices

Content: Standards of airworthiness for personal flotation devices (PFDs) required by CARs 602.62.

Document: CARs 551.404

Subject: Lifesaving equipment over water — Life rafts

Content: Standards of airworthiness for life rafts required by CARs 602.63. TSO-C70a is the current standard.

Document: CARs 602.63

Subject: Life rafts and survival equipment for flights over water

Content:

"(1) No person shall operate over water a single-engined [airplane], or a multi-engined [airplane] that is unable to maintain flight with any engine failed, at more than 100 nautical miles, or the distance that can be covered in 30 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board.

"(2) Subject to subsection (3), no person shall operate over water a multi-engined [airplane] that is able to maintain flight with any engine failed at more than 200 nautical miles, or the distance that can be covered in 60 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board.

"(3) A person may operate over water a transport category aircraft that is an [airplane], at up to 400 nautical miles, or the distance that can be covered in 120 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site without the life rafts referred to in subsection (2) being carried on board.

"(4) No person shall operate over water a single-engined helicopter, or a multi-engined helicopter that is unable to maintain flight with any engine failed, at more than 25 nautical miles, or the distance that can be covered in 15 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board.

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(5) No person shall operate over water a multi-engined helicopter that is able to maintain flight with any engine failed at more than 50 nautical miles, or the distance that can be covered in 30 minutes of flight at the cruising speed filed in the flight plan or flight itinerary, whichever distance is the lesser, from a suitable emergency landing site unless life rafts are carried on board and are sufficient in total rated capacity to accommodate all of the persons on board;

"(6) The life rafts referred to in this section shall be

"(a) stowed so that they are easily accessible for use in the event of a ditching;

"(b) installed in conspicuously marked locations near an exit; and,

"(c) equipped with an attached survival kit, sufficient for the survival on water of each person on board the aircraft, given the geographical area, the season of the year and anticipated seasonal climatic variations, that provides a means for

"(i) providing shelter;

"(ii) providing or purifying water; and,

"(iii) visually signaling distress;

"(7) Where a helicopter is required to carry life rafts pursuant to subsection (4) or (5), no person shall operate the helicopter over water having a temperature of less than 10 degrees C [Celsius; 50 degrees Fahrenheit] unless

"(a) a helicopter-passenger [cold-water immersion suit] system is provided for the use of each person on board; and,

"(b) the pilot-in-command directs each person on board to wear the helicopter-passenger [immersion suit] system; [and,]

"(8) Every person who has been directed to wear a helicopter-passenger [immersion suit] system pursuant to paragraph (7)(b) shall wear that suit system."

Document: CARs 602.89

Subject: Passenger briefings

Content: Includes, among other provisions, the following:

"(2) The pilot-in-command of an aircraft shall ensure that all of the passengers on board the aircraft are briefed

"(a) in the case of an overwater flight where the carriage of life [vests], individual flotation devices or personal flotation devices is required pursuant to Section 602.62, before commencement of the overwater portion of the flight, with respect to the location of those items; …

"(3) The pilot-in-command of an aircraft shall, before takeoff, ensure that all of the passengers on board the aircraft are provided with information respecting the location and use of

"(a) first aid kits and survival equipment;

"(b) where the aircraft is a helicopter or a small aircraft that is an [airplane], any ELT that is required to be carried on board pursuant to section 605.38; and,

"(c) any life raft that is required to be carried on board pursuant to Section 602.63."

Document: CARs 604.73

Subject: Private-operator training program

Content: Includes, among other provisions, the following:

"(3) A private operator's ground and flight training program shall include

"(a) for flight crewmembers …

"(ii) initial and annual training, including …

"(B) emergency procedures training; …

"(b) for flight attendants, initial and annual training, including …

"(ii) safety procedures training;

"(iii) emergency procedures training; … [and,]

"(v) first aid training."

Document: CARs 605.38

Subject: ELTs

Content: Includes a table of types of ELT that must be carried on different categories of aircraft and exceptions to the rule.

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: CARs 605.39

Subject: Use of ELTs

Content:

"(1) An aircraft that is required to be equipped with one or more ELTs under section 605.38 may be operated without a serviceable ELT if the operator

"(a) repairs the ELT or removes it from the aircraft at the first [airport] at which repairs or removal can be accomplished;

"(b) on removal of the ELT, sends the ELT to a maintenance facility; and,

"(c) displays on a readily visible placard within the aircraft cockpit, until the ELT is replaced, a notice stating that the ELT has been removed and setting out the date of removal;

"(2) If an aircraft is required to have one ELT under section 605.38, the operator shall re-equip the aircraft with a serviceable ELT within

"(a) 10 days after the date of the removal, if the aircraft is operated under subpart [Commuter Operations] 4 or 5 [Airline Operations] of Part VII [Commercial Air Services]; or

"(b) 30 days after the date of removal in the case of any other aircraft; [and,]

"(3) If an aircraft is required to have two ELTs under section 605.38, the operator shall

"(a) if one of the ELTs is unserviceable, repair or replace it within 10 days after the date of removal; and,

"(b) if both ELTs are unserviceable, repair or replace

"(i) one ELT at the first [airport] at which a repair or replacement can be accomplished; and,

"(ii) the second ELT within 10 days after the date of removal."

Document: CARs 605.40

Subject: ELT activation

Content:

"(1) Subject to subsection (2), no person shall activate an ELT except in an emergency;

"(2) A person may activate an ELT during the first five minutes of any hour UTC [coordinated universal time] for a duration of not more than five seconds for the purpose of testing it; [and,]

"(3) Where an ELT has been inadvertently activated during flight, the pilot-in-command of the aircraft shall ensure that

"(a) the nearest air traffic control unit, flight service station or community [airport] radio station is so informed as soon as possible; and,

"(b) the ELT is switched off."

Document: CARs 704.115

Subject: Commuter-operations training

Content: Includes, among other provisions, the following:

"(2) An air operator's ground and flight training program shall include

"(a) for flight crew members: …

"(v) initial and annual training, including …

"(C) emergency procedures training."

Document: Civil Aviation Order (CAO) Section 20.11

Subject: Emergency and lifesaving equipment and requirements for passenger control in emergencies

Content: Includes, among other provisions, the following:

"**5 Flotation Equipment for Overwater Flights**

"5.1 Life [Vests]

"5.1.1 Aircraft shall be equipped with one life [vest] for each occupant when the aircraft is over water and at a distance from land:

"(a) In the case of a single-engine aircraft — greater than that which would allow the aircraft to reach land with the engine inoperative; and,

"(b) In the case of multi-engine aircraft — greater than 50 miles; …

"5.1.2 Land aircraft that carry passengers and are engaged in:

"(a) Regular public transport operations; or

"(b) Charter operations shall be equipped with a life [vest] or flotation device for each occupant on all flights where the takeoff or approach path is so disposed over water that in the event of a mishap occurring during the departure or the arrival it is reasonably possible that the aircraft would be forced to land onto water;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"5.1.3 Where required by paragraph 5.1.1 or paragraph 5.1.2, a life [vest] or individual flotation device shall be stowed at or immediately adjacent to each seat. In addition, sufficient additional life [vests] or individual flotation devices shall be carried in easily accessible positions for use by infants or children for whom a life [vest] or individual flotation device is not available or adjacent to their seated position;

"5.1.4 Amphibious aircraft when operating on water, helicopters equipped with fixed flotation equipment when operating on water, and all seaplanes and flying boats on all flights shall be equipped with:

"(i) One life [vest] for each occupant; and,

"(ii) An additional number of life [vests] (equal to one-fifth of the total number of occupants) in a readily accessible position near the exits;

"5.1.5 Life [vests] shall be so stowed in the aircraft that one life [vest] is readily accessible to each occupant and, in the case of passengers, within easy reach of their seats;

"5.1.6 Life [vests] shall comply with the standards specified in Section 103.13 and flotation devices shall comply with the FAA requirements TSO-C72b;

"5.1.7 Where life [vests] are required to be carried in accordance with subparagraph 5.1.1(a), each occupant shall wear a life [vest] during flight over water. However, occupants of [airplanes] need not wear life [vests] during flight above 2,000 feet above the water;

"5.1.8 Where life [vests] are required to be carried in accordance with subparagraph 5.1.1(a), each occupant shall wear a life [vest] during flight over water when the aircraft is operated beyond gliding distance from land or water, as appropriate, suitable for an emergency landing. However, occupants need not wear life [vests] when the aircraft is taking off or landing at an [airport] in accordance with a normal navigational procedure for departing from or arriving at that [airport], and occupants of [airplanes] need not wear life [vests] during flight above 2,000 feet above the water; [and,]

"5.1.9 Notwithstanding paragraph 5.1.8 above, each occupant of a helicopter operating to or from an offshore landing site located on a fixed platform or vessel shall wear a life [vest] during the entire flight over water, regardless of the class of operation or the one-engine-inoperative performance capability of the helicopter;

"5.2 Life Rafts

"5.2.1 An aircraft that is flown over water at a distance from land greater than the permitted distance must carry, as part of the emergency and lifesaving equipment, sufficient life rafts to provide a place in a life raft for each person on board the aircraft.

"5.2.1.1 For the purposes of paragraph 5.2.1, the permitted distance is:

"(a) In the case of an aircraft that has (i) four engines, or (ii) three turbine engines, or (iii) two turbine engines and is engaged in an extended-range operation … : a distance equal to 120 minutes at normal cruising speed, or 400 miles, whichever is the less; or

"(b) In any other case — a distance equal to 30 minutes at normal cruising speed, or 100 miles, whichever is the less;

"5.2.2 Notwithstanding the requirements of paragraph 5.2.1, CASA may require the carriage of life rafts on such other overwater flights as CASA considers necessary;

"5.2.3 Life rafts carried in accordance with paragraphs 5.2.1 shall be in addition to life [vests] carried in accordance with paragraphs 5.1.1 and 5.1.2;

"5.2.4 Life rafts carried in accordance with this section shall be stowed so as to be readily accessible in the event of a ditching without appreciable time for preparatory procedures. When life rafts are stowed in compartments or containers, such compartments or containers shall be appropriately and conspicuously marked. … [and,]

"Life rafts shall comply with the standards specified in Section 103.15.

"5.3 Helicopter Flotation Systems

"5.3.1 A single-engine helicopter engaged in passenger-carrying charter operations shall be equipped with an approved flotation system whenever the helicopter is operated beyond autorotative gliding distance from land; …

"5.3.2 A single-engine helicopter engaged in regular public transport operations shall be equipped with an approved flotation system whenever the helicopter is operated beyond autorotative gliding distance from land; [and,]

"5.3.3 A multi-engine helicopter engaged in passenger-carrying charter or regular public transport operations over water and which is not operated in accordance with one-engine-inoperative accountability procedures shall be equipped with an approved flotation system.

"**6 Signaling Equipment**

"6.1 Aircraft on flights where the carriage of life rafts is required by paragraph 5.2.1, or on such other overwater flights as CASA specifies, shall carry approved types of the following signaling equipment:

"(a) One emergency locator transmitter when one life raft is carried and at least two transmitters when more than one raft is carried. The transmitters shall operate on frequencies of 121.5 MHz and 243 MHz, shall be an approved emergency locator transmitter under regulation 252A … and shall be stowed so as to facilitate their ready use in an emergency; and,

"(b) A supply of pyrotechnic distress signals. …

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

"**7** **Survival Equipment**

"7.1 An aircraft shall carry survival equipment for sustaining life appropriate to the area being overflown on the following flights:

"(a) Where the carriage of life rafts [is] required by paragraphs 5.2.1 and 5.2.2; …

"**8** **Accessories for Water Operations**

"8.1 Amphibious aircraft when operating over water and all seaplanes and flying boats shall carry at least one sea anchor (drogue) and appropriate fittings shall be provided for the attachment of the sea anchor to the aircraft. …

"**10** **Emergency Procedures**

"10.1 The operator of an aircraft engaged on charter or regular public transport operations shall specify in the aircraft's operations manual the procedures for handling: …

"(e) Ditching, where appropriate.

"**14** **Briefing of Passengers**

"14.1 General

"14.1.1 The operator of an aircraft shall ensure that all passengers are orally briefed before each takeoff on: …

"(e) The use of flotation devices where applicable. …

"14.2 Overwater Operations

"14.2.1 In addition to the oral briefing required by paragraph 14.1.1, the operator of an aircraft required to carry life [vests] or other individual flotation devices, and … appropriate life rafts, in accordance with paragraphs 5.1.1, 5.1.2, 5.1.4, 5.2.1 and 5.2.2, shall ensure that all passengers are orally briefed by a crewmember on the location and use of any individual flotation devices, including the method of donning and inflating a life [vest], and the location of life rafts. In the case of aircraft engaged on charter or regular public transport operations required to carry life [vests] in accordance with paragraphs 5.1.1 or 5.1.4, this briefing shall include a demonstration of the method of donning and inflating a life [vest].

"**15** **Demonstration of Emergency Evacuation Procedures**

"15.2 Ditching Demonstration

"15.2.1 Before each type and model of aircraft with a seating capacity of more than 44 passengers is used for the carriage of passengers on charter or regular public transport operations where life rafts are required by subsection 5, the operator shall, unless specifically exempted by CASA, show by demonstration in accordance with Appendix II* of this section that the ditching procedures allow for the removal of the rafts and the evacuation of the occupants from the aircraft in an orderly and expeditious manner. … "

* Appendix II lists 19 criteria for a ditching demonstration.

Document: CAO Section 103.13

Subject: Equipment standards — Life vests

Content: Includes, among other provisions, the following:

"**2** **Approval**

"2.1 Life [vests] certified by a Contracting State as complying with one of the following specifications, as appropriate, are acceptable for use in Australian-registered aircraft subject to the life [vest] also complying with the additional requirements specified in Subsection 3:

"(a) (U.S.) Federal Aviation Administration Technical Standard Order TSO-C13e, *Life Preservers*, or

"(b) A specification approved by the Civil Aviation Authority of the United Kingdom; [and,]

"2.2 Life [vests] not complying with the specifications listed at paragraph 2.1 may be approved by the Secretary when it can be demonstrated that the life [vest] provides an equivalent standard of safety. A life [vest] so approved shall be clearly and permanently marked 'ANO 103.13 APPROVED.'

"**3** **Additional Requirements**

"3.1 The life [vest] shall be of the inflatable type; [and,]

"3.2 A whistle in a suitable stowage shall be fitted to life [vests] other than infant life [vests]."

Document: CAO Section 103.15

Subject: Equipment standards — Life rafts

Content: Includes, among other provisions, the following:

"**2** **Approval**

"2.1 Life rafts certified by a Contracting State as complying with one of the following specifications, as appropriate, are acceptable for use in Australian-registered aircraft:

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(a) USA. Federal Aviation Administration Technical Standard Order TSO-C12c, *Life Rafts (Twin-tube)*;

"(b) USA. Federal Aviation Administration Technical Standard Order TSO-C70a, *Life Rafts [Reversible and Nonreversible]*;

"(c) USA. Federal Aviation Administration Technical Standard Order TSO-C69a, *Emergency Evacuation Slides, Ramps and Slide/raft Combinations;*

"(d) A specification approved by the Civil Aviation Authority of the United Kingdom; [and,]

"2.2 Life rafts complying with the specifications listed in paragraph 2.1 may be approved by the Secretary when it can be shown that they provide an equivalent standard of safety. A life raft so approved shall be clearly and permanently marked: 'ANO 103.15 APPROVED.'"

Document: CAO Section 103.40

Subject: Equipment standards — Buoyant survival radio beacons operating on 121.5 megahertz (MHz) and 243 MHz

Contents: Includes, among other provisions, the following:

"**2 Design Requirements**

"2.1 The equipment shall be buoyant unless it is designed to be either a part of, attached to or enclosed within, other survival equipment which is buoyant. In all cases the equipment shall be self-righting to maintain the antenna substantially vertical;

"2.2 The equipment shall be designed with features which minimize any variation of radiation efficiency caused by the effects of rough water;

"2.3 The equipment shall be fitted with a towline to enable it to be tethered to a life raft unless it is designed to be a part of, or permanently attached to, a life raft. The towline shall be so attached to the equipment that it will not adversely affect the buoyancy or self-righting characteristics of the equipment;

"2.4 The equipment shall be self-activating on flotation in water and shall function normally within 15 minutes of dropping into water. Atmospheric moisture shall not cause the beacon to operate prematurely;

"2.5 The equipment shall be capable of activation without immersion in water, that is, in the event of it being required by survivors on land;

"2.6 The equipment shall be capable of being set in operation by unskilled persons. Operation shall be initiated by a simple action, and the equipment shall subsequently operate automatically;

"2.7 Simple operating instructions, preferably pictorial, in a clear and durable form, shall be permanently affixed to the equipment;

"2.8 The date when the battery is to be replaced, to ensure the specified endurance, shall be clearly and durably marked on the equipment and battery;

"2.9 The equipment shall be designed so that it can be stowed and used without prejudice to the safety of inflatable survival equipment. When not in operation, the equipment shall have no sharp projections and should present a smooth external contour;

"2.10 The equipment shall be designed so that it can be conveniently stowed in a manner appropriate to its intended method of use in an emergency. *Note: It is desirable that the equipment be designed for stowage and use as a single unit*; [and,]

"2.11 Cables interconnecting units of the equipment shall be robust and terminated in a manner which prevents incorrect connection and inadvertent or accidental disconnection;

"2.12 Reliability of operation shall be a principal design objective. Design and construction of the equipment shall be such that the possibility of internal or external damage during stowage or use is minimal. The equipment shall be resistant to the chemical effects of salt water and fungus growth;

"**3 Minimum Performance Requirements**

"3.1 The beacon shall be capable of meeting all minimum performance requirements specified in this subsection after being repeatedly subjected to the altitude, temperature and vibration conditions for which the manufacturer has rated it. Further, the beacon shall meet those minimum performance requirements under any possible combination of the following conditions:

"(a) Ambient … temperatures within the range of –20 degrees C [Celsius] to 55 degrees C [–26 degrees F (Fahrenheit) to 131 degrees F]; and,

"(b) When the beacon has functioned continuously for at least 48 hours using batteries which are at the end of their declared non-operating life. *Note: Manufacturers should take into account that the temperature under which the beacon may operate could exceed 55 degrees C. It is recommended that beacons be designed to operate at higher temperatures and have surfaces, that may be exposed, painted white to minimize solar heating*;

"3.2 The carrier frequencies shall be 121.5 [MHz] and 243 MHz within a tolerance range, in each case, of ±0.005 percent;

"3.3 The radio frequency carrier(s) shall be amplitude modulated with an audio frequency tone swept downwards through at least 700 Hz [hertz] within the range 1600 [Hz] with a sweep-repetition rate of two [per second] to four per second;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

"3.4 The emission shall be type A2 or A9 with the following characteristics:

"(a) The modulation factor shall be at least 0.85;

"(b) The modulation may be essentially or entirely negative going and the modulation envelope may be essentially rectangular;

"(c) The level of any emission 12.5 KHz [kilohertz] or more removed from the carrier frequency (or frequencies) shall be at least 25 dB [decibels] below the level of the wanted emission, except that the level of any emission more than 37.5 KHz removed from the carrier frequency (or frequencies) shall be at least 35 dB below the level of the wanted emission;

"(d) The modulated carrier(s) shall have a duty cycle of at least 33 percent; and,

"(e) The peak effective radiated power shall be at least 75 milliwatts on each frequency; [and,]

"**4 Equipment Approval**

"4.1 To gain approval for any model of survival radio beacon under the terms of this Section, the manufacturer shall certify to the Secretary that all examples of that model will comply with the design requirements and [will] be capable of meeting the minimum performance requirements specified herein when operated after prolonged stowage in aircraft;

"4.2 The manufacturer shall declare the permissible environmental conditions to which the equipment may be exposed during stowage in aircraft. *Note: The equipment should be capable of withstanding environmental cycling between –55 degrees C and 70 degrees C [–67 degrees F and 158 degrees F], atmospheric pressures equivalent to at least 50,000 feet and vibration throughout the range from 10 to 2,000 Hz, 2.5 mm [millimeters] or 0.1 inch total excursion up to 10 g acceleration*; [and,]

"4.3 The manufacturer or his agent shall provide the Secretary with descriptive information, a complete performance specification and other such data as may be required to demonstrate that the equipment for which approval is sought is designed, manufactured and capable of performance as specified in this Section. *Note: The Secretary may require that a sample beacon be made available for examination and nondestructive testing*."

Document: Civil Aviation Advisory Publication (CAAP) 252A-1 (0)

Subject: Installation of emergency locator transmitters (ELTs)

Content: Includes guidance about existing ELT installations, type approval, ELT installation, antenna installation, ELT remote controls, activation monitor, placarding, environmental considerations, aircraft maintenance schedule, test requirements, registration of ownership and recording/reporting.

Document: CAAP 253-1 (0)

Subject: Ditching

Content: Includes guidance on general technique, behavior of the airplane on impact, escape from the airplane, survival aspects of ditching, checklist, ongoing survival considerations and rescue.

Civil Aviation Authority of New Zealand

Document: Rule 91.211

Subject: Passenger briefing

Content: Contains, among other provisions, the following:

"(a) A person operating an aircraft carrying passengers must ensure that each passenger has been briefed on — …

"(4) When required to be carried by this Part —

"(i) the location of survival and emergency equipment for passenger use; [and,]

"(ii) the use of flotation equipment required under 91.525 for a flight over water; and,

"(5) Procedures in the case of an emergency landing … ."

Document: Rule 91.219

Subject: Familiarity with operating limitations and emergency equipment

Content: Contains, among other provisions, the following:

"Each pilot of an aircraft shall, before beginning a flight, be familiar with — …

"(3) The emergency equipment installed on the aircraft;

"(4) Which crewmember is assigned to operate the emergency equipment; and,

"(5) The procedures to be followed for the use of the emergency equipment in an emergency situation."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: Rule 91.231

Subject: Right-of-way rules for overwater operations

Content: "Each pilot of an aircraft on the water shall comply with the requirements of the International Regulations for Preventing Collisions at Sea."

Document: Rule 91.515

Subject: Communication and navigation equipment for visual flight rules (VFR) overwater flight

Content: "Each aircraft operating under VFR over water, at a distance that is more than 30 minutes flying time from the nearest shore, shall be equipped with —

"(1) Communication equipment that —

"(i) meets level 1 or 2 standards specified in Appendix A, A.9; and,

"(ii) is capable of providing continuous two-way communications with an appropriate ATS [air traffic service] unit or aeronautical telecommunications facility; and,

"(2) Navigation equipment that is capable of navigating the aircraft in accordance with the flight plan."

Document: Rule 91.525

Subject: Equipment required for flights over water

Content:

"(a) An aircraft operated on overwater flights must be equipped with —

"(1) For single-engine aircraft, or multi-engine aircraft unable to maintain a height of at least 1,000 feet AMSL [above mean sea level] with one engine inoperative, on flights more than gliding distance from shore, one life [vest] for each person on board stowed in a position readily accessible from each seat or berth;

"(2) For multi-engine aircraft capable of maintaining a height of at least 1,000 feet AMSL with one engine inoperative, on flights more than 50 nautical miles from shore, one life [vest] for each person on board stowed in a position readily accessible from each seat or berth;

"(3) For single-engine aircraft, or multi-engine aircraft unable to maintain a height of at least 1,000 feet AMSL with one engine inoperative, on flights of more than 100 nautical miles from shore —

"(i) sufficient life rafts with buoyancy and rated capacity to accommodate each occupant of the aircraft;

"(ii) a survivor-locator light on each life raft;

"(iii) a survival kit, appropriately equipped for the route to be flown, attached to each life raft;

"(iv) at least one pyrotechnic signaling device on each life raft; and,

"(v) one ELT(S) [survival ELT] or one EPIRB [emergency position-indicating radio beacon]; and,

"(4) For multi-engine aircraft capable of continuing flight with one or more engines inoperative, on flights of more than 200 nautical miles from shore, the equipment specified in paragraph (a)(3); and,

"(5) For aircraft in excess of 5,700 kilograms MCTOW [maximum certified takeoff weight], on flights more than 200 nautical miles from shore, the equipment specified in paragraph (a)(3) and an additional ELT(S) or EPIRB;

"(b) Life rafts, life [vests] and signaling devices must be installed in conspicuously identified locations and must be easily accessible in the event of a ditching of the aircraft."

Document: Rule 91.527

Subject: Aircraft operations on water

Content: "An aircraft operating on water must be equipped with —

"(1) One life [vest] for each person on board, stowed in a position readily accessible from each seat or berth; and,

"(2) For each aircraft in excess of 5,700 kilograms MCTOW, one sea anchor."

Document: Rule 91.529

Subject: Emergency locator transmitter (ELT)

Content: Includes, among other provisions, the following:

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(a) Except as provided in paragraphs (b), (c), (d), (e) and 121.353(b), no person may operate an aircraft that does not have an automatic ELT installed;

"(b) An aircraft may be ferried from the place where possession of the aircraft was taken to a place where the automatic ELT is to be installed if no passengers are carried on the aircraft;

"(c) An aircraft with an inoperative ELT may be ferried from a place where repairs or replacement cannot be made to a place where the repairs or replacement can be made if no passengers are carried on the aircraft; [and,]

"(d) An aircraft with an inoperative automatic ELT may be operated for a period of seven days inclusive if the aircraft is equipped with a portable ELT that is accessible to each person on board the aircraft. … "

Document: Rule 91.615

Subject: Emergency locator transmitter (ELT) tests and inspections

Content: "No person shall operate an aircraft unless the emergency locator transmitter required to be installed in that aircraft by Subpart F has —

"(1) Been tested and inspected, within the preceding 12 calendar months, in accordance with Part 43, Appendix F; and,

"(2) had its batteries replaced or recharged —

"(i) when the transmitter has been in use for more than one cumulative hour; or

"(ii) when their useful life or, for rechargeable batteries, their useful life of charge, as established by the manufacturer, has expired."

Document: Part 91, Appendix A, A.14

Subject: Emergency equipment

Content:

"(a) Each life [vest] must have a light that meets the requirements of TSO-C85 and —

"(1) For inflatable life [vests] —

"(i) a minimum inflated buoyancy of 150 newtons; and,

"(ii) manually operated CO_2 inflation with oral top-up; and,

"(2) For constant-wear anti-exposure coveralls, a minimum inherent buoyancy of 75 newtons provided by nonflammable closed-cell buoyancy foam;

"(b) Each life [vest] must meet the requirements of —

"(1) For inflatable life [vests] —

"(i) TSO-C13; or

"(ii) European Norm EN 396; or

"(iii) Maritime rule 42A.18, made pursuant to the Maritime Transport Act of 1994; or

"(2) For constant-wear anti-exposure coveralls, U.S. Coast Guard Type V PFD;

"(c) Each life raft must meet the requirements of TSO-C70 and contain a survival kit;

"(d) Each survival kit must include —

"(1) one canopy;

"(2) one radar reflector or flare kit;

"(3) one life raft–repair kit;

"(4) one bailing bucket;

"(5) one signaling mirror;

"(6) one whistle;

"(7) one raft knife;

"(8) one compressed-gas bottle for emergency inflation;

"(9) one inflation pump;

"(10) one 25-meter retaining line;

"(11) one magnetic compass;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(12) one dye marker;
"(13) one flashlight having at least two 'D' cells or equivalent;
"(14) one fishing kit;
"(15) two oars or two glove paddles;
"(16) a two-day supply of food rations supplying at least 1,000 calories per day for each person the raft is rated to carry;
"(17) 1,200 milliliters of water for every two persons the raft is rated to carry, or one seawater-desalting kit;
"(18) one first aid kit suitable for treatment of minor injuries;
"(19) one book on survival appropriate for the area over which the aircraft is operated;
"(20) a sea anchor; and,
"(21) a water-collection bag or cups; [and,]
"(e) Each survival-locator light must meet the requirements of TSO-C85."

Document: Part 91, Appendix A, A.15

Subject: Emergency locator transmitters

Content:

"(a) Except as provided in paragraph (f), each automatic ELT must meet the requirements of —
"(1) TSO-C91a for transmitting on 121.5 MHz [megahertz]; or
"(2) TSO-C126 for transmitting on 406 MHz;
"(b) Each automatic ELT must —
"(1) be attached to the aircraft in such a manner that —
"(i) the probability of damage in the event of an accident or impact is minimized;
"(ii) mounting is to primary load-carrying structure but does not degrade the structural capability of the aircraft;
"(iii) a force of 450 newtons applied to the mount in the most flexible direction will not cause a static deflection greater than 2.5 millimeters relative to a section of adjacent structure located between 0.3 meters and 1.0 meter from the mount site;
"(iv) the transmitter and any external antenna can support a 100-g load in the plus and minus directions of the three principal axes of the aircraft;
"(v) the transmitter and any external antenna are as close to each other as possible; and,
"(vi) for fixed and deployable automatic-type transmitters, the ELT is as far aft as possible;
"(2) have its crash-activation sensor —
"(i) located to prevent inadvertent operation; and,
"(ii) axis orientated to sense a primary crash pulse along the longitudinal axis of the aircraft;
"(3) have its antenna mounted —
"(i) to provide vertical polarization with the aircraft in normal flight;
"(ii) for an external antenna, no closer than 0.6 meter from any other VHF [very-high frequency] aerial unless specified by the manufacturer; [and,]
"(iii) for an internal antenna, exposed to a window at least 0.3 meter square and insulated from metal parts;
"(4) be fitted with vibration-proof RF [radio-frequency] connectors on each end of the transmitter-antenna coaxial cable; and,
"(5) have its location identified near the point of access;
"(c) Each ELT(S) [survival ELT] and EPIRB [emergency position-indicating radio beacon] must —
"(1) be self-buoyant;
"(2) be water-resistant; and,
"(3) be portable.
"(d) Each ELT(S) must meet the requirements of —
"(1) TSO-C91a; or
"(2) TSO-C126;
"(e) Each EPIRB must meet the requirements of —
"(1) Australian/New Zealand Standard AS/NZS 4330:2000; or
"(2) Australian Ministerial Standard MS241;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(f) Each automatic ELT or ELT(S) installed prior to 1 April 1997 must —

"(1) meet the requirements of TSO-C91 or TSO-C91a; and,

"(2) when the automatic ELT or ELT(S) becomes unserviceable, be replaced with an automatic ELT meeting the requirements of TSO-C91a or TSO-C126;

"(g) For the purposes of paragraph (f)(2), an automatic ELT or ELT(S) is not considered unserviceable when performing the maintenance required by 91.615;

"(h) A portable ELT must be stowed in the aircraft so as to ensure that it is readily accessible to each person in the event of an emergency; [and,]

"(i) Each portable ELT must meet the requirements of —

"(1) TSO-C91a for ELT(S) equipment; or

"(2) TSO-C126 for ELT(S) equipment; or

"(3) Australian/New Zealand Standard AS/NZS 4330:2000; or

"(4) Australian Ministerial Standard MS241."

Document: Rule 125.557

Subject: Initial training for crewmembers of medium airplanes

Content: Includes, among other provisions, the following:

"(a) Each holder of an air operator certificate shall ensure that each of its crewmembers, who has not qualified and served as a crewmember on an aircraft, complete initial training conducted —

"(1) in a structured manner; and,

"(2) in accordance with a syllabus that includes training applicable to — …

"(iv) location and operation of emergency equipment available for use by crewmembers; and, …

"(vi) location and use of all normal and emergency exits, including evacuation slides and escape ropes."

Document: Rule 125.559

Subject: Transition training for crewmembers of medium airplanes

Content: Includes, among other provisions, the following:

"(b) The transition training course shall address —

"(1) the use of all safety and emergency equipment and procedures applicable to the aircraft type or variant."

Document: Rule 135.59

Subject: Emergency and survival equipment on helicopters and small airplanes

Content: Includes, among other provisions, the following:

"(a) Each holder of an air operator certificate shall have available, for immediate communication to rescue-coordination centers, information on the emergency and survival equipment carried on board each of its aircraft; [and,]

"(b) For air operations performed in excess of 10 nautical miles from shore, the information required by paragraph (a) shall include —

"(1) the number, color and type of life rafts;

"(2) whether pyrotechnics are carried;

"(3) details of emergency medical supplies and water supplies; and,

"(4) the type and operating frequencies of any emergency portable radio equipment."

Document: Rule 135.87

Subject: Flights over water of helicopters and small airplanes

Content:

"(a) A person performing an air operation must not operate over water more than 10 nautical miles beyond gliding or autorotational distance from shore unless —

"(1) life rafts are carried of sufficient capacity to carry all occupants of the aircraft; and,

"(2) a life [vest] is worn by each passenger;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(b) A person performing an air operation in a single-engine helicopter must not operate over water more than 10 nautical miles beyond autorotational distance from shore unless —

"(1) the helicopter is equipped with an operable flotation device; or

"(2) the occupants are wearing immersion suits;

"(c) The operator of a multi-engine aircraft may, instead of the requirement in paragraph (a)(2), have life [vests] available for use in a position accessible to each passenger; [and,]

"(d) Each person performing an air transport operation over water beyond 100 nautical miles from shore must conduct the flight under IFR [instrument flight rules]."

Document: Rule 135.557

Subject: Initial training for crewmembers

Content: Includes, among other provisions, the following:

"(a) Each holder of an air operator certificate shall ensure that each of its crewmembers, who has not qualified and served as a crewmember on an aircraft, complete initial training conducted —

"(1) in a structured manner; and,

"(2) in accordance with a syllabus that includes training applicable to — …

"(iv) location and operation of emergency equipment available for use by crewmembers; and, …

"(vi) location and use of all normal and emergency exits, including evacuation slides and escape ropes."

Document: Rule 135.559

Subject: Transition training for crewmembers changing to a different type or variant, or when new procedures or equipment are introduced on an existing type or variant

Content: Includes, among other provisions, the following:

"(b) The transition training shall address —

"(1) the use of all safety and emergency equipment and procedures applicable to the aircraft type or variant."

SAE International

Document: Aerospace Recommended Practice ARP496

Subject: Stowage of cabin emergency-flotation equipment

Content: Recommendations for stowage of individual life vests; life raft; slide/raft; auxiliary flotation equipment such as seat cushions; and slide.

Document: Aerospace Recommended Practice ARP1282

Subject: Recommendations for survival kit (survival equipment pack) to be carried with life rafts or slide/rafts on transport category airplanes

Content: Recommended contents of survival kit.

Document: Aerospace Recommended Practice ARP1354

Subject: Individual inflatable life vests

Content: Recommendations for flotation attitude, donning of the life vest, general configuration, mechanical inflation system, oral inflation system and attached equipment. An appendix describes a donning test.

Document: Aerospace Recommended Practice ARP1356

Subject: Life rafts

Content: Recommendations for operational environmental conditions, buoyancy, capacity ratings, inflation system, packaging, marking, mooring line, sea anchor, canopy, heaving/trailing line, locator lights, survival equipment pack, boarding assists and knife.

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: Aerospace Standard AS4492

Subject: Survivor-locator lights

Content: Performance and design recommendations for steady-type lights (Type I) and flashing-type lights (Type II). Specifications are given for configuration/design, materials, light characteristics, power source (battery), light activation, service-life limitations, attachment provisions, moisture protection and tests.

Document: Aerospace Standard AS5134

Subject: Aviation distress signal

Content: Recommended minimum performance standards.

U.S. Federal Aviation Administration

Document: U.S. Federal Aviation Regulations (FARs) Part 23.237

Subject: Operation on water of normal, utility, acrobatic and commuter airplanes

Content: "A wave height, demonstrated to be safe for operation, and any necessary water-handling procedures for seaplanes and amphibians, must be established."

Document: FARs Part 23.239

Subject: Spray characteristics of normal, utility, acrobatic and commuter airplanes

Content: "Spray may not dangerously obscure the vision of the pilots or damage the propellers or other parts of a seaplane or amphibian at any time during taxiing, takeoff and landing."

Document: FARs Part 23.521, Part 23.523, Part 23.525, Part 23.527, Part 23.529, Part 23.531, Part 23.533, Part 23.535 and Part 23.537

Subject: Water loads for normal, utility, acrobatic and commuter airplanes

Content: These sections provide design requirements for load factors for seaplanes and amphibians.

Document: FARs Part 23.751

Subject: Main-float buoyancy for normal, utility, acrobatic and commuter seaplanes or amphibian airplanes

Content:

"(a) Each main float must have —

"(1) A buoyancy of 80 percent in excess of the buoyancy required by that float to support its portion of the maximum weight of the seaplane or amphibian in fresh water; and,

"(2) Enough watertight compartments to provide reasonable assurance that the seaplane or amphibian will stay afloat without capsizing if any two compartments of any main float are flooded; [and,]

"(b) Each main float must contain at least four watertight compartments approximately equal in volume."

Document: FARs Part 23.753

Subject: Main-float design for normal, utility, acrobatic and commuter seaplanes

Content: "Each seaplane main float must meet the requirements of [Part] 23.521."

Document: FARs Part 23.755

Subject: Hull design of normal, utility, acrobatic and commuter seaplane and amphibian airplanes

Content:

"(a) The hull of a hull seaplane or amphibian of 1,500 pounds [680 kilograms] or more maximum weight must have watertight compartments designed and arranged so that the hull auxiliary floats, and tires (if used), will keep the airplane afloat without capsizing in fresh water when —

"(1) For airplanes of 5,000 pounds or more maximum weight, any two adjacent compartments are flooded; and,

"(2) For airplanes of 1,500 pounds up to, but not including, 5,000 pounds [2,268 kilograms] maximum weight, any single compartment is flooded; [and,]

"(b) Watertight doors in bulkheads may be used for communication between compartments."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: FARs Part 23.757

Subject: Auxiliary floats for normal, utility, acrobatic and commuter seaplane and amphibian airplanes

Content: "Auxiliary floats must be arranged so that, when completely submerged in fresh water, they provide a righting moment of at least 1.5 times the upsetting moment caused by the seaplane or amphibian being tilted."

Document: FARs Part 23.1411

Subject: Safety equipment for normal, utility, acrobatic and commuter airplanes

Content:

"(a) Required safety equipment to be used by the flight crew in an emergency, such as automatic life raft releases, must be readily accessible;

"(b) Stowage provisions for required safety equipment must be furnished and must —

"(1) Be arranged so that the equipment is directly accessible and its location is obvious; and,

"(2) Protect the safety equipment from damage caused by being subjected to the inertia loads resulting from the ultimate static load factors specified in [Part] 23.561(b)(3) ['Emergency landing conditions'] of this part."

Document: FARs Part 23.1415

Subject: Ditching equipment for normal, utility, acrobatic and commuter airplanes

Content:

"(a) Emergency flotation and signaling equipment required by any operating rule in this chapter must be installed so that it is readily available to the crew and passengers;

"(b) Each raft and each life [vest] must be approved;

"(c) Each raft released automatically or by the pilot must be attached to the airplane by a line to keep it alongside the airplane. This line must be weak enough to break before submerging the empty raft to which it is attached; [and,]

"(d) Each signaling device required by any operating rule in this chapter must be accessible, function satisfactorily and must be free of any hazard in its operation."

Document: FARs Part 25.239

Subject: Spray characteristics, control and stability on water of transport category seaplanes and amphibious airplanes

Content:

"(a) For seaplanes and amphibians, during takeoff, taxiing and landing, and in the conditions set forth in paragraph (b) of this section, there may be no —

"(1) Spray characteristics that would impair the pilot's view, cause damage or result in the taking in of an undue quantity of water;

"(2) Dangerously uncontrollable porpoising, bounding or swinging tendency; or

"(3) Immersion of auxiliary floats for sponsons, wing tips, propeller blades or other parts not designed to withstand the resulting water loads;

"(b) Compliance with the requirements of paragraph (a) of this section must be shown —

"(1) In water conditions, from smooth to the most adverse condition established in accordance with [Part] 25.231 ['Longitudinal stability and control'];

"(2) In wind and crosswind velocities, water currents and associated waves and swells that may reasonably be expected in operation on water;

"(3) At speeds that may reasonably be expected in operation on water;

"(4) With sudden failure of the critical engine at any time while on water; and,

"(5) At each weight and center-of-gravity position, relevant to each operating condition, within the range of loading conditions for which certification is requested; [and,]

"(c) In the water conditions of paragraph (b) of this section, and in the corresponding wind conditions, the seaplane or amphibian must be able to drift for five minutes with engines inoperative, aided, if necessary, by a sea anchor."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: FARs Part 25.521, Part 25.523, Part 25.525, Part 25.527, Part 25.529, Part 25.531, Part 25.533, Part 25.535 and Part 25.537

Subject: Water loads for transport category airplanes

Content: These sections provide design requirements for load factors for transport category seaplanes and amphibious airplanes.

Document: FARs Part 25.563

Subject: Structural strength for ditching provisions for transport category airplanes

Content: "Structural-strength considerations of ditching provisions must be in accordance with [Part] 25.801(e)."

Document: FARs Part 25.751

Subject: Main-float buoyancy for transport category seaplanes and amphibious airplanes

Content: "Each main float must have —

"(a) A buoyancy of 80 percent in excess of that required to support the maximum weight of the seaplane or amphibian in fresh water; and,

"(b) Not less than five watertight compartments approximately equal in volume."

Document: FARs Part 25.753

Subject: Main-float design for transport category seaplanes and amphibious airplanes

Content: "Each main float must be approved and must meet the requirements of [Part] 25.521."

Document: FARs Part 25.755

Subject: Hulls for transport category seaplanes and amphibious airplanes

Content:

"(a) Each hull must have enough watertight compartments so that, with any two adjacent compartments flooded, the buoyancy of the hull and auxiliary floats (and tires, if used) provides a margin of positive stability great enough to minimize the probability of capsizing in rough, fresh water; [and,]

"(b) Bulkheads with watertight doors may be used for communication between compartments."

Document: FARs Part 25.801

Subject: Certification with ditching provisions for transport category airplanes

Content: Includes, among other provisions, the following:

"(a) The airplane must meet the requirements of this [Part] and [Parts] 25.807(e) ['Emergency exits'], 25.1411 and 25.1415(a);

"(b) Each practicable design measure, compatible with the general characteristics of the airplane, must be taken to minimize the probability that in an emergency landing on water, the behavior of the airplane would cause immediate injury to the occupants or would make it impossible for them to escape;

"(c) The probable behavior of the airplane in a water landing must be investigated by model tests or by comparison with airplanes of similar configuration for which the ditching characteristics are known. Scoops, flaps, projections, and any other factor likely to affect the hydrodynamic characteristics of the airplane, must be considered;

"(d) It must be shown that, under reasonably probable water conditions, the flotation time and trim of the airplane will allow the occupants to leave the airplane and enter the life rafts required by [Part] 25.1415. If compliance with this provision is shown by buoyancy and trim computations, appropriate allowances must be made for probable structural damage and leakage. If the airplane has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume; [and,]

"(e) Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behavior of the airplane in a water landing (as prescribed in paragraphs (c) and (d) of this [Part]), the external doors and windows must be designed to withstand the probable maximum local pressures."

Document: FARs Part 25.1411

Subject: Safety equipment for transport category airplanes

Content:

"(a) *Accessibility.* Required safety equipment to be used by the crew in an emergency must be readily accessible;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

"(b) *Stowage provisions.* Stowage provisions for required emergency equipment must be furnished and must —

"(1) Be arranged so that the equipment is directly accessible and its location is obvious; and,

"(2) Protect the safety equipment from inadvertent damage;

"(c) *Emergency exit descent device.* The stowage provisions for the emergency exit descent device required by [Part] 25.809(f) must be at the exits for which they are intended;

"(d) *Life rafts.*

"(1) The stowage provisions for the life rafts described in [Part] 25.1415 must accommodate enough rafts for the maximum number of occupants for which certification for ditching is requested;

"(2) Life rafts must be stowed near exits through which the rafts can be launched during an unplanned ditching;

"(3) Rafts automatically or remotely released outside the airplane must be attached to the airplane by means of the static line prescribed in [Part] 25.1415; [and,]

"(4) The stowage provisions for each portable life raft must allow rapid detachment and removal of the raft for use at other than the intended exits;

"(e) *Long-range signaling device.* The stowage provisions for the long-range signaling device required by [Part] 25.1415 must be near an exit available during an unplanned ditching;

"(f) *Life [vest] stowage provisions.* The stowage provisions for life [vest(s)] described in [Part] 25.1415 must accommodate one life [vest] for each occupant for which certification for ditching is requested. Each life [vest] must be within easy reach of each seated occupant; [and,]

"(g) *Life line stowage provisions.* If certification for ditching under [Part] 25.801 is requested, there must be provisions to store life lines. These provisions must —

"(1) Allow one life line to be attached to each side of the fuselage; and,

"(2) Be arranged to allow the life lines to be used to enable the occupants to stay on the wing after ditching."

Document: FARs Part 25.1415

Subject: Ditching equipment used in airplanes to be certificated for ditching under Part 25.801

Content:

(a) "Ditching equipment used in airplanes to be certificated for ditching under [Part] 25.801, and required by the operating rules of this chapter, must meet the requirements of this [Part];

(b) "Each life raft and each life [vest] must be approved. In addition —

(1) "Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss of one raft of the largest rated capacity; and,

(2) "Each raft must have a trailing line, and must have a static line designed to hold the raft near the airplane but to release it if the airplane becomes totally submerged;

(c) "Approved survival equipment must be attached to each life raft;

(d) "There must be an approved survival-type emergency locator transmitter for use in one life raft; [and,]

(e) "For airplanes not certificated for ditching under [Part] 25.801 and not having approved life [vest(s)], there must be an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane."

Document: FARs Part 25.1561

Subject: Marking of safety equipment for transport category airplanes

Content:

"(a) Each safety-equipment control to be operated by the crew in an emergency, such as controls for automatic life raft releases, must be plainly marked as to its method of operation;

"(b) Each location, such as a locker or compartment, that carries any fire extinguishing, signaling or other lifesaving equipment must be marked accordingly;

"(c) Stowage provisions for required emergency equipment must be conspicuously marked to identify the contents and facilitate the easy removal of the equipment;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(d) Each life raft must have obviously marked operating instructions; [and,]

"(e) Approved survival equipment must be marked for identification and method of operation."

Document: FARs Part 27.239

Subject: Spray characteristics for water-based normal category rotorcraft

Content: "If certification for water operation is requested, no spray characteristics during taxiing, takeoff or landing may obscure the vision of the pilot or damage the rotors, propellers or other parts of the rotorcraft."

Document: FARs Part 27.521

Subject: Float-landing conditions for normal category rotorcraft

Content: "If certification for float operation is requested, the rotorcraft, with floats, must be designed to withstand the following loading conditions (where the limit load factor is determined under [Part] 27.473(b) ['Ground loading conditions and assumptions'] or assumed to be equal to that determined for wheel landing gear):

"(a) Up-load conditions in which —

"(1) A load is applied so that, with the rotorcraft in the static level attitude, the resultant water reaction passes vertically through the center of gravity; and,

"(2) The vertical load prescribed in paragraph (a)(1) of this section is applied simultaneously with an aft component of 0.25 times the vertical component; [and,]

"(b) A side-load condition in which —

"(1) A vertical load of 0.75 times the total vertical load specified in paragraph (a)(1) of this section is divided equally among the floats; and,

"(2) For each float, the load share determined under paragraph (b)(1) of this section, combined with a total side load of 0.25 times the total vertical load specified in paragraph (b)(1) of this section, is applied to the float only."

Document: FARs Part 27.563

Subject: Structural ditching provisions for normal category rotorcraft

Content: "If certification with ditching provisions is requested, structural strength for ditching must meet the requirements of this [Part] and [Part] 27.801(e).

"(a) *Forward speed landing conditions*. The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 30 knots in likely pitch, roll and yaw attitudes. The rotorcraft limit vertical-descent velocity may not be less than five feet per second relative to the mean water surface. Rotor lift may be used to act through the center of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out touchdown;

"(b) *Auxiliary or emergency float conditions* —

"(1) *Floats fixed or deployed before initial water contact*. In addition to the landing loads in paragraph (a) of this [Part], each auxiliary or emergency float, or its support and attaching structure in the airframe of the fuselage, must be designed for the load developed by a fully immersed float unless it can be shown that full immersion is unlikely. If full immersion is unlikely, the highest likely float-buoyancy load must be applied. The highest likely buoyancy load must include consideration of a partially immersed float creating restoring moments to compensate the upsetting moments caused by side wind, unsymmetrical rotorcraft loading, water wave action, rotorcraft inertia and probable structural damage and leakage considered under [Part] 27.801(d).

"Maximum roll and pitch angles determined from compliance with [Part] 27.801(d) may be used, if significant, to determine the extent of immersion of each float. If the floats are deployed in flight, appropriate air loads derived from the flight limitations with the floats deployed shall be used in substantiation of the floats and their attachment to the rotorcraft. For this purpose, the design airspeed for limit load is the float-deployed airspeed-operating limit multiplied by 1.11; [and,]

"(2) *Floats deployed after initial water contact*. Each float must be designed for full or partial immersion prescribed in paragraph (b)(1) of this [Part]. In addition, each float must be designed for combined vertical and drag loads using a relative limit speed of 20 knots between the rotorcraft and the water. The vertical load may not be less than the highest likely buoyancy load determined under paragraph (b)(1) of this [Part]."

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: FARs Part 27.751

Subject: Main-float buoyancy for normal category rotorcraft

Content:

"(a) For main floats, the buoyancy necessary to support the maximum weight of the rotorcraft in fresh water must be exceeded by—

"(1) 50 percent, for single floats; and,

"(2) 60 percent, for multiple floats; [and,]

"(b) Each main float must have enough watertight compartments so that, with any single main float compartment flooded, the main floats will provide a margin of positive stability great enough to minimize the probability of capsizing."

Document: FARs Part 27.753

Subject: Main-float design for normal category rotorcraft

Content:

"(a) *Bag floats*. Each bag float must be designed to withstand —

"(1) The maximum pressure differential that might be developed at the maximum altitude for which certification with that float is requested; and,

"(2) The vertical loads prescribed in [Part] 27.521(a), distributed along the length of the bag over three-quarters of its projected area; [and,]

"(b) *Rigid floats*. Each rigid float must be able to withstand the vertical, horizontal and side loads prescribed in [Part] 27.521. These loads may be distributed along the length of the float."

Document: FARs Part 27.755

Subject: Hulls for normal category rotorcraft taking off from, and landing on, water

Content: "For each rotorcraft with a hull and auxiliary floats that is to be approved for both taking off from and landing on water, the hull and auxiliary floats must have enough watertight compartments so that, with any single compartment flooded, the buoyancy of the hull and auxiliary floats (and wheel tires if used) provides a margin of positive stability great enough to minimize the probability of capsizing."

Document: FARs Part 27.801

Subject: Certification with ditching provisions for normal category rotorcraft

Content:

"(a) If certification with ditching provisions is requested, the rotorcraft must meet the requirements of this [Part] and [Parts] 27.807(d), 27.1411 and 27.1415;

"(b) Each practicable design measure, compatible with the general characteristics of the rotorcraft, must be taken to minimize the probability that in an emergency landing on water, the behavior of the rotorcraft would cause immediate injury to the occupants or would make it impossible for them to escape;

"(c) The probable behavior of the rotorcraft in a water landing must be investigated by model tests or by comparison with rotorcraft of similar configuration for which the ditching characteristics are known. Scoops, flaps, projections, and any other factor likely to affect the hydrodynamic characteristics of the rotorcraft must be considered;

"(d) It must be shown that, under reasonably probable water conditions, the flotation time and trim of the rotorcraft will allow the occupants to leave the rotorcraft and enter the life rafts required by [Part] 27.1415. If compliance with this provision is shown by buoyancy and trim computations, appropriate allowances must be made for probable structural damage and leakage. If the rotorcraft has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume; [and,]

"(e) Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behavior of the rotorcraft in a water landing (as prescribed in paragraphs (c) and (d) of this [Part]), the external doors and windows must be designed to withstand the probable maximum local pressures."

Document: FARs Part 27.807

Subject: Emergency exits for normal category rotorcraft

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Content:

"(a) Number and location. Rotorcraft with closed cabins must have at least one emergency exit on the opposite side of the cabin from the main door;

"(b) *Type and operation.* Each emergency exit prescribed in paragraph (a) of this [Part] must —

"(1) Consist of a movable window or panel, or additional external door, providing an unobstructed opening that will admit a 19-[inch] by 26-inch ellipse;

"(2) Be readily accessible, require no exceptional agility of a person using it and be located so as to allow ready use, without crowding, in any probable attitudes that may result from a crash;

"(3) Have a simple and obvious method of opening and be arranged and marked so as to be readily located and operated, even in darkness; and,

"(4) Be reasonably protected from jamming by fuselage deformation.

"(c) *Tests.* The proper functioning of each emergency exit must be shown by test;

"(d) *Ditching emergency exits for passengers.* If certification with ditching provisions is requested, one emergency exit on each side of the fuselage must be proven by test, demonstration or analysis to —

"(1) Be above the waterline;

"(2) Have at least the dimensions specified in paragraph (b) of this [Part]; and,

"(3) Open without interference from flotation devices whether stowed or deployed."

Document: FARs Part 27.1411

Subject: Safety equipment for normal category rotorcraft

Content:

"(a) Required safety equipment to be used by the crew in an emergency, such as flares and automatic life raft releases, must be readily accessible; [and,]

"(b) Stowage provisions for required safety equipment must be furnished and must —

"(1) Be arranged so that the equipment is directly accessible and its location is obvious; and,

"(2) Protect the safety equipment from damage caused by being subjected to the inertia loads specified in [Part] 27.561."

Document: FARs Part 27.1415

Subject: Ditching equipment for normal category rotorcraft

Content: Specifies required ditching equipment:

- "Each [life] raft and each life [vest] must be approved and must be installed so that it is readily available to the crew and passengers. The storage provisions for life [vest(s)] must accommodate one life [vest] for each occupant for which certification for ditching is requested;
- "Each [life] raft released automatically or by the pilot must be attached to the rotorcraft by a line to keep it alongside the rotorcraft. This line must be weak enough to break before submerging the empty raft to which it is attached; [and,]
- "Each signaling device must be free from hazard in its operation and must be installed in an accessible location."

Document: FARs Part 27.1561

Subject: Marking of safety equipment for normal category rotorcraft

Content: Equivalent to FARs Part 25.1561(a) and (b)

Document: FARs Part 29.239

Subject: Spray characteristics for water-based transport category rotorcraft

Content: Equivalent to FARs Part 27.239.

Document: FARs Part 29.519

Subject: Water loads for water-based and amphibious transport category rotorcraft

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Content:

"(a) *General.* For hull-type rotorcraft, the structure must be designed to withstand the water loading set forth in paragraphs (b), (c) and (d) of this [Part] considering the most severe wave heights and profiles for which approval is desired. The loads for the landing conditions of paragraphs (b) and (c) … must be developed and distributed along and among the hull and auxiliary floats, if used, in a rational and conservative manner, assuming a rotor lift not exceeding two-thirds of the rotorcraft weight to act throughout the landing impact;

"(b) *Vertical landing conditions.* The rotorcraft must initially contact the most critical wave surface at zero forward speed in likely pitch and roll attitudes which result in critical design loadings. The vertical descent velocity may not be less than 6.5 feet per [1.9 meters] second relative to the mean water surface;

"(c) *Forward speed landing conditions.* The rotorcraft must contact the most critical wave at forward velocities from zero up to 30 knots in likely pitch, roll and yaw attitudes and with a vertical descent velocity of not less than 6.5 feet per second relative to the mean water surface. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out landing; [and,]

"(d) *Auxiliary float immersion condition.* In addition to the loads from the landing conditions, the auxiliary float, and its support and attaching structure in the hull, must be designed for the load developed by a fully immersed float unless it can be shown that full immersion of the float is unlikely, in which case the highest likely float buoyancy load must be applied that considers loading of the float immersed to create restoring moments compensating for upsetting moments caused by side wind, asymmetrical rotorcraft loading, water wave action and rotorcraft inertia."

Document: FARs Part 29.521

Subject: Float-landing conditions for transport category rotorcraft

Content: "If certification for float operation (including float amphibian operation) is requested, the rotorcraft, with floats, must be designed to withstand the following loading conditions (where the limit load factor is determined under [Part] 29.473(b) or assumed to be equal to that determined for wheel landing gear):

"(a) Up-load conditions in which —

"(1) A load is applied so that, with the rotorcraft in the static level attitude, the resultant water reaction passes vertically through the center of gravity; and,

"(2) The vertical load prescribed in paragraph (a)(1) of this [Part] is applied simultaneously with an aft component of 0.25 times the vertical component; [and,]

(b) A side load condition in which —

"(1) A vertical load of 0.75 times the total vertical load specified in paragraph (a)(1) of this [Part] is divided equally among the floats; and,

"(2) For each float, the load share determined under paragraph (b)(1) of this [Part], combined with a total side load of 0.25 times the total vertical load specified in paragraph (b)(1) of this [Part], is applied to that float only."

Document: FARs Part 29.563

Subject: Structural ditching provisions for transport category rotorcraft

Content: Equivalent to FARs Part 27.563

Document: FARs Part 29.751

Subject: Main-float buoyancy for transport category rotorcraft

Content: Equivalent to FARs Part 27.751.

Document: FARs Part 29.753

Subject: Main-float design for transport category rotorcraft

Content: Equivalent to FARs Part 27.753.

Document: FARs Part 29.755

Subject: Hull buoyancy for water-based transport category rotorcraft

Content: Equivalent to FARs Part 27.755.

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: FARs Part 29.757

Subject: Hull and auxiliary-float strength for water-based transport category rotorcraft

Content: "The hull, and auxiliary floats if used, must withstand the water loads prescribed by [Part] 29.519 with a rational and conservative distribution of local and distributed water pressures over the hull and float bottom."

Document: FARs Part 29.801

Subject: Certification with ditching provisions for transport category rotorcraft

Content: Equivalent to FARs Part 27.801

Document: FARs Part 29.807

Subject: Certification for ditching of transport category rotorcraft

Content: Includes, among other provisions, the following:

"(d) *Ditching emergency exits for passengers*. If certification with ditching provisions is requested, ditching emergency exits must be provided in accordance with the following requirements and must be proven by test, demonstration or analysis unless the emergency exits required by paragraph (b) of this section already meet these requirements.

"(1) For rotorcraft that have a passenger seating configuration, excluding pilots' seats, of nine seats or less, one exit above the waterline in each side of the rotorcraft, meeting at least the dimensions of a Type IV exit;

"(2) For rotorcraft that have a passenger seating configuration, excluding pilots' seats, of 10 seats or more, one exit above the waterline in a side of the rotorcraft meeting at least the dimensions of a Type III exit, for each unit (or part of a unit) of 35 passenger seats, but no less than two such exits in the passenger cabin, with one on each side of the rotorcraft. However, where it has been shown through analysis, ditching demonstrations or any other tests found necessary by the Administrator, that the evacuation capability of the rotorcraft during ditching is improved by the use of larger exits, or by other means, the passenger seat to exit ratio may be increased; [and,]

"(3) Flotation devices, whether stowed or deployed, may not interfere with or obstruct the exits."

Document: FARs Part 29.1411

Subject: Safety equipment for transport category rotorcraft

Content:

"(a) *Accessibility.* Required safety equipment to be used by the crew in an emergency, such as automatic life raft releases, must be readily accessible;

"(b) *Stowage provisions.* Stowage provisions for required emergency equipment must be furnished and must —

"(1) Be arranged so that the equipment is directly accessible and its location is obvious; and,

"(2) Protect the safety equipment from inadvertent damage;

"(c) *Emergency-exit-descent device.* The stowage provisions for the emergency-exit-descent device required by [Part] 29.809(f) must be at the exits for which they are intended;

"(d) *Life rafts.* Life rafts must be stowed near exits through which the rafts can be launched during an unplanned ditching. Rafts automatically or remotely released outside the rotorcraft must be attached to the rotorcraft by the static line prescribed in [Part] 29.1415;

"(e) *Long-range signaling device.* The stowage provisions for the long-range signaling device required by [Part] 29.1415 must be near an exit available during an unplanned ditching; [and,]

"(f) *Life [vest(s)].* Each life [vest] must be within easy reach of each occupant while seated."

Document: FARs Part 29.1415

Subject: Ditching equipment for transport category rotorcraft

Content: Specifies required ditching equipment:

- "Each life raft and each life [vest] must be approved. In addition —
  - "Provide not less than two rafts, of an approximately equal-rated capacity and buoyancy to accommodate the occupants of the rotorcraft; and,
  - "Each raft must have a trailing line, and must have a static line designed to hold the raft near the rotorcraft but to release it if the rotorcraft becomes totally submerged;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

- "Approved survival equipment must be attached to each life raft; [and,]
- "There must be an approved survival-type emergency locator transmitter for use in one life raft."

Document: FARs Part 29.1561

Subject: Marking of safety equipment for transport category aircraft

Content: Equivalent to FARs Part 25.1561.

Document: FARs Part 91.115

Subject: Right-of-way rules for water operations

Content:

"(a) *General*. Each person operating an aircraft on the water shall, insofar as possible, keep clear of all vessels and avoid impeding their navigation, and shall give way to any vessel or other aircraft that is given the right-of-way by any rule of this section;

"(b) *Crossing*. When aircraft, or an aircraft and a vessel, are on crossing courses, the aircraft or vessel to the other's right has the right-of-way;

"(c) *Approaching head-on*. When aircraft, or an aircraft and a vessel, are approaching head-on, or nearly so, each shall alter its course to the right to keep well clear;

"(d) *Overtaking*. Each aircraft or vessel that is being overtaken has the right-of-way, and the one overtaking shall alter course to keep well clear; [and,]

"(e) *Special circumstances*. When aircraft, or an aircraft and a vessel, approach so as to involve risk of collision, each aircraft or vessel shall proceed with careful regard to existing circumstances, including the limitations of the respective craft."

Document: FARs Part 91.205

Subject: Instrument and equipment requirements for powered civil aircraft with standard category U.S. airworthiness certificates

Content: For visual flight rules (VFR) flight during the day, required equipment includes the following:

"(b) (12) If the aircraft is operated for hire over water and beyond power-off gliding distance from shore, approved flotation gear readily available to each occupant and at least one pyrotechnic signaling device. As used in this section, 'shore' means that area of the land adjacent to the water which is above the high-water mark and excludes land areas which are intermittently under water."

Document: FARs Part 91.207

Subject: Emergency locator transmitters (ELTs)

Content:

"(a) Except as provided in paragraphs (e) and (f) of this section, no person may operate a U.S.-registered civil airplane unless —

"(1) There is attached to the airplane an approved automatic-type emergency locator transmitter that is in operable condition for the following operations, except that after June 21, 1995, an emergency locator transmitter that meets the requirements of TSO-C91 may not be used for new installations:

"(i) Those operations governed by the supplemental air carrier and commercial operator rules of Parts 121 and 125;

"(ii) Charter flights governed by the domestic and flag air carrier rules of Part 121 of this chapter; and

"(iii) Operations governed by Part 135 of this chapter; or

"(2) For operations other than those specified in paragraph (a)(1) of this section, there must be attached to the airplane an approved personal type or an approved automatic type emergency locator transmitter that is in operable condition, except that after June 21, 1995, an emergency locator transmitter that meets the requirements of TSO-C91 may not be used for new installations;

"(b) Each emergency locator transmitter required by paragraph (a) of this section must be attached to the airplane in such a manner that the probability of damage to the transmitter in the event of crash impact is minimized. Fixed and deployable automatic type transmitters must be attached to the airplane as far aft as practicable;

"(c) Batteries used in the emergency locator transmitters required by paragraphs (a) and (b) of this section must be replaced (or recharged, if the batteries are rechargeable) —

"(1) When the transmitter has been in use for more than one cumulative hour; or

"(2) When 50 percent of their useful life (or, for rechargeable batteries, 50 percent of their useful life of charge) has expired, as established by the transmitter manufacturer under its approval.

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"The new expiration date for replacing (or recharging) the battery must be legibly marked on the outside of the transmitter and entered in the aircraft maintenance record. Paragraph (c)(2) of this section does not apply to batteries (such as water-activated batteries) that are essentially unaffected during probable storage intervals;

"(d) Each emergency locator transmitter required by paragraph (a) of this section must be inspected within 12 calendar months after the last inspection for —

"(1) Proper installation;

"(2) Battery corrosion;

"(3) Operation of the controls and crash sensor; and,

"(4) The presence of a sufficient signal radiated from its antenna;

"(e) Notwithstanding paragraph (a) of this section, a person may —

"(1) Ferry a newly acquired airplane from the place where possession of it was taken to a place where the emergency locator transmitter is to be installed; and,

"(2) Ferry an airplane with an inoperative emergency locator transmitter from a place where repairs or replacements cannot be made to a place where they can be made.

"No person other than required crewmembers may be carried aboard an airplane being ferried under paragraph (e) of this section; [and,]

"(f) Paragraph (a) of this section does not apply to —

"(1) Before January 1, 2004, turbojet-powered aircraft;

"(2) Aircraft while engaged in scheduled flights by scheduled air carriers;

"(3) Aircraft while engaged in training operations conducted entirely within a 50-nautical-mile [93-kilometer] radius of the airport from which such local flight operations began;

"(4) Aircraft while engaged in flight operations incident to design and testing;

"(5) New aircraft while engaged in flight operations incident to their manufacture, preparation, and delivery;

"(6) Aircraft while engaged in flight operations incident to the aerial application of chemicals and other substances for agricultural purposes;

"(7) Aircraft certificated by the Administrator for research and development purposes;

"(8) Aircraft while used for showing compliance with regulations, crew training, exhibition, air racing or market surveys;

"(9) Aircraft equipped to carry not more than one person;

"(10) An aircraft during any period for which the transmitter has been temporarily removed for inspection, repair, modification or replacement, subject to the following:

"(i) No person may operate the aircraft unless the aircraft records contain an entry which includes the date of initial removal, the make, model, serial number and reason for removing the transmitter, and a placard located in view of the pilot to show 'ELT not installed.'

"(ii) No person may operate the aircraft more than 90 days after the ELT is initially removed from the aircraft; and,

"(11) On and after January 1, 2004, aircraft with a maximum payload capacity of more than 18,000 pounds [8,165 kilograms] when used in air transportation."

Document: FARs Part 91.505

Subject: Familiarity with emergency equipment on large and turbine-powered multi-engine airplanes

Content: Includes, among other provisions, the following:

"(b) Each required member of the crew shall, before beginning a flight, become familiar with the emergency equipment installed on the airplane to which that crewmember is assigned and with the procedures to be followed for the use of that equipment in an emergency situation."

Document: FARs Part 91.509

Subject: Survival equipment for large and turbine-powered multi-engine airplanes

Content:

"(a) No person may take off an airplane for a flight over water more than 50 nautical miles [93 kilometers] from the nearest shore unless that airplane is equipped with a life [vest] or an approved flotation means for each occupant of the airplane;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(b) **Except as provided in paragraph (c) of this section,** no person may take off an airplane for a flight over water more than 30 minutes flying time or 100 nautical miles [185 kilometers] from the nearest shore unless it has on board the following survival equipment:

"(1) A life [vest], equipped with an approved survivor-locator light, for each occupant of the airplane;

"(2) Enough life rafts (each equipped with an approved survival locator light) of a rated capacity and buoyancy to accommodate the occupants of the airplane;

"(3) At least one pyrotechnic signaling device for each life raft;

"(4) One self-buoyant, water-resistant, portable emergency radio signaling device that is capable of transmission on the appropriate emergency frequency or frequencies and not dependent upon the airplane power supply; [and,]

"(5) A lifeline stored in accordance with [Part] 25.1411(g) of this chapter;

"(c) A fractional-ownership program manager under subpart K [*Fractional Ownership Operations*] of this Part may apply for a deviation from paragraphs (b)(2) through (5) of this section for a particular overwater operation or the Administrator may amend the management specifications to require the carriage of all or any specific items of the equipment listed in paragraphs (b)(2) through (5) of this section;

"(d) The required life rafts, life [vest(s)] and signaling devices must be installed in conspicuously marked locations and [be] easily accessible in the event of a ditching without appreciable time for preparatory procedures;

"(e) A survival kit, appropriately equipped for the route to be flown, must be attached to each required life raft; [and,]

"(f) As used in this [Part], the term shore means that area of the land adjacent to the water that is above the high-water mark and excludes land areas that are intermittently under water."

Editorial note: Wording in **bold** type is an amendment effective Nov. 17, 2003.

Document: FARs Part 91.511

Subject: Radio equipment for overwater operations for large and turbine-powered multi-engine airplanes

Content:

"(a) Except as provided in paragraphs (c), (d) and (f) of this section, no person may take off an airplane for a flight over water more than 30 minutes flying time or 100 nautical miles from the nearest shore unless it has at least the following operable equipment:

"(1) Radio communication equipment appropriate to the facilities to be used and able to transmit to, and receive from, any place on the route, at least one surface facility:

"(i) Two transmitters;

"(ii) Two microphones;

"(iii) Two headsets or one headset and one speaker;

"(iv) Two independent receivers; [and,]

"(2) Appropriate electronic navigational equipment consisting of at least two independent electronic navigation units capable of providing the pilot with the information necessary to navigate the airplane within the airspace assigned by air traffic control. However, a receiver that can receive both communications and required navigational signals may be used in place of a separate communications receiver and a separate navigational signal receiver or unit.

"(b) For the purposes of paragraphs (a)(1)(iv) and (a)(2) of this section, a receiver or electronic navigation unit is independent if the function of any part of it does not depend on the functioning of any part of another receiver or electronic navigation unit;

"(c) Notwithstanding the provisions of paragraph (a) of this section, a person may operate an airplane on which no passengers are carried from a place where repairs or replacement cannot be made to a place where they can be made, if not more than one of each of the dual items of radio communication and navigational equipment specified in paragraphs (a)(1)(i) through (iv) and (a)(2) of this [Part] malfunctions or becomes inoperative;

"(d) Notwithstanding the provisions of paragraph (a) of this section, when both VHF [very-high frequency] and HF [high frequency] communications equipment are required for the route and the airplane has two VHF transmitters and two VHF receivers for communications, only one HF transmitter and one HF receiver is required for communications;

"(e) As used in this section, the term *shore* means that area of the land adjacent to the water which is above the high-water mark and excludes land areas which are intermittently under water; [and,]

"(f) Notwithstanding the requirements in paragraph (a)(2) of this section, a person may operate in the Gulf of Mexico, the Caribbean Sea and the Atlantic Ocean west of a line which extends from 44° 47 min 00 sec N / 67° 00 min 00 sec W to 39° 00 min 00 sec N / 67° 00 min 00 sec W to 38° 30 min 00 sec N / 60° 00 min 00 sec W south along the 60° 00 min 00 sec W longitude line to the point where the line intersects with the northern coast of South America, when:

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(1) A single long-range navigation system is installed, operational and appropriate for the route; and,

"(2) Flight conditions and the aircraft's capabilities are such that no more than a 30-minute gap in two-way radio very high frequency communications is expected to exist.

Document: FARs Part 91.519

Subject: Passenger briefing

Content: Includes, among other provisions, the following:

"(a) Before takeoff, the pilot-in-command of an airplane carrying passengers shall ensure that all passengers have been orally briefed on — …

"(4) Location of survival equipment; [and,]

"(5) Ditching procedures and the use of flotation equipment required under [Part] 91.509 for a flight over water … ; [and,]

"(d) For operations under subpart K [*Fractional Ownership Operations*] of this Part, the passenger briefing requirements of [Part] 91.1035 apply, instead of the requirements of paragraphs (a) through (c) of this section."

Editorial note: Wording in **bold** type is an amendment effective Nov. 17, 2003. Paragraphs (a)(5) and (a)(6) in Part 91.1035 are worded identically to paragraphs (a)(4) and (a)(5), respectively, in Part 91.519.

Document: FARs Part 91.1083

Subject: Crewmember emergency training in fractional-ownership operations

Content: Includes, among other provisions, the following:

"(a) Each training program must provide emergency training under this section for each aircraft type, model and configuration, each crewmember, and each kind of operation conducted, as appropriate for each crewmember and the program manager.

"(b) Emergency training must provide the following:

"(1) Instruction in emergency assignments and procedures, including coordination among crewmembers; [and,]

"(2) Individual instruction in the location, function and operation of emergency equipment including —

"(i) Equipment used in ditching and evacuation; …

"(c) Each crewmember must perform at least the following emergency drills, using the proper emergency equipment and procedures, unless the Administrator finds that, for a particular drill, the crewmember can be adequately trained by demonstration:

"(1) Ditching, if applicable;

"(2) Emergency evacuation; …

"(3) Instruction in the handling of emergency situations including —

"(iii) Ditching and evacuation; …

"(4) Operation and use of emergency exits, including deployment and use of evacuation slides, if applicable; …

"(6) Removal of life rafts from the aircraft, inflation of the life rafts, use of lifelines and boarding of passengers and crew, if applicable; [and,]

"(7) Donning and inflation of life vests and the use of other individual flotation devices, if applicable."

Document: FARs Part 121.339

Subject: Emergency equipment for extended overwater operations on flights conducted under Part 121

Content:

"(a) Except where the Administrator, by amending the operations specifications of the certificate holder, requires the carriage of all or any specific items of the equipment listed below for any overwater operation, or upon application of the certificate holder, the Administrator allows deviation for a particular extended overwater operation, no person may operate an airplane in extended overwater operations without having on the airplane the following equipment:

"(1) A life [vest] equipped with an approved survivor-locator light, for each occupant of the airplane;

"(2) Enough life rafts (each equipped with an approved survivor-locator light) of a rated capacity and buoyancy to accommodate the occupants of the airplane. Unless excess rafts of enough capacity are provided, the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss of one raft of the largest rated capacity;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(3) At least one pyrotechnic signaling device for each life raft; [and,]

"(4) An approved survival-type emergency locator transmitter. Batteries used in this transmitter must be replaced (or recharged, if the battery is rechargeable) when the transmitter has been in use for more than one cumulative hour, or when 50 percent of their useful life (or for rechargeable batteries, 50 percent of their useful life of charge) has expired, as established by the transmitter manufacturer under its approval. The new expiration date for replacing (or recharging) the battery must be legibly marked on the outside of the transmitter. The battery useful life (or useful life of charge) requirements of this paragraph do not apply to batteries (such as water-activated batteries) that are essentially unaffected during probable storage intervals;

"(b) The required life rafts, life [vests] and survival-type emergency locator transmitter must be easily accessible in the event of a ditching without appreciable time for preparatory procedures. This equipment must be installed in conspicuously marked, approved locations; [and,]

"(c) A survival kit, appropriately equipped for the route to be flown, must be attached to each required life raft."

Document: FARs Part 121.340

Subject: Emergency flotation means on flights conducted under FARs Part 121

Content:

"(a) Except as provided in paragraph (b) of this section, no person may operate an airplane in any overwater operation unless it is equipped with life [vests] in accordance with [Part] 121.339(a)(1) or with an approved flotation means for each occupant. This means must be within easy reach of each seated occupant and must be readily removable from the airplane; [and,]

"(b) Upon application by the air carrier or commercial operator, the Administrator may approve the operation of an airplane over water without the life [vests] or flotation means required by paragraph (a) of this section, if the air carrier or commercial operator shows that the water over which the airplane is to be operated is not of such size and depth that life [vests] or flotation means would be required for the survival of its occupants in the event the flight terminates in that water."

Document: FARs Part 121.351

Subject: Radio equipment for extended overwater operations and for certain other operations on flights conducted under Part 121

Content:

"(a) Except as provided in paragraph (c) of this section, no person may conduct an extended overwater operation unless the airplane is equipped with the radio communication equipment necessary to comply with [Part] 121.349, an independent system that complies with Part 121.347 (a)(1), and two long-range navigation systems when VOR [very-high-frequency omnidirectional radio] or ADF [automatic direction finder] radio navigation equipment is unusable along a portion of the route;

"(b) No certificate holder conducting a flag or supplemental operation or a domestic operation within the State of Alaska may conduct an operation without the equipment specified in paragraph (a) of this section, if the Administrator finds that equipment to be necessary for search-and-rescue operations because of the nature of the terrain to be flown over; [and,]

"(c) Notwithstanding the requirements of paragraph (a) of this section, installation and use of a single LRNS [long-range navigation system] and a single LRCS [long-range communication system] may be authorized by the Administrator and approved in the certificate holder's operations specifications for operations and routes in certain geographic areas. The following are among the operational factors the Administrator may consider in granting an authorization:

"(1) The ability of the flight crew to reliably fix the position of the airplane within the degree of accuracy required by ATC,

"(2) The length of the route being flown, and

"(3) The duration of the very high frequency communications gap."

Document: FARs Part 121.417

Subject: Crewmember emergency training for flights conducted under Part 121

Content: Includes, among other provisions, the following:

"(a) Each training program must provide the emergency training set forth in this section with respect to each airplane type, model, and configuration, each required crewmember, and each kind of operation conducted, insofar as appropriate for each crewmember and the certificate holder;

"(b) Emergency training must provide the following: …

"(2) Individual instruction in the location, function, and operation of emergency equipment including —

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(i) Equipment used in ditching and evacuation; …
"(ii) First aid equipment and its proper use; … [and,]
"(iv) Emergency exits in the emergency mode with the evacuation slide/raft pack attached (if applicable), with training emphasis on the operation of the exits under adverse conditions;
"(3) Instruction in the handling of emergency situations including — …
"(iii) Ditching and other evacuation, including the evacuation of persons and their attendants, if any, who may need the assistance of another person to move expeditiously to an exit in the event of an emergency; … [and,]
"(c) Each crewmember must accomplish the following emergency training during the specified training periods, using those items of installed emergency equipment for each type of airplane in which he or she is to serve (alternate recurrent training required by [Part] 121.433(c) of this part may be accomplished by approved pictorial presentation or demonstration):
"(1) One-time emergency drill requirements to be accomplished during initial training. Each crewmember must perform — …
"(iii) An emergency evacuation drill with each person egressing the airplane or approved training device using at least one type of installed emergency evacuation slide. The crewmember may either observe the airplane exits being opened in the emergency mode and the associated exit slide/raft pack being deployed and inflated, or perform the tasks resulting in the accomplishment of these actions; [and,]
"(2) Additional emergency drill requirements to be accomplished during initial training and once each 24 calendar months during recurrent training. Each crewmember must —
"(i) Perform the following emergency drills and operate the following equipment:
"(A) Each type of emergency exit in the normal and emergency modes, including the actions and forces required in the deployment of the emergency evacuation slides; …
"(D) Donning, use and inflation of individual flotation means, if applicable; and,
"(E) Ditching, if applicable, including but not limited to, as appropriate:
"(1) Cockpit preparation and procedures;
"(2) Crew coordination;
"(3) Passenger briefing and cabin preparation;
"(4) Donning and inflation of life [vests];
"(5) Use of life-lines; and
"(6) Boarding of passengers and crew into raft or a slide/raft pack; [and,]
"(ii) Observe the following drills:
"(A) Removal from the airplane (or training device) and inflation of each type of life raft, if applicable;
"(B) Transfer of each type of slide/raft pack from one door to another;
"(C) Deployment, inflation, and detachment from the airplane (or training device) of each type of slide/raft pack; and,
"(D) Emergency evacuation including the use of a slide."

Document: FARs Part 121.573

Subject: Briefing passengers in extended overwater operations conducted under Part 121

Content:

"(a) In addition to the oral briefing required by [Part] 121.571(a), each certificate holder operating an airplane in extended overwater operations shall ensure that all passengers are orally briefed by the appropriate crewmember on the location and operation of life [vests], life rafts and other flotation means, including a demonstration of the method of donning and inflating a life [vest];
"(b) The certificate holder shall describe in its manual the procedure to be followed in the briefing required by paragraph (a) of this section;
"(c) If the airplane proceeds directly over water after takeoff, the briefing required by paragraph (a) of this section must be done before takeoff; [and,]
"(d) If the airplane does not proceed directly over water after takeoff, no part of the briefing required by paragraph (a) of this section has to be given before takeoff, but the entire briefing must be given before reaching the overwater part of the flight."

Document: FARs Part 135.117

Subject: Passenger briefing

Content: Equivalent to FARs Part 91.519

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: FARs Part 135.123

Subject: Emergency and emergency evacuation duties on flights conducted under Part 135

Content:

"(a) Each certificate holder shall assign to each required crewmember for each type of aircraft as appropriate, the necessary functions to be performed in an emergency or in a situation requiring emergency evacuation. The certificate holder shall ensure that those functions can be practicably accomplished, and will meet any reasonably anticipated emergency including incapacitation of individual crewmembers or their inability to reach the passenger cabin because of shifting cargo in combination cargo-passenger aircraft; [and,]

"(b) The certificate holder shall describe in the manual required under [Part] 135.21 ['Manual requirements'] the functions of each category of required crewmembers assigned under paragraph (a) of this section."

Document: FARs Part 135.165

Subject: Radio and navigational equipment for extended overwater or instrument flight rules (IFR) operations conducted under Part 135

Content:

"(a) No person may operate a turbojet airplane having a passenger seating configuration, excluding any pilot seat, of 10 seats or more, or a multi-engine airplane in a commuter operation, … under IFR or in extended overwater operations unless it has at least the following radio communication and navigational equipment appropriate to the facilities to be used which are capable of transmitting to, and receiving from, at any place on the route to be flown, at least one ground facility:

"(1) Two transmitters, (2) two microphones, (3) two headsets or one headset and one speaker, (4) a marker-beacon receiver, (5) two independent receivers for navigation, and (6) two independent receivers for communications;

"(b) No person may operate an aircraft other than that specified in paragraph (a) of this section, under IFR or in extended overwater operations unless it has at least the following radio communication and navigational equipment appropriate to the facilities to be used and which are capable of transmitting to, and receiving from, at any place on the route, at least one ground facility:

"(1) A transmitter, (2) two microphones, (3) two headsets or one headset and one speaker, (4) a marker-beacon receiver, (5) two independent receivers for navigation, (6) two independent receivers for communications, and (7) for extended overwater operations only, an additional transmitter;

"(c) For the purpose of paragraphs (a)(5), (a)(6), (b)(5) and (b)(6) of this section, a receiver is independent if the function of any part of it does not depend on the functioning of any part of another receiver. However, a receiver that can receive both communications and navigational signals may be used in place of a separate communications receiver and a separate navigational-signal receiver; [and,]

"(d) Notwithstanding the requirements of paragraphs (a) and (b) of this section, installation and use of a single long-range navigation system and a single long-range communication system, for extended overwater operations, may be authorized by the Administrator and approved in the certificate holder's operations specifications. The following are among the operational factors the Administrator may consider in granting an authorization:

"(1) The ability of the flight crew to reliably fix the position of the airplane within the degree of accuracy required by ATC [air traffic control];

"(2) The length of the route being flown; and,

"(3) The duration of the very-high-frequency communications gap."

Document: FARs Part 135.167

Subject: Emergency equipment required for extended overwater operations conducted under Part 135

Content:

"**(a) Except where the Administrator, by amending the operations specifications of the certificate holder, requires the carriage of all or any specific items of the equipment listed below for any overwater operation, or, upon application of the certificate holder, the Administrator allows deviation for a particular extended overwater operation, no person may operate an aircraft in extended overwater operations unless it carries, installed in conspicuously marked locations easily accessible to the occupants if a ditching occurs, the following equipment:**

"(1) An approved life [vest] equipped with an approved survivor-locator light for each occupant of the aircraft. The life [vest] must easily be accessible to each seated occupant;

"(2) Enough approved life rafts of a rated capacity and buoyancy to accommodate the occupants of the aircraft;

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

"(b) Each life raft required by paragraph (a) of this [Part] must be equipped with or contain at least the following:

"(1) One approved survivor-locator light;

"(2) One approved pyrotechnic signaling device;

"(3) Either —

"(i) One survival kit, appropriately equipped for the route to be flown; or

"(ii) One canopy (for sail, sun shade or rain catcher);

"(iii) One radar reflector;

"(iv) One life raft–repair kit;

"(v) One bailing bucket;

"(vi) One signaling mirror;

"(vii) One police whistle;

"(viii) One raft knife;

"(ix) One CO_2 [carbon dioxide] bottle for emergency inflation;

"(x) One inflation pump;

"(xi) Two oars;

"(xii) One 75-foot [23-meter] retaining line;

"(xiii) One magnetic compass;

"(xiv) One dye marker;

"(xv) One flashlight having at least two size D cells or equivalent;

"(xvi) A two-day supply of emergency food rations supplying at least 1,000 calories per day for each person;

"(xvii) For each two persons the raft is rated to carry, two pints of water or one seawater-desalting kit;

"(xviii) One fishing kit; and,

"(xix) One book on survival appropriate for the area in which the aircraft is operated; [and,]

"(c) No person may operate an airplane in extended overwater operations unless there is attached to one of the life rafts … an approved survival-type emergency locator transmitter. …"

Editorial note: Wording in **bold** type is an amendment effective Nov. 17, 2003.

Document: FARs Part 135.183

Subject: Performance requirements for land aircraft in overwater operations conducted under Part 135

Content: "No person may operate a land aircraft carrying passengers over water unless —

"(a) It is operated at an altitude that allows it to reach land in the case of engine failure;

"(b) It is necessary for takeoff or landing;

"(c) It is a multi-engine aircraft operated at a weight that will allow it to climb, with the critical engine inoperative, at least 50 feet [15 meters] a minute, at an altitude of 1,000 feet above the surface; or

"(d) It is a helicopter equipped with helicopter-flotation devices."

Document: FARs Part 135.331

Subject: Crewmember emergency training for airplanes operating under Part 135

Content: Emergency training must provide instruction in the handling of "ditching and evacuation." Each crewmember must perform emergency drills, including:

- "Ditching, if applicable;
- "Removal of life rafts from the aircraft, inflation of the life rafts, use of lifelines and boarding of passengers and crew, if applicable; [and,]
- "Donning and inflation of life vests and the use of other individual flotation devices, if applicable."

Document: FARs Part 135.349

Subject: Initial and transition ground training for flight attendants in aircraft operating under Part 135

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures *(continued)*

Content: Includes, among other provisions, the following:

"Initial and transition ground training for flight attendants must include instruction in at least the following— …

"(b) For each aircraft type —

"(1) A general description of the aircraft emphasizing physical characteristics that may have a bearing on ditching, evacuation, and in-flight emergency procedures and on other related duties. … "

Technical Standard Orders (TSOs)

Document: FARs Part 21.607

Subject: Holders of TSO authorizations

Content: "Each manufacturer of an article for which a TSO authorization has been issued under this part shall —

"(a) Manufacture the article in accordance with this part and the applicable TSO;

"(b) Conduct all required tests and inspections and establish and maintain a quality control system adequate to ensure that the article meets the requirements of paragraph (a) of this [Part] and is in condition for safe operation;

"(c) Prepare and maintain, for each model of each article for which a TSO authorization has been issued, a current file of complete technical data and records in accordance with [Part] 21.613 ['Recordkeeping requirements']; and,

"(d) Permanently and legibly mark each article to which this [Part] applies with the following information: (1) The name of the manufacturer. (2) The name, type, part number or model designation of the article. (3) The serial number or the date of manufacture of the article or both. (4) The applicable TSO number."

Document: TSO-C13f

Subject: Life [vest(s)] to be identified with the TSO marking

Content: The basic TSO providing U.S. Federal Aviation Administration (FAA) specifications for life [vest(s)]. For complete provisions, see "FAA Technical Standard Order (TSO) C13f, *Life Preservers [Life Vests],*" page 452.

Document: TSO-C69c

Subject: Emergency evacuation slides, ramps, ramp/slides and slide/rafts

Content: The basic TSO providing U.S. Federal Aviation Administration (FAA) specifications for emergency evacuation slides, ramps, ramp/slides, and slide/rafts

---

Document: TSO-C70a

Subject: Life rafts (reversible and nonreversible) to be identified with the TSO marking

Content: The basic TSO providing U.S. Federal Aviation Administration (FAA) specifications for life rafts. For complete provisions, see "FAA Technical Standard Order (TSO)-C70a, *Life Rafts (Reversible and Nonreversible),*" page 396.

Document: TSO-C72c

Subject: Individual flotation devices to be identified with the TSO marking

Content: The basic TSO providing U.S. Federal Aviation Administration (FAA) specifications for individual flotation devices. For complete provisions, see "FAA Technical Standard Order (TSO)-C72c, *Individual Flotation Devices,*" page 459.

Document: TSO-C85a

Subject: Survivor-locator lights to be identified with the TSO marking

Content: The basic TSO providing U.S. Federal Aviation Administration (FAA) specifications for survivor-locator lights. For complete provisions, see "FAA Technical Standard Orders (TSO)-85a, *Survivor-locator Lights*," page 462.

Document: TSO-C91a

Subject: Emergency locator transmitter (ELT) equipment to be identified with the TSO marking

Content: The basic TSO providing U.S. Federal Aviation Administration (FAA) specifications for ELT equipment

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: TSO-C126

Subject: Emergency locator transmitter (ELT) equipment operating at 406 MHz [megahertz] to be identified with the TSO marking

Content: The basic TSO providing U.S. Federal Aviation Administration (FAA) specifications for 406-MHz ELT equipment

Air Carrier Operations Bulletins (ACOBs)

Document: ACOB 8-80-2

Subject: Crewmember survival training

Content: Outlines recommended crewmember survival training based on the Flight Crew Survival Course conducted by the Aeromedical Education Branch, U.S. Federal Aviation Administration (FAA) Aeronautical Center.

[Part] F, "Survival Equipment," lists the following:

- Minimum survival gear;
- First aid kit;
- Life [vest] operation;
- Rafts;
- Water survival kits;
- Operation of radios; and,
- Flotation-type cushions/life vests.

Section K, "Ditching and Water Survival," lists the following:

- Preparation-for-ditching phase;
- Alert phase;
- Rescue phase;
- Raft actions;
- Survival needs;
- Water-connected medical problems;
- Signaling techniques; and,
- Recovery operations.

Advisory Circulars (ACs)

Document: AC 25-17

Subject: Transport airplane cabin interiors crashworthiness

Content: Includes guidance for FARs Part 25.801 (ditching certification for transport category airplanes); Part 25.1411 (safety equipment); Part 25.1415 (ditching equipment); and Part 25.1561 (safety equipment).

Document: AC 27-1B

Subject: Certification of normal category rotorcraft

Content: Offers guidance for FARs Part 27.801 on ditching certification.

Document: AC 29-2C

Subject: Certification of transport category rotorcraft

Content: Offers guidance for FARs Part 29.801 on ditching certification.

Document: AC 43.13-1B

Subject: Acceptable methods, techniques and practices for aircraft inspection and repair

Content: Includes guidance on inspection and repair for life rafts, survival equipment packs and life vests.

Document: AC 91-38A

Subject: Large and turbine-powered multi-engine airplanes, FARs Part 91, Subpart D

Content: Includes guidance for survival equipment on overwater flights under Part 91. Dated 1978, the AC includes information that is not current.

Table 2

Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Overwater Operations and Related Procedures ***(continued)***

Document: AC 91-44A

Subject: ELTs required by FARs

Content: Clarifies operational and maintenance practices for emergency locator transmitters (ELTs) and receivers.

Document: AC 91-58A

Subject: Part 91 oceanic flights

Content: Lists current U.S. Coast Guard approved pyrotechnic visual distress signaling devices.

Document: AC 91-69A

Subject: Seaplane safety for Part 91 operators, generally in not-for-hire operations

Content: Offers guidance about seaplane preflight, oral briefings for seaplane passengers, the use of safety belts and shoulder harnesses, escape/egress after capsizing, water survival and flotation gear for seaplane occupants.

Document: AC 91-70

Subject: Oceanic operations

Content: Chapter 11, "General Aviation Short-range Aircraft Oceanic Operations," includes specific guidance for Part 91 operations.

Document: AC 120-47

Subject: Recommended survival equipment to be carried on overwater flights

Content: "The recommended equipment should meet [the] applicable TSO. This equipment includes, but is not limited to, the following:

"a. Life [vest] for each occupant of the aircraft;

"b. Rafts or slide/rafts with appropriate buoyancy and sufficient capacity for everyone on board the aircraft and which have a boarding station; [and,]

"c. Rafts (and slide/rafts where appropriate) should be equipped with the following:

- "(1) Lines, including an inflation/mooring line with a snaphook, rescue or life line, and a heaving or trailing line;
- "(2) Sea anchors;
- "(3) Raft-repair equipment such as repair clamps, rubber plugs and leak stoppers;
- "(4) Inflation devices, including hand pumps and cylinders (i.e., carbon dioxide bottles), for emergency inflation;
- "(5) Safety/inflation relief valves;
- "(6) Canopy and appropriate equipment to erect the canopy;
- "(7) Position lights;
- "(8) Hook-type knife, sheathed and secured by a retaining line;
- "(9) Placards that give the location of raft equipment and are consistent with placard requirements;
- "(10) Propelling devices such as oars, or in smaller rafts, glove paddles;
- "(11) Water-catchment devices, including bailing buckets, reincatchment equipment, cups and sponges;
- "(12) Signaling devices including:
  - "(i) At least one approved pyrotechnic signaling device;
  - "(ii) One signaling mirror;
  - "(iii) One spotlight or flashlight (including a spare bulb) having at least two 'D'-cell batteries or equivalent;
  - "(iv) One police whistle;
  - "(v) One dye marker;
  - "(vi) Radio beacon with water-activated battery; [and,]
  - "(vii) Radar reflector;
- "(13) One magnetic compass;
- "(14) A two-day supply of emergency food rations supplying at least 1,000 calories a day for each person;
- "(15) One salt water desalting kit for each two persons the raft is rated to carry or two pints of water for each person the life raft is rated to carry;

Table 2
Regulations and Recommendations Concerning Life Rafts, Water-survival Equipment, Certification for Water Operations and Related Procedures *(continued)*

"(16) One fishing kit;
"(17) One book on survival, appropriate for any area; [and,]
"(18) A survival kit, appropriately equipped. Some of the items which could be included in the survival kit are:
  "(i) Triangular cloths;
  "(ii) Bandages;
  "(iii) Eye ointments;
  "(iv) Water disinfection tablets;
  "(v) Sun-protection balsam;
  "(vi) Heat-retention foils;
  "(vii) Burning glass;
  "(viii) Seasickness tablets;
  "(ix) Ammonia inhalants; [and,]
  "(x) Packets with plaster."

Document: AC 150/5200-31A
Subject: Airport emergency plans
Content: Section 8 prescribes procedures for responding to water rescue situations.

Document: AC 150/5210-13A
Subject: Airport emergency plans
Content: Offers guidance in preparing for water rescue operations.

Airworthiness Directives (ADs)
(Effective date of 1989 or later)

Document: AD 89-06-01
Subject: Switlik TSO-C13 life [vests] and TSO-C72 individual flotation devices
Content: Inspect the carbon dioxide inflators for cracks and chipping. Replace if necessary.

Document: AD 89-02-05
Subject: BF Goodrich seven-person life raft
Content: Inspect cylinders to eliminate cylinders that might leak because of certain material used in their fabrication.

Notices of Proposed Rulemaking (NPRMs)

Document: NPRM 64 FR 61042
Subject: Certain Air Cruisers emergency evacuation slide/rafts.
Content: Proposes a new airworthiness directive that would require a one-time repacking and repetitive folding of all affected slide/rafts.

capacities that differ considerably from one another can meet the standard. TSO'd life rafts include a single-tube life raft in which the canopy is stowed with SEP items in an accessory case; a double-tube life raft that includes a foam-insulated floor designed to protect against hypothermia; and a double-tube life raft that features such refinements as a three-position canopy that can be adjusted according to the weather and "a cool-blue interior."

Round, octagonal and oval designs have been manufactured to the TSO. The canopy may be automatically erected or manually erected. In at least one TSO'd life raft, the SEP does not come as standard equipment, although an SEP is required to be carried on extended overwater operations by FARs Part 91.509 and Part 135.167. A hand-operated water maker may be standard or optional.

Such variations are possible because manufacturers are permitted to modify their life rafts, as long as the rafts meet TSO requirements, in any way that they believe is beneficial (and marketable).

The operator who purchases a life raft has a variety of choices.

The most basic is a standard or "off-the-shelf" model, available in sizes that are rated to accommodate various numbers of occupants. Some models offer little beyond what is specified in the applicable TSO. A minimal TSO'd life raft can satisfy the legal requirements, but operators should consider seriously whether it is in the best interest of the crew and passengers.

Even with "off-the-shelf" life rafts, the customer has some choices, primarily concerning the SEP to be carried in the life raft (e.g., for Part 91 operations or Part 135 operations) and the packing configuration. Many manufacturers are willing to devise means of packing their rafts to fit the storage space aboard an operator's aircraft. One manufacturer says of its individualized packing techniques, "We are limited only by the laws of physics."

The next level in adapting the life raft and SEP to the operator is selection from the variety of options offered by many manufacturers to enhance the life raft's performance or the occupants' comfort. Examples include dual floors (which provide insulation, especially in cold water), plastic view ports, storage pouches, extra rations, a hand-operated water maker, anti-seasickness tablets, bandages, sunscreen, specialized flares or a 406-megahertz emergency radio beacon such as a survival-type ELT or an emergency position-indicating radio beacon (EPIRB; see "The Search-and-rescue System Will Find You — If You Help," page 111).

An even greater level of adaptation allows personal items to be inserted in the life raft package. Such items include medications, eyeglasses, reading or writing materials and other nonrequired equipment.

Of course, options add weight, volume and cost to a life raft pack. Moreover, some operators may balance financial considerations against life raft enhancements that most operators consider unlikely to be used.

Changes are pending for TSO-C70a, *Life Rafts (Reversible and Nonreversible)*, the U.S. standard since 1984, and TSO-C13f, *Life Preservers*, both of which also have been adopted by civil aviation authorities in Australia, Canada and New Zealand. The SAE International Safety Equipment and Survival Systems Subcommittee — which comprises representatives from manufacturers, air carriers, pilots, flight attendants, industry groups and regulators (including FAA and Transport Canada), as well as individuals — has been commissioned by FAA to revise both TSOs. Gustavo Fanjul, chairman of the subcommittee, estimates that it will be at least another year before the proposed new TSOs will be ready for FAA review.[3]

Regulations are not specific about the minimum requirements.

Operators Determine If SEP Is 'Appropriately Equipped'

Regulations are not specific about the minimum requirements.

For example, FARs Part 91.509, "Survival equipment for overwater operations," says only that the "survival kit" (SEP) must be "appropriately equipped for the route to be flown." Part 135.167, "Emergency equipment: Extended overwater operations," requires the life raft to contain *either* a route-appropriate SEP *or* 18 specific items (see Table 2, page 404), which include a bailing bucket, a signaling mirror and a flashlight. The "appropriately equipped" provision in both regulations gives the aircraft operator the option of including or excluding almost any item that it chooses.

Canadian Aviation Regulations (CARs), although adopting FAA TSOs, take a different position concerning survival equipment on life rafts. CARs 725.95 (page 416) lists 14 equipment items that must be carried, at a minimum, in an SEP.

The Civil Aviation Authority of New Zealand also, while adopting FAA TSO-C70a, specifies the equipment that must be carried in the life raft SEP (Part 91, Appendix A, A.14, page 426). European Joint Aviation Authorities (JAA) Joint Airworthiness Requirements — Operations (JAR-OPS) 1.830 (for airplanes in extended overwater flight) lists, under its "acceptable means of compliance" (AMC) section, a number of specific items that should be "readily available with each life raft" and as far as is practicable "should be contained in a pack" (page 406). The AMC for JAR-OPS 3.830 (for helicopters in extended overwater flight) lists specific items that a SEP, at a minimum, "shall" contain (AMC OPS 3.830(a)(2), page 409).

The language of FARs Part 135.167 specifies "approved life rafts" — meaning life rafts built to TSO-C70a. Part 91.509 requires only "life rafts," although it adds, "(each equipped with an approved survivor-locator light)." Thus, a flight conducted under Part 91, in an aircraft that has not been certificated for ditching under Part 25 — the certification standards for transport category airplanes — could be technically in compliance while carrying a life raft that satisfies only the flight operator's purchasing manager.

Continued on page 458

FAA Technical Standard Order (TSO)-C13f, *Life Preservers [Life Vests]*

Includes, among other provisions, the following:

"**Minimum Performance Standards.** This technical standard order (TSO) prescribes the minimum performance standards that life [vests] must meet in order to be identified with the applicable TSO marking. This TSO has been prepared in accordance with the procedural rules set forth in Subpart O of the Federal Aviation Regulations (FARs) Part 21. New models of life vests that are to be so identified and that are manufactured on or after the date of this TSO must meet the standard set forth in Appendix I, Federal Aviation Administration Standard for Life Preservers [Life Vests], as amended and supplemented by this TSO. …

Appendix 1. Federal Aviation Administration Standard for Life Preservers [Life Vests]

1. **Purpose.** This standard provides the minimum performance standards for life [vests].

2. **Scope.** This standard covers inflatable (Type I) and noninflatable (Type II) life [vests]. Both Type I and Type II life [vests] are divided into the following four categories: "Adult," "Adult–Child," "Child" and "Infant–Small Child".

3. **Materials.** The materials used must be of a quality which experience and/or tests have demonstrated to be suitable for use in life [vests].

3.1 **Nonmetallic Materials.**

3.1.1 The finished device must be clean and free from any defects that might affect its function.

3.1.2 Coated fabrics and other items, such as webbing, subject to deterioration must have been manufactured not more than 18 months prior to the date of delivery of the finished product or requalified per paragraph 5.1, Material Tests, of this standard.

3.1.3 The materials must not support fungus growth.

3.1.4 Coated fabrics, including seams, subject to deterioration used in the manufacture of the devices must retain at least 90 percent of their original physical properties after these fabrics have been subjected to accelerated aging test specified in paragraph 5.1, Material Tests, of this standard.

3.1.4.1 **Strength.** Coated fabrics used for these applications must conform to the following minimum strengths after aging:

- **Tensile Strength (Grab Test):**
  - Warp 210 pounds/inch;
  - Fill 180 pounds/inch; [and,]
- **Tear Strength:**
  - 10 x 10 pounds/inch (Tongue Test); or,
  - 10 x 8 pounds/inch (Trapezoid Test);

3.1.4.2 **Adhesion.** In addition to the requirements of 3.1.4.1, coated fabrics must meet the following minimum strength after aging:

- **Coat Adhesion:**
  - 10 pounds/inch width at 70 [degrees F] ± 5 degrees F [Fahrenheit] at a separation rate of 2.0 [inches/minute] to 2.5 inches/minute.

3.1.4.3 **Permeability.** For coated fabrics used in the manufacture of inflation chambers, the maximum permeability to helium may not exceed five liters per square meter in 24 hours at 77 degrees F or its equivalent using hydrogen. The permeameter must be calibrated for the gas used. In lieu of this permeability test, an alternate test may be used provided the alternate test has been approved as an equivalent to this permeability test by the manager of the FAA ACO [Aircraft Certification Office] to which this TSO data is to be submitted, as required in Paragraph (c), Data Requirements.

3.1.5 **Seam Strength and Adhesives.** Cemented or heat-sealable seams used in the manufacture of the device must meet the following minimum strength requirements:

3.1.5.1 **Cemented Seams.** Seams using adhesive on coated fabrics must be sealed with tape having a minimum width of 1 3/16 inches. Devices manufactured with cemented seams must meet the following minimum strength requirements:

- **Seam-shear Strength (Grab Test):**
  - 175 pounds/inch width at 75 degrees F;
  - 40 pounds/inch width at 140 degrees F; [and,]
- **Peel Strength (Peel Test):**
  - 10 pounds/inch width at 70 degrees F.

3.1.5.2 **Heat-sealed Seams.** The application of tape over heat-sealed seams is optional. Devices manufactured with heat-sealed seams used in the manufacture of the device must meet the following minimum strength requirements:

- **Seam Strength (Grab Test):**
  - 45 pounds/inch width at 70 degrees F; [and,]
  - 30 pounds/inch width at 140 degrees F.

3.1.6 **Seam Tape.** If tape is used, the fabric used for the seam tape must have a minimum breaking strength (Grab Test) of not less than 50 pounds/inch width in both the warp and fill directions. When applied to the seam area, the adhesion-strength characteristics must meet the seam-strength requirements in paragraph 3.1.5.

3.1.7 **Materials Other Than Coated Fabrics.**

3.1.7.1 **Webbing.** Webbing used to attach the life [vest] to the wearer must have a minimum tensile strength of 230 pounds.

3.1.7.2 **Thread.** Thread used in the life [vest] must be Size E nylon or equivalent with a minimum tensile strength of 8.5 pounds.

3.1.8 **Flammability.** The device (including packaging) must be constructed of materials which are in compliance with FARs [Part] 25.853(a) [Appendix F, Part I (a)(1)(iv)] in effect on July 20, 1990.

3.1.9 **Molded Nonmetallic Fittings.** Molded nonmetallic fittings must retain their physical characteristics when subjected to temperatures of –60 [degrees F] to +160 degrees F.

3.2 **Metallic Parts.** All metallic parts must be made of corrosion-resistant material or must be suitably protected against corrosion;

4. **Detail Requirements.**

4.1 **Design and Construction.**

4.1.1 **Reversibility.** The life [vest] must perform its intended function when reversed, unless the design of the [life vest] precludes the probability of improper donning.

4.1.2 **Compartmentation, Type I Life [Vest].** An inflatable life [vest] may have one or more separate gas-tight flotation chambers. Each separate flotation chamber must meet the inflation requirements of paragraph 4.1.4.

4.1.3 **Protection Against Abrasion and Chafing, Type I Life [Vest].** The flotation chambers must be protected in such a manner that metallic or nonmetallic parts do not cause chafing or abrasion of the material in either the packed or inflated condition

4.1.4 **Inflation, Type I Life [Vest].**

4.1.4.1 **Oral Inflation.** A means must be provided by which the wearer, excluding child and infant–small child wearers who would require adult assistance, without previous instruction, may inflate each flotation chamber by blowing into a mouthpiece. The mouthpiece for oral inflation must be readily available to the wearer without interfering with the wearer's face or body. For infant–small child and child life [vests], the oral inflation means must be readily available to assisting persons.

4.1.4.2 **Oral Inflation Valve.** The opening pressure of the oral inflation valve, with no back pressure applied to the valve, may not exceed 0.44 pounds per square inch gauge (psig). The oral inflation valve may not leak when back pressure throughout the range from zero psig through 10 psig is applied. The joint between the oral inflation valve and the flotation chamber may not fail when a 100-pound tensile load is applied for at least three seconds outwardly from, and perpendicular to, the surface of the flotation chamber at the point of valve attachment. To support the flotation chamber fabric during load application, an adapter having an inside diameter at least 3/4 inch larger than the outside diameter of the valve at the point of attachment must be used.

4.1.4.3 **Manual Mechanical Inflation.** A means must be provided by which the wearer, or person assisting a child or infant–small child wearer who would require adult assistance, without previous instruction, may inflate each flotation chamber of the life [vest] by manual operation.

4.1.4.3.1 **Gas Reservoir.** A reservoir containing a suitable compressed gas must be provided to inflate each flotation chamber of the life [vest]. If carbon dioxide [CO_2] cylinders are used, the standards of [Military Specification] MIL-C-601G, Amendment 1, dated Aug. 31, 1972, or the equivalent are acceptable notwithstanding any size or weight limitations.

4.1.4.3.2 **Pull-cord Assembly.** The mechanical-inflation means must have a pull-cord assembly for each gas reservoir. The pull cords must be identical in length, clearly visible and extend between 1 1/2 to three inches below the edge of the life [vest]. The end of each pull-cord assembly must be attached to a red pull knob or tab having rounded edges.

4.1.5 **Deflation, Type I Life [Vest].** A means by which the wearer, or the person assisting a child or infant–small child wearer who would require adult assistance, may quickly deflate each flotation chamber must be provided. Use of the deflation means may not preclude subsequent reinflation of the flotation chamber by either oral or mechanical inflation means. Inadvertent deflation of the flotation chamber must be precluded. In particular, inadvertent deflation from movement of a child or infant–small child and deliberate deflation by a child or small child must be precluded.

4.1.6 **Functional Temperature Range.** The life [vest] must be cable of satisfactory inflation after exposure to the temperature range from –40 [degrees F] to +140 degrees F for a minimum period of five minutes.

4.1.7 **Overpressure Protection, Type I Life [Vest].** A flotation chamber, when orally inflated to an operating pressure not less than one psig, must not burst upon subsequent discharge of the mechanical inflation system.

4.1.8 **Buoyancy.** The life [vest] must provide a buoyant force not less than that shown in Table I, Minimum Buoyant Force. The buoyant force of the life [vest] is equal to the weight of the volume of fresh water displaced by the life [vest] when totally submerged. Buoyancy must be demonstrated using the standard gas reservoirs described in 4.1.4.3.1 without further oral inflation, starting from a vacuumed-flat unit.

Table 1
Minimum Buoyant Force

Category of [life vest]	Weight of wearer (pounds)	Minimum buoyant force in fresh water at 70 [degrees F] ± 5 degrees F (pounds)
Adult	Above 90	35
Adult–Child Combination	35 and above	35
Child	35 to [no figure]	25
Infant–Small Child	Under 35	20

4.1.9 **Flotation Attitude.**

4.1.9.1 **Adult, Adult–Child and Child Life [Vests].** The life [vest] must, within five seconds, right the wearer, who is in the water in a face-down attitude. The life [vest] must provide lateral and rear support to the wearer's head such that the mouth and nose of a completely relaxed wearer [are] held clear of the water line with the trunk of the body inclined backward from the vertical position at an angle of 30 degrees minimum.

4.1.9.2 **Infant–Small Child Life [Vests].** The life [vest] must prevent contact of the wearer's upper torso (i.e., from the waist up) with the water. There must be a means to confine the wearer in the proper position for utilization of the life [vest] and prevent the wearer from releasing the confining means. With the wearer in the most adverse condition of weight and position attainable when the confining means are properly used, there must be no tendency of the life [vest] to capsize or become unstable, take on water or allow contact of the upper torso with water. Means must be provided to prevent the entrapment of rain or choppy water.

4.1.10 **Tether Infant–Small Child Category Life [Vest].** A tether, not less than 72 inches in length, must be attached to the infant–small child life [vest]. The attach point must be located such that the flotation attitude specified in paragraph 4.1.9.2 is maintained when the line is under sufficient tension to remove the slack as when held by an adult in the water. With the life [vest] on the infant–small child, there must be provisions for stowing or securing the tether in a manner that it remains readily accessible and will not dangle loosely so as to pose a hazard during an emergency evacuation.

4.1.11 **Life [Vest] Retention and Donning Characteristics.** The means of retaining the life [vest] on the wearer, excluding infant–small child wearers, must require that the wearer secure no more than one attachment and make no more than one adjustment for fit. It must be demonstrated, in accordance with the donning tests specified in paragraph 5.9, that at least 75 percent of the total number of test subjects and at least 60 percent of the test subjects in each age group specified in paragraph 5.9 can don the life [vest] within 25 seconds unassisted, starting with the life [vest] in its storage package. Percentage calculations may not be increased when rounded off. It must be demonstrated that an adult unassisted can install an appropriate life [vest] on another adult or a child within 30 seconds. It also must be demonstrated, in accordance with the donning tests specified in paragraph 5.9, that 60 percent of the adult test subjects can install an infant–small child dummy in an infant–small child life [vest] within 90 seconds.

4.1.12 **Comfort, Fit and Adaptability.** The design of the life [vest] must be such that:

4.1.12.1 After donning, inadvertent release by the wearer is not likely.

4.1.12.2 Adjustment may be made by the wearer, or the person assisting a child or infant–small child wearer, while in the water.

4.1.12.3 Unobstructed view by the wearer, excluding infant–small child wearers, is allowed in both the forward and sideward directions. An observation window must be provided for viewing of an infant–small child wearer by the assisting person if the life [vest] is enclosed.

4.1.12.4 Blood circulation of the wearer is not restricted.

4.1.12.5 The wearer's breathing is not restricted.

4.1.13 **Survivor-locator Light.** The life [vest] must be equipped with a survivor-locator light which meets the requirements of TSO-C85. The light must be automatically activated. This can be accomplished upon contact with water, upon inflation or by any other means not requiring additional user action.

4.1.14 **Life [Vest] Package.** A package must be provided for the life [vest] for storage of the life [vest] on board the aircraft. The means of opening the package must be simple and obvious, and must be accomplished in one operation without the use of any tool or excessive physical force.

4.1.15 **Color.** The color of the life [vest] must be an approved international orange-yellow or similar high-visibility color. The color of the flight crew life [vests] may be an approved red-orange or similar high-visibility contrasting color.

4.2 **Marking.** The following information and instructions must be shown:

4.2.1 **Pictorial Presentation.** The proper donning procedure and other operational instructions on the use of the life [vest] must be simple, obvious and presented primarily pictorially with minimum use of words.

4.2.1.1 **Orientation of Instructions.** Instructions pertaining to operations which would normally be accomplished after the life [vest] has been donned must be oriented so that the wearer, or the person assisting a child or an infant–small child wearer, may read them while in the water.

4.2.1.2 **Readability in Emergency Lighting Conditions.** Size, position and contrast of instructions must be such that the pictorial descriptions and written instructions are easily distinguishable and readable in low-level illumination. The markings and instructions must be readable by a person having 20/20 vision at a minimum viewing distance of 24 inches with illumination no greater than 0.05 foot-candle. For written instructions, an acceptable means of complying with this requirement is by use of bold lettering approximately 0.22 inch (5.6 millimeters [mm]) high with a stroke width of 0.047 inch (1.2 mm).

4.2.3 Date of manufacture of fabric (month and year).

4.2.4 Size category: "Adult," "Adult–Child," "Child" or "Infant–Small Child," as appropriate and weight limitation of each category.

4.2.5 The life [vest] package must clearly indicate that it contains a life [vest], the size category and the weight limitation of the life [vest]. The package also must be marked with the life [vest] TSO and part number or the information must be visible through the package.

5. Tests.

5.1 Material Tests. The material properties specified in paragraph 3 of this standard must be conducted in accordance with the following test methods or other approved equivalent methods:

Accelerated Age	Method 5850(9)(1)
Tensile Strength (Grab Test)	Method 5100(9)(7)
Tear Strength (Trapezoid Test)	Method 5136(9)(5)
Tear Strength (Tongue Test)	Method 5134(9) (Alternate to Trapezoid Test: see 3.1.4.1)
Ply Adhesion	Method 5960(9)(3)
Coat Adhesion	Method 5970(9)(8)
Permeability	Method 5460 (5)(6)
Seam Shear Strength	(9)(2)
Seam Peel Strength	Method 5960(9)(3)
Flammability	FARs Part 25, Appendix F, Part I(b)(5), Horizontal Burn Rate (4)

(1) Samples of coated fabric and seams for the accelerated aging tests must be exposed to a temperature of 158 [degrees F] + 5 degrees F for not less than 168 hours. After exposure, the samples must be allowed to cool to 70 [degrees F] + 2 degrees F for neither less than 16 hours nor more than 96 hours before determining their physical properties in accordance with paragraph 3.1 of this standard;

(2) Samples must consist of two strips of material two inches maximum width by five inches maximum length. Strips must be bonded or heat-sealed together along the width with an overlap of 3/4 inch maximum. Heat-sealed seams must have a 1/8 + 1/32 inch width minimum heat-seal bead with the heat seal 1/4 inch from each end. The free ends must be placed in the testing machine described in [Federal Test Method Standard] 191A, Method 5100 and separated at a rate of 2 [inches/minute] + 0.5 inches/minute. The average value of two samples must be reported. Samples may be multilayered to ensure

against premature material failure. Samples may be gripped across the full two inches of width.

(3) Separation rate must be 2.0 [inches/minute] to 2.5 inches/minute. Sample shall be one inch.

(4) The material must meet the flammability requirements of FARs [Part] 25.853(a) [Appendix F, Part I (a) (l) (iv)] in effect July 20, 1990.

(5) Federal Test Method Standard No. 191 in effect Dec. 31, 1968.

(6) ASTM Method D1434-82, Procedure V, approved July 30, 1982, is an acceptable alternate method.

(7) Use of pneumatic grips, for holding test samples, is an acceptable alternate to the mechanical grips described in Method 5100.

(8) The sample shall be prepared using the adhesive and construction methods used to manufacture the life [vest]. Separation rate must be 2.0 [inches/minute] to 2.5 inches/minute.

(9) Federal Test Method Standard No. 191A dated July 20, 1978.

5.2 **Leakage Test, Type I Life [Vest].** The life [vest] may not lose more than 1/2 psig per flotation chamber after each flotation chamber has been inflated to not less than two psig and hung in a rack for at least 12 hours.

5.3 **Overpressure Test, Type I Life [Vest].** Each flotation chamber of the life [vest] must withstand an inflation pressure of not less than 10 psig for at least five minutes.

5.4 **Submersion Test.** The life [vest] must be submerged in fresh water at 72 [degrees F] ± 5 degrees F so that no part of it is less than 24 inches below the surface. The buoyancy of the [vest] must not be less than the value specified in paragraph 4.1.8 of this standard. Submersion must continue for at least eight hours, except that the test may be discontinued in less than eight hours if buoyancy measurements taken at four successive 30-minute intervals show that the buoyancy of the [life vest] has stabilized at a value at least equal to the value specified in paragraph 4.1.8 of this standard.

5.5 **Salt Spray Test.**

5.5.1 **Salt Spray Test Procedure.** All metal parts must be placed in an atomized salt solution spray for a period of not less than 100 hours. The solution must be atomized in the chamber at a rate of three quarts per 10 cubic feet of chamber volume per each 24-hour period. The temperature in the chamber must be maintained at 95 [degrees F] ± 2 degrees F throughout the test.

5.5.2 **Salt Spray Solution.** The salt used must be sodium chloride or equivalent containing not more than 0.2 percent of impurities on the dry-weight basis. The spray solution must be prepared by dissolving 20 ± 2 parts by weight of salt in 80 ± 2 parts by weight of water containing not more than 200 parts per million of solids. The spray solution must be kept from exceeding this level of solids throughout the test. The spray solution must be maintained at a specific gravity of from 1.126 to 1.157 and a pH between 6.5 and 7.2 when measured at 95 [degrees F] ± 2 degrees F.

5.6 **Inflator Test, Type I Life [Vest].**

5.6.1 **Operating Force.** The force necessary to operate the mechanical inflation means may not exceed 15 pounds when applied through the pull cord.

5.6.2 **Pull Cord Strength.** The pull cord may not fail or separate from the mechanical inflation means when a minimum tension load of 60 pounds is applied to the cord for at least three seconds. If the pull cord is designed to separate from the mechanical inflation means when operated, the pull cord shall be capable of withstanding a minimum tension load of 30 pounds for three seconds without failure.

5.6.3 **Proof Pressure.** The mechanical inflation means must withstand a hydrostatic pressure of not less than 1,500 psig without deformation or leakage. The mechanical inflation means may not leak when subjected to two psig air pressure and may not lose more than 0.5 psig when subjected to 40 psig air pressure. Each test pressure must be applied for not less than 30 seconds.

5.6.4 **Mechanical Inflation Valve.** The mechanical inflation valve must allow a minimum flow of four liters of air per minute at 40 psig inlet pressure. The valve may not leak when subjected to a vacuum of 12 inches of water applied so as to reduce the seating spring pressure and with atmospheric pressure on the opposite side. The joint between the valve and the flotation chamber may not fail when a 250-pound load is applied, for at least three seconds, outwardly from and perpendicular to the surface of the flotation chamber at the point of valve attachment. To secure the joint during application of the load, an adapter having an inside diameter at least 3/4 inch larger than the outside diameter of the valve at the point of attachment must be used.

5.7 **Jump Test.**

5.7.1 **Adult, Adult-Child or Child.** An inflated adult, adult-child or child Type I or Type II life [vest], excluding infant-small child life [vests], must remain attached and not cause injury to the wearer when the wearer jumps into the water at any attitude from a height above the water of at least five feet. There must not be any damage to the [vest] following the jump. Minor skin chafing is not considered an injury in this respect.

5.7.2 **Infant-Small Child.** An infant-small child life [vest] must remain inflated and undamaged and the infant-small child dummy, specified in paragraph 5.9.1, must remain properly secured when an adult holding the dummy, with the [life vest] installed on the dummy, jumps into the water from a height above the water of at least five feet. The adult must be wearing an inflated life [vest] for the test.

5.8 **Fire Protection Test.** Materials used in the life [vest] and the storage package for the life [vest] must be tested by the horizontal burn-rate test prescribed in paragraph 5.1 of this standard.

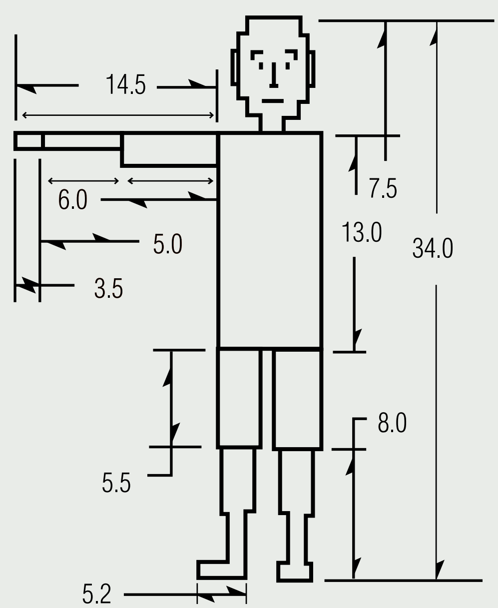
5.9 **Donning Test.**

5.9.1 **Test Subjects.** There must be a minimum of 25 test subjects. There must be a minimum of five test subjects in each of the following age groups: 20–29 years; 30–39 years; 40–49 years; 50–59 years; and 60–69 years. Not more than 60 percent of the test subjects in any age group may be of the same sex. The number of test subjects in any age group may not exceed 30 percent of the total number of test subjects. Infant-small child donning tests must be performed by a minimum of five adult test subjects of both sexes between the ages of 20 and 40. Tests must be performed using an articulating infant-small child dummy, as described below. Adult test subjects must have no prior experience in donning tests of life [vests].

5.9.2 **Infant-Small Child Test Dummy.** The dummy to be used in the donning tests must have the basic physical characteristics for a composite 50th percentile unisex child of 24 months with a height of

Table 2
Anthropometric Characteristics of Two-year-old Child

Body Segment	Length (inches)	Weight (grams)	Volume (%)
Top of Head (ref.)–Top of Shoulder/Upper Arm Pivot	7.5*	1,591.6	12.9
Elbow Pivot	6.0	876.0 (2)	7.1
Wrist Pivot	5.0	530.5 (2)	4.3
Finger Tip	3.5	123.5 (2)	1.0
Top of Shoulder/Upper Arm Pivot–Crotch/ Thigh Pivot	13.0*	5,564.4	45.1
Knee Pivot	5.5*	579.9 (2)	4.7
Bottom of Foot	8.0*	481.1 (2)	3.9
Total	***34.0 Height**	**12,338.0 (27.2 pounds)**	**100.0**
Shoulder Breadth	9.2		
Chest Breadth	6.6		
Chest Depth	4.6		
Waist Breadth	5.9		
Waist Depth, seated	5.9		
Hip Breadth	7.3		
Foot	5.2		
Circumferences			
Head	19.2		
Neck	9.2		
Chest	19.2		
Waist	18.1		
Hip	18.5		
Mid-thigh	9.9		
Calf	7.7		
Ankle	5.3		
Upper Arm	5.9		
Forearm	5.8		
Wrist	5.1		



34 inches and weighing 27.2 pounds. The dummy shall have articulating joints and, if used for water testing, must not absorb water. The anthropometric values for the dummy are presented in Table II. These data are considered valid for the stated chronological age plus or minus three months and are representative of U.S. children, as reported by the University of Michigan from 1975–1985.

5.9.3 **Test Arrangement.** Subjects must be seated in actual or simulated air carrier coach class seating with a seat row in front of the subjects creating a seat row pitch not exceeding 31 inches. Each subject must have the seat belt fastened. Subjects may be tested singularly or in groups seated side by side. Infant-small child life [vest] donning tests must be performed with adults in adjacent seats who must not assist or hamper the adult performing the donning test. Subjects must receive no donning information other than a typical preflight briefing and donning demonstration on the use of life [vests].

5.9.4 **Test Procedure.** The donning test must be begun with the life [vest] contained in the storage package required by paragraph 4.1.14, and the package held in the test subject's hand. Separate timing must be kept for each test subject. Timing starts on signal when the test subject has both hands on the packaged life [vest] and stops when the life [vest] is properly donned, secured and adjusted for fit. During the test, the test subject may release the seat belt and rise from the seat but may not move to any extent from the area immediately in front of the seat. ■

TSOs Are Not 'The Last Word'

A TSO does not define the optimum design for a piece of equipment. Each TSO takes into account the needs and viewpoints of different affected parties — predominantly regulators, manufacturers and operators. Compromises in TSOs are inevitable, because a standard for an ideal piece of equipment (assuming anyone knows what that would be) could make such a product prohibitively expensive for most users. In addition, a standard must be flexible enough to allow innovative improvements.

Different technical specialists, confronted with the same task of codifying standards, have differed somewhat in their conclusions.

For example, until recently, the U.K. Civil Aviation Authority (CAA) had its own Specification no. 2, *Inflatable Liferafts*. (Specification no. 2 is no longer enforced by the CAA because aviation safety in the European Union is now under the jurisdiction of the European Aviation Safety Agency [EASA]. EASA can still enforce Specification no. 2 until it approves its own TSO, which is expected to be modeled after FAA TSO-C70a.) A comparison of the FAA life raft TSO and Specification no. 2 illustrates how equivalent standards can differ, with one being stricter in certain aspects, and the other stricter in other aspects.

In general, Specification no. 2 emphasizes design and capability, whereas the FAA TSO emphasizes test methods for materials and function. Both provide for emergency inflation of all inflation chambers — the Specification describing the means as a "hand-operated pump," the TSO prescribing "means readily accessible to occupants of the [life] raft." Some other standards, although worded differently or including minor variations, are essentially equivalent in the two documents. But there are also significant differences:

- **Types.** Specification no. 2 includes an appendix containing provisions for helicopter life rafts for operations within helicopter search-and-rescue (SAR) coverage and where all aircraft occupants wear cold-water immersion suits (also known as survival suits, exposure suits, helicopter passenger suits, air crew immersion suits and helicopter offshore transport suits).

  TSO-C70a has no separate specifications for helicopter life rafts, but has two classifications: Type I rafts, for use in any aircraft, and Type II rafts, for use in aircraft other than transport category aircraft.

- **Inflation.** Specification no. 2 says, "The packed life raft shall be designed to inflate by means of its primary inflation system and be suitable for boarding in respect of buoyancy and stability within 30 seconds of the start of inflation."

  TSO-C70a has a similar provision but specifics that the life rafts must ready to support the first occupant within one minute after inflation starts.

- **Floor insulation.** Areas of the life raft floor with which occupants come in contact must contain insulation equal to that given by a 25-millimeter (one-inch) air cushion, according to Specification no. 2.

  The FAA standard has no equivalent requirement.

- **Occupancy ratings.** Specification no. 2 assumes an average occupant weight of 91 kilograms (200 pounds).

Continued on page 461

FAA Technical Standard Order (TSO)-C72c, *Individual Flotation Devices*

Includes, among other provisions, the following:

1.0 Purpose.

To specify minimum performance standards for individual flotation devices other than life [vests] defined in the TSO-C13 series.

2.0 Types and Description of Devices.

This standard covers the following two categories of individual flotation devices:

a. Inflatable types (compressed gas inflation).

b. Noninflatable types.

2.0.1 **Description of Inflatable Types.** Inflation must be accomplished by release of a compressed gas contained in a cartridge into the inflation chamber. The cartridge must be activated by a means readily accessible and clearly marked for its intended purpose. The flotation chamber must also be capable of oral inflation in the event of failure of the gas cartridge.

2.0.2 **Description of Noninflatable Types.** Seat cushions, head rests, arm rests, pillows or similar aircraft equipment are eligible as flotation devices under this standard provided they fulfill minimum requirements for safety and performance. Compression through extended service use, perspiration and periodic cleaning must not reduce the buoyancy characteristics of these devices below the minimum level prescribed in this standard.

2.1 **Instructions for Use.** Where the design features of the device relative to its purpose and proper use are not obvious to the user, clear instructions must be visible under conditions of emergency lighting.

3.0 Definitions.

The following are definitions of terms used throughout the standard:

a. **Buoyancy.** The amount of weight a device can support in fresh water at 85 degrees F [Fahrenheit].

b. **Flame Resistant.** Not susceptible to combustion to the point of propagating a flame beyond safe limits after the ignition source is removed.

c. **Corrosion Resistant.** Not subject to deterioration or loss of strength as a result of prolonged exposure to a humid atmosphere.

4.0 General Requirements.

4.0.1 **Materials and Processes.** Materials used in the finished product must be of the quality which experience and tests have demonstrated to be suitable for the use intended throughout the service life of the device. The materials and process must conform to specifications selected or prepared by the manufacturer which will [ensure] that the performance, strength and durability incorporated in the prototype are continued or exceeded in subsequently produced articles.

4.0.2 **Fungus Protection.** Materials used in the finished product must contain no nutrient which will support fungus growth unless such materials are suitably treated to prevent such growth.

4.0.3 **Corrosion Protection.** Metallic parts exposed to the atmosphere must be corrosion resistant or protected against corrosion.

4.0.4 **Fire Protection.** If the device is not used as part of a seat or berth, materials used in the device, including any covering, must meet Paragraph 6.0.2 of this standard. If the device is to be used as part of a seat or berth, all materials used in the device must meet Paragraph 7.0.3 of this standard.

4 0.5 **Temperature Range.** Materials used in the construction of the device must be suitable for the intended purpose following extended exposures through a range of operating temperatures from –40 degrees F to +140 degrees F.

4.1 **Design and Construction.**

4.1.1 **General.** The design of the device, the inflation means if provided and straps or other accessories provided for the purpose of donning by the user must be simple and obvious, thereby making its purpose and actual use immediately evident to the user.

4.1.2 **Miscellaneous Design Features.** The devices must be adaptable for children as well as adults. The devices must have features which enable the users to retain them when jumping into water from a height of at least five feet. Attachment straps must not pass between the user's leg for retention or restrict breathing or blood circulation.

5.0 Performance Characteristics.

5.0.1 **Buoyancy Standard.** The device must be shown by the tests specified in paragraph 7.0.1 to be capable of providing not less than 14 pounds of buoyancy in fresh water at 85 degrees F for a period of eight hours.

5.0.2 **Utilization.** The device must be capable of being utilized by the intended user with ease.

5.0.3 **Function Under Temperature Limits.** The device must function from –40 degrees F to +140 degrees F.

6.0 Standard Tests.

6.0.1 **Salt Spray Test Solution.** The salt used must be sodium chloride or equivalent containing on the dry basis not more than 0.1 percent of sodium iodide and not more than 0.2 percent of impurities. The solution must be prepared by dissolving 20 ±2 parts by weight of salt in 80 parts by weight of distilled or other water containing not more than 200 parts per million of total solids. The solution must be kept free from solids by filtration decantation, or any other suitable means. The solution must be adjusted to be maintained at a specific gravity of from 1.126 to 1.157 and a pH of between 6.5 and 7.2 when measured at a temperature in the exposure zone maintained at 95 degrees F.

6.0.2 **Flame Resistance.** Except for devices required to be tested in accordance with 7.0.3 the following applies: Three specimens, approximately four inches wide and 14 inches long, must be tested. Each specimen must be clamped in a metal frame so that the two long edges and one end are held securely. The frame must be such that the exposed area of the specimen is at least two inches wide and 13 inches long with the free end at least one-half inch from the end of the frame for ignition purposes. In case of fabrics, the direction of the weave corresponding to the most critical burn rate must be parallel to the 14-inch dimension. A minimum of 10 inches of the specimen must be used for timing purposes, and approximately one and one-half inches must burn before the burning front reaches the timing zone. The specimen must be long enough so that the timing is stopped at least one inch before the burning front reaches the end of the exposed area.

The specimens must be supported horizontally and tested in draft-free conditions. The surface that will be exposed when installed in the aircraft must face down for the test. The specimens must be ignited by the Bunsen or Tirrell burner. To be acceptable, the average burn rate of the three specimens must not exceed four inches per minute. Alternatively, if the specimens do not support combustion after the ignition flame is applied for 15 seconds or if the flame extinguishes itself and any subsequent burning without a flame does not extend into the undamaged areas, the material is also acceptable.

7.0 Test Requirements.

7.0.1 **Buoyancy Testing.** The flotation device, including all dress covers, fire blocking layer (if used) and straps that would normally be used by a survivor in an emergency, must be tested in accordance with either subparagraph (a) or (b) of this paragraph, as applicable, or an equivalent test procedure. The test may be conducted using nonfresh water, or at a temperature other than 85 degrees F, or both, provided the result can be converted to the standard water condition specified in Paragraph 5.0.1. The test may be conducted in open (ocean or lake) or restricted (swimming pool) water. The test specimen of noninflatable devices, such as pillows or seat cushions, must either be preconditioned to simulate any detrimental effects on buoyancy resulting from extended service or an increment must be added to buoyancy standard in paragraph 5.0.1 sufficient to offset any reduction in buoyancy which would result from extended service use.

a. **Test Procedures Applicable to Inflatable Devices and to Noninflatable Devices Made From Closed Cell Material.** The device must be tested by submerging it in water so that no part of it is less than 24 inches below the surface. It must be shown that the buoyancy of the device is at least equal to the value specified in paragraph 5.0.1 after submersion for at least eight hours, except that the test may be discontinued in less than eight hours if buoyancy measurements taken at four successive 30-minute intervals show that the buoyancy of the device has stabilized at a value at least equal to the value specified in Paragraph 5.0.1.

b. **Test Procedures Applicable to Noninflatable Devices Made from Open Cell Material.** The device must be completely submerged and must either support a human subject or be attached to a mechanical apparatus that simulates the movements characteristic of a nonswimmer. During the test, the device must be subjected to a squeezing action comparable to that caused by the movements characteristic of a nonswimmer. It must be shown that the buoyancy of the device is at least equal to the value specified in Paragraph 5.0.1 after testing for at least eight hours, except that the test may be discontinued in less than eight hours if the buoyancy measurements taken at four successive 30-minute intervals show that the buoyancy of the device has stabilized at a value at least equal to the value specified in Paragraph 5.0.1.

7.0.2 **Salt Spray Testing.** All metallic operating parts must be placed in an enclosed chamber and sprayed with an atomized salt solution for a period of 24 hours.

The solution must be atomized in the chamber at a rate of three quarts per 10 cubic feet of chamber volume per 24-hour period. At the end of the test period, it must be demonstrated that the parts operate properly.

7.0.3 **Test for Fire Protection of Materials.** Materials used in flotation devices that are to be used as part of a transport category aircraft seat or berth must comply with the self-extinguishing fire protection provisions of section 25.853(b) of FARs [U.S. Federal Aviation Regulations] Part 25. In all other applications, the materials in the flotation devices must be tested in accordance with paragraph 6.0.2 of this standard to substantiate adequate flame-resistant properties.

7.0.3.1 **Test for Fire Blocking of Seat Cushions.** Tests must be conducted in accordance with Appendix F, Part II of FARs Part 25.

7.0.4 **Extreme Temperature Testing.** Tests must be performed to demonstrate that the device is operable throughout the temperature range specified in paragraph 5.0.3. In performing these tests, preconditioning of tests, specimens must be accomplished to simulate conditions of immediate use of the device following an aircraft takeoff.

Note: An acceptable procedure for preconditioning may involve storage of the device for eight hours at the extreme temperatures specified, followed by exposure to room temperature conditions for a period of time not to exceed 10 minutes. ■

A minimum average occupant weight of 170 pounds (77 kilograms) must be used in all tests and calculations for TSO-C70a.

- **Seaworthiness.** Specification no. 2 says, "The life raft shall be capable of withstanding, without any malfunction of the life raft or its equipment, sea and wind conditions of at least Sea State 6 and 60 kilometers per hour (40 miles per hour) respectively." Sea State 6 (page 46) is a near gale with winds of 28 knots to 33 knots (50 kilometers per hour to 61 kilometers per hour) and an average wave height of 14 feet (four meters) with a maximum wave height of 18 feet (5.5 meters).

  Under TSO-C70a, "the life raft must be demonstrated by tests or analysis, or a combination of both, to be seaworthy in an open-sea condition of 17[-knot] to 27-knot winds and waves of six [feet] to 10 feet [1.8 meters to three meters]."

- **Canopy.** "The canopy shall be automatically erected in sequence with the inflation of the life raft," says Specification no. 2. "Facilities shall be provided for the collection and retention of rainwater from the external surface of the canopy."

  TSO-C70a says, "If the canopy is not integral with the [life] raft, it must be capable of being erected by occupants following conspicuously posted, simple instructions. It must be capable of being erected by one occupant of an otherwise empty [life] raft and by occupants of a [life] raft filled to rated capacity." There is no requirement for collecting rainwater.

- **Righting aids.** Both standards require a righting aid to be provided for use if the raft inflates in the inverted position.

  Specification no. 2 requires that the aid be capable of righting the raft in conditions of at least Sea State 6 and winds of 60 kilometers per hour.

  TSO-C70a does not specify wind or sea conditions that must be met for righting, but notes that the means provided for righting must be usable by one person in the water.

- **Valise or container.** Specification no. 2 requires that the packed life raft be capable of being dropped from a height of three meters (10 feet) onto a hard surface without adversely affecting performance. Specification no. 2 provides that the valise or container shall include lifting handles for moving the packed life raft within the aircraft.

  TSO-C70a specifies that a complete life raft package must be drop tested by dropping it from a height of five feet (1.5 meters) onto a hard floor, after which it must be inflated and meet the pressure-retention requirements of the standard. The TSO says, "It must be demonstrated that the complete life raft package can be moved from a typical stowage installation by no more than two persons and then deployed at another suitable exit."

- **Attached equipment.** Specification no. 2 includes a provision for an internal light that will enable all printed instructions on the life raft's internal surfaces or attached equipment to be read in darkness. Specification no. 2 requires an external light that provides "maximum practical conspicuity" for SAR operations, including both a vertical light beam and a horizontal light beam. The output of the light must be visible at night in clear atmospheric conditions for at least two nautical miles (four kilometers) for at least 12 continuous hours.

  TSO-C70a specifies that survivor-locator lights must be approved under

Continued on page 463

FAA Technical Standard Order (TSO)-C85a, *Survivor-locator Lights*

a. Applicability.

(1) **Minimum Performance Standards.** This technical standard order (TSO) prescribes the minimum performance standards that survivor-locator lights must meet in order to be identified with the applicable TSO marking. New models of survivor-locator lights that are to be so identified and that are manufactured on or after the date of this TSO [May 7, 1996] must meet the standard set forth in Society of Automotive Engineers Inc. (SAE), Aerospace Standard (AS) 4492, *Survivor-locator Lights*, dated January 1995. [Editorial note: SAE is now called SAE International.]

(2) **Environmental Standards.** SAE AS 4492 incorporates by reference the environmental test procedures specified in RTCA Inc. (RTCA) Document No. DO-160C, "Environmental Conditions and Test Procedures for Airborne Equipment," dated December 1989. A more recent version of this standard and tests may be substituted, if approved by the manager of the aircraft certification office (ACO), Federal Aviation Administration (FAA), having geographical purview over the manufacturer's facilities.

(3) **Previously Approved Articles.** Survivor-locator lights approved prior to the date of this TSO may continue to be manufactured under the provisions of their original approval.

b. Marking. Each survivor-locator light must be marked in accordance with [U.S. Federal Aviation Regulations (FARs) Part] 21.607(d).

c. Data Requirements.

(1) In addition to the documentation specified in [Part] 21.605(a), the manufacturer shall furnish or have available for review, at the discretion of the manager of the ACO, FAA having geographical purview of the manufacturer's facilities, one copy each of the following technical data:

(i) A complete description of the survivor-locator light, including detail drawings or drawing list, material identification and process specification.

(ii) Operating instructions and limitations.

(iii) Installation instructions and limitations, including stowage area temperatures.

(iv) Packaging instructions and limitations.

(v) Maintenance instructions, including information regarding inspection, repair, stowage of materials, recommended inspection intervals and service life.

(vi) Manufacturer's TSO qualification test report with an environmental qualification form, as described in RTCA/DO-160C.

(vii) The quality-control inspection and functional-test specification to be used to test each production article to ensure compliance with this TSO, as required by reference in [Part] 21.605(a)(3) to [Part] 21.143.

(2) In addition, the manufacturer must furnish, to each person receiving for use one or more of the articles manufactured under an authorization of this TSO, one copy of the following:

(i) The technical data and information specified in paragraphs (c)(1)(ii) through (c)(1)(v) of this TSO and any other data or information that are necessary for continued airworthiness of the survivor-locator lights.

(ii) A note with the following statement:

"The conditions and test required for TSO approval of this article are minimum performance standards. It is the responsibility of those desiring to install the article either on or within a specific type or class of aircraft to determine that the aircraft installation conditions are within the TSO standards, the article may be installed only if further evaluation by the applicant documents an acceptable installation and is approved by the Administrator."

d. Availability of Referenced Documents.

(1) Copies of SAE AS 4492 may be purchased from [SAE International], Department 331, 400 Commonwealth Drive, Warrendale, PA 15096.

(2) Copies of RTCA Document No. DO-160C may be purchased from the RTCA Inc., 1140 Connecticut Avenue NW, Suite 1020, Washington, DC 20036-9325.

(3) Federal Aviation Regulations, Part 21, Subpart O, and Part 25, Subpart D, may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325. [Editorial note: The FARs are available at the Internet site <http://www.access.gpo.gov/cgi-bin/cfrassemble.cgi?title=200314>.]

(4) Advisory Circular 20-110H, "Index of Aviation Technical Standard Orders," or latest revision may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785. [Editorial note: Advisory Circulars are also available at the Internet site <http://www.faa.gov/regulations/index.cfm>.]

— /S/ John K. McGrath
Manager, Aircraft Engineering Division,
Aircraft Certification Service

TSO-C85. TSO-C85 (page 462) is largely concerned with requirements for manufacturers to submit data to FAA. Performance standards for survivor-locator lights manufactured after March 7, 1996, are referenced to SAE International Aerospace Standard (AS) 4492, *Survivor-locator Lights*. TSO-C70a requires one or more lights to be automatically activated when the life raft enters the water, and for the lights to be visible from any direction by persons in the water.

- **Helicopter life rafts.** Specification no. 2's appendix, *Helicopter Liferafts*, applies to life rafts used within helicopter SAR range and where all the helicopter's occupants wear immersion suits. Some provisions of Specification no. 2 — such as a requirement for floor insulation and for a rainwater-collecting facility — are omitted under the assumption that the life raft will be occupied for a relatively short time and that the immersion suits will afford extra protection. But a helicopter life raft must be fully reversible, unless it can be demonstrated that it is self-righting when fully inflated. Furthermore, the container must be capable of being moved to, and launched from, an emergency exit by one person (male or female).

  TSO-C70a has no helicopter-specific requirements for life rafts.

SAE Recommended Practice Offers Another Viewpoint

SAE International's Aerospace Recommended Practice (ARP) 1356, *Life Rafts*, provides other opportunities for comparison with the TSO. Some areas in which the ARP (a purely "model" standard that has no regulatory force) and the TSO differ are as follows:

- **Carrying case.** The ARP says, "Opening of the carrying case shall be automatic upon activation of the [life] raft's inflation means."

  The TSO has no equivalent provision.

- **Canopy strength.** The ARP says, "The canopy, when erected, shall be capable of withstanding sea conditions of 27-knot winds and waves of 10 feet (three meters)."

  The TSO says, "The erected canopy must be capable of withstanding 35-knot winds and 52-knot gusts in open water."

- **Canopy openings.** The ARP says, "As a minimum, the canopy shall be provided with closable openings at each of the boarding stations and adjacent to the static-line attach point. These openings shall be at least 39.4 inches (one meter) wide and sufficiently high to permit unrestricted boardings of an adult with life [vest] donned. Canopy openings shall be from the bottom up, and shall be resistant to jamming and corrosion. The openings shall provide cross-ventilation of the raft interior."

  The TSO says, "The canopy … must have provision for openings 180 degrees apart."

- **Survivor-locator lights.** The ARP says, "Approved survivor-locator lights (which comply with TSO-C85, *Survivor-locator Lights*) easily seen from the water and above the [life] raft shall be permanently installed near each boarding station."

  The TSO says, "One or more survivor-locator lights must be provided that are approved under TSO-C85. The lights must be automatically activated upon [life] raft inflation in the water, and visible from any direction by persons in the water."

- **Water collection.** The ARP says, "A means for the collection and storage of rainwater shall be provided."

  The TSO has no equivalent provision.

- **Accessory-case tiedowns.** The ARP has no recommendation for a means of tying an accessory case to the life raft.

  The TSO says, "Provisions must be made for tiedowns to hold any accessory case. Each accessory case tiedown must withstand a pull of 250 pounds [113 kilograms]."

Compare Life Rafts, Not Standards

A life raft built to TSO-C70a can exceed the TSO requirements. Nevertheless, the most important comparisons are among life rafts, not among the various standards under which life rafts can be approved.

Indeed, a life raft can be approved under more than one standard. One manufacturer's corporate-aviation life rafts, for example, are approved by FAA, the U.K. CAA, and the French Direction Générale de l'Aviation Civile (DGAC). The choice of which standard or standards a company meets depends on where the raft is to be marketed.

The European Joint Aviation Authorities (JAA) has proposed six Joint Technical Standard Orders (JTSOs) for life vests, life rafts and safety equipment for personnel involved in helicopter operations. (For European Union member nations, it is expected that equivalent European TSOs [ETSOs] will be adopted by EASA.) As part of the ongoing harmonization of FAA and JAA regulations, two of the proposed JTSOs for life rafts (JTSO-C70a) and life vests (JTSO-C13f) largely parallel those to be found in FAA TSOs TSO-C70a and TSO-C13f, respectively. Proposed JTSO-2C505 is for life rafts to be carried on helicopters operating to or from helidecks located in a hostile-sea area. Its specifications closely follow those of the Specification no. 2 appendix, *Helicopter Liferafts*.

The other proposed JTSOs, concerning immersion suits for helicopter occupants (see "Cold Outside, Warm Inside: Immersion Suits," page 357), and for helicopter constant-wear life vests (see "Your Life Vest Can Save Your Life … If It Doesn't Kill You First," page 346), have no parallel in FAA TSOs.

Marine Life Raft Regulations Offer Insight Into Conditions of Use

Another way to look at the regulations for aviation life rafts is to compare them with those for marine life rafts (that is, life rafts carried aboard and launched from seagoing vessels).

"Once you ditch, you're no longer an aviator, you're a marine survivor," said Howard Kaufmann, president, RFD/Revere. "Judge your life raft from a marine perspective. And improvements have been incorporated into the standards for marine life rafts more frequently than they have been in those for aviation life rafts."[4]

Martin Schwartz, chief engineer, EAM, agreed that standards for marine life rafts have been revised more often than those for aviation life rafts. "But I don't believe that has much relevance to the way you should judge an aviation [life] raft," he said. "The marine and aviation industries have different requirements, goals and expectations. There are many things both industries can learn from each other."[5]

Marine life rafts serve the same purpose as aviation life rafts, have many of the same features and may appear similar to aviation life rafts. Nevertheless, many marine life rafts have superior equipment and may be subject to more demanding regulations.

One reason for the discrepancy is that higher quality is to some extent correlated with more weight, and weight is a less-important factor for most marine vessels than for aircraft. Moreover, the maritime industry is more attuned to actual conditions that survivors in a life raft will encounter than are aviation authorities and pilots. Phrases in marine life raft specifications such as "capable of being opened and resealed easily and used with cold, wet, numbed hands" and "must work when wet and be capable of being applied during violent motion" suggest that those who wrote them were working from the "cold, wet, numbed" hands-on experience of maritime survivors.

Safety requirements for large commercial ships in international waters are contained in the International Convention for the Safety of Life at Sea (SOLAS),[6] and the SOLAS Life-Saving Appliances (LSA) Code.[7] Corporate airplanes and racing yachts share a common design goal: speed. Therefore, the dimensions and weight of life rafts are important factors for both.

Life rafts manufactured to specifications published by the International Sailing Federation (ISAF) for life rafts carried on racing yachts[8] include a similar capacity range — four persons to 12 persons — as the aviation rafts carried on many helicopters and corporate aircraft.

The following are some provisions of the ISAF specifications not found in, or different from, FAA TSO C70a:

- **Strength.** "Every life raft shall be so constructed as to be capable of withstanding exposure for 20 days afloat in all sea conditions, in air temperatures between –15 [degrees C] to 65 degrees C [5 degrees F to 149 degrees F]."
- **Viewing ports.** "The canopy shall be provided with at least one viewing port such that a viewing horizon of 360 degrees is available."
- **Carrying capacity.** The ISAF specifications do not specify the minimum amount of space allotted to each occupant of a life raft in the same way as aviation life raft specifications do. The TSO requires life rafts to have a rated capacity of 3.6 square feet (0.3 square meter) per person and an overload capacity of 2.4 square feet (0.2 square meter) per person. Based on that ratio and the provisions in JAR-OPS 1.830 and FARs Part 25.1415 requiring that "the buoyancy and seating capacity beyond the rated capacity of the rafts must accommodate all occupants of the airplane in the event of a loss ["the loss" in JAR-OPS 1.830] of one raft of the largest rated capacity," the aviation life raft industry has settled on a standard overload capacity that is 1.5 times the rated capacity of each life raft. For example, a life raft with a rated capacity of eight is designed for an overload capacity of 12.

ISAF specifications do not discuss the concept of overload capacity.

ISAF defines the number of people a life raft may accommodate as the least among three formulas, derived from SOLAS:

- "The greatest whole number obtained by dividing by 0.096 the volume, measured in cubic meters, of the main buoyancy tubes (which for this purpose shall include neither the [canopy] arches nor the thwarts [crosspieces], if fitted) when inflated; or,
- "The greatest whole number obtained by dividing by 0.372 the inner horizontal cross-sectional area of the life raft measured in square meters (which for this purpose may include the thwart or thwarts, if fitted) measured to the innermost edge of the buoyancy tubes; or,
- "The number of persons [with an average weight of 75 kilograms (165 pounds)] that

can be seated with reasonable comfort and headroom without interfering with any of the life raft's equipment."

In practice, the industry standard for marine life rafts is four square feet per occupant. "Our civilian marine life rafts are designed to the four-square-feet standard, and I believe that all other manufacturers' are as well," said David Williams, senior technical representative of Winslow LifeRaft Co. "Any marine life raft with less space for each occupant would be at a competitive disadvantage."[9]

- **Ballast pockets.** ISAF also provides details on water-ballast pockets (also called water-ballast bags) and equipment pockets. "The life raft shall be fitted with water-ballast pocket(s) complying with the following requirements:
  - "The pocket(s) shall fill to at least 60 percent of its/their capacity within 25 seconds of deployment;
  - "The pocket(s) shall have an aggregate capacity of at least 220 liters [58 U.S. gallons] for life rafts certified to carry four to 10 persons and an aggregate capacity of at least 240 liters [63 U.S. gallons] for life rafts certified to carry 10 to 12 persons;
  - "If more than one pocket, they shall be positioned symmetrically [around] the circumference of the life raft. If only one pocket, its periphery shall be positioned symmetrically [around] the circumference of the life raft; [and,]
  - "Where appropriate, means shall be provided to enable air to readily escape from underneath the life raft."
- **Equipment pockets.** "At least two equipment pockets shall be provided, made from transparent flexible plastic material with drain holes and provided with Velcro flaps, appropriately fixed to a canopy arch tube. [The] purpose is to stow loose equipment where it can be seen and kept readily available but safe against loss and as far as possible away from constant wetting."

ISAF Life Raft Equipment Specifications More Stringent

The ISAF specifications list 20 items of standard life raft equipment, a list that ISAF says "closely but not precisely follows that of SOLAS B." Some are not included in U.S., U.K. or Canadian aviation regulations or recommendations (see Table 2, page 404). In addition, the ISAF specifications for survival equipment specifications are more detailed and often mandate higher quality standards than those for comparable aviation life raft items.

For example, FAA Advisory Circular (AC) 120-47 recommends only that the aviation life raft carry "one spotlight or flashlight (including a spare bulb) having at least two D-cell batteries or equivalent." Canadian Aviation Regulations (CARs) 725.95 specifies "a waterproof flashlight." ISAF requires "two waterproof sealed-for-life torches [flashlights]. Each torch shall be sealed in clearly marked packaging which prevents the operation of the torch until the packaging is removed. Torch packaging shall be clearly marked with the [expiration] date of the torch. Each torch shall be capable of providing a continuous light of six hours."

General provisions of the ISAF specifications for equipment packed inside the life raft include the following:

- "Every package, closure and item of equipment shall be
  - "Capable of being opened and resealed easily and used with cold, wet, numbed hands and without an implement of any kind; [and,]
  - "Impervious to water and rust;
- "Every package shall have readily resealable closures of Velcro, large zips, captive [attached] elastic shockcord loops, shockcords or cords with jamb cleats, or other suitable materials;
- "Portable items shall be capable of being fitted into installed pockets provided in the interior of the life raft;
- "Portable items shall have lanyard or tape 'tails' with Velcro self-seal strips at the ends to facilitate making [them] captive without tying knots;
- "Portable items shall (except where essential) be without sharp corners, sharp edges and unnecessary protrusions which could injure survivors or cause damage to the life raft fabric; [and,]
- "The equipment pack shall be inherently buoyant, brightly colored and captive by a line to the inside of the raft. Instructions shall be marked on each item as appropriate."

Some of the other items that must be packed inside the life raft according to the ISAF specifications are the following:

- **First aid kit.** "A basic first aid kit shall include at least two tubes of sunscreen and one tube of sunburn-treatment cream. If water is not included in the life raft kit, at least 0.5 liter [0.53 U.S. quart] to aid taking seasickness or analgesic tablets, etc., shall be provided in a soft plastic drinking pack with a built-in valve. Small bottle caps, etc., shall if possible be captive to aid the action of resealing. All dressings shall if possible be capable of being effectively used in wet conditions. The first aid kit shall be clearly marked and, it is recommended, should fit into a prepared and clearly marked stowage pocket."

- **Flares.** "Three hand flares, in accordance with SOLAS regulation 36."

- **Survival bags.** "Two thermal protective aids, in accordance with SOLAS LSA 2.5 (waterproof, and designed to reduce convective and evaporative heat loss from the wearer's body)."

- **Repair outfit.** "To enable persons with numbed, wet, cold hands to repair leaks in the inflatable compartments, including, e.g., buoyancy tubes, inflatable floor (if fitted), inflatable canopy support (if fitted), inflatable boarding ramp (if fitted). Repair systems must work when wet and be capable of being applied during violent motion. The repair outfit shall include at least six leak-stop plugs."

- **Air pump.** "Must be simple, robust and complete with all necessary connections (loose parts must be captive to the main apparatus), ready for instant use to enable persons with numbed, wet, cold hands to pump air into the inflatable compartments including, e.g., buoyancy tubes, inflatable floor (if fitted), inflatable canopy support (if fitted), inflatable boarding ramp (if fitted). The air pump must be designed and built specifically for easy operation by hand."

Another difference between aviation life rafts and marine life rafts derives from the environment in which they are carried. If a marine life raft inflation cylinder malfunctions, the gas is released into the raft, inflating the raft. An inadvertent inflation of a raft aboard an aircraft could be disastrous, however, making the raft impossible to remove from the aircraft in a ditching situation. Aviation life rafts are designed to be "fail-safe": If a malfunction of the inflation system occurs, the cylinder vents into the atmosphere, not into the raft.[10]

This overview of some regulations and advisories suggests that they are not an exact science and should be considered as one factor in survival planning, but not the only factor.

Each operator should base its survival-equipment decisions on the typical characteristics of its own flights, such as whether they are within helicopter SAR range, whether they are conducted over relatively benign bodies of water or in extreme cold-water environments and the SAR capabilities along the routes. That analysis will enable the operator to determine the equipment best suited for its operations. ■

The bottom line, in our opinion …

- **That a life raft is manufactured to a technical standard order (TSO) does not ensure that it will be of the highest quality.**

- **Operators of extended overwater flights conducted under U.S. Federal Aviation Regulations (FARs) Part 91 and Part 135 have considerable leeway in what they include in the life raft's survival equipment pack (SEP). Canada, New Zealand and the European Joint Aviation Authorities are more specific about SEP contents.**

- **FAA advisory circulars, JAR-OPS acceptable means of compliance and SAE aerospace recommended practices provide guidance on compliance with the regulations or recommendations by industry specialists in water-survival equipment.**

- **Regulations are not all that matter. The minimum requirements leave ample room for the operator to further strengthen overwater safety.**

Notes

1. U.S. Federal Aviation Regulations (FARs) Part 21.601(b)(1).
2. Jensen, Hal. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Nov. 18, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
3. Fanjul, Gustavo. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Nov. 18, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. Kaufmann, Howard. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Jan. 19, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.
5. Schwartz, Martin. E-mail communication to Darby, Rick. Alexandria, Virginia, U.S., Jan. 22, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.
6. *SOLAS Consolidated Edition, 2001*. London, England: International Maritime Organization, 2001.
7. *Life-Saving Appliances, 2003 Edition.* London, England: International Maritime Organization, 2003.
8. *Minimum Specifications for Yachtsmen's Liferafts*. Special Regulations, Appendix A, part 2. Southampton, England: International Sailing Federation, 2002.
9. Williams, David. Telephone interview by Darby, Rick. Alexandria, Virginia, U.S., Dec. 4, 2003. Flight Safety Foundation, Alexandria, Virginia, U.S.
10. *General Aviation Safety Sense Leaflet 21A: Ditching*. U.K. Civil Aviation Authority, 2000.

Aviation Statistics

Aviation Statistics

About 75 Percent of Airplane Occupants and More Than 87 Percent of Helicopter Occupants Survived Ditchings, Data Show

Although nonditching water-contact accidents resulted in larger percentages of fatalities than ditching accidents, more than 37 percent of airplane occupants and more than 61 percent of helicopter occupants survived.

— FSF EDITORIAL STAFF

The majority of occupants survived in ditching accidents involving airplanes (Figure 1, page 470) and helicopters (Figure 2, page 471), according to data compiled and analyzed by Flight Safety Foundation. The data include water-contact accidents from Jan. 1, 1976, to July 8, 2003, for airplanes (Table 1, page 473) and from Jan. 1, 1980, to Feb. 23, 2003, for helicopters (Table 2, page 594).

In accidents for which sufficient data were available, the data show that the majority of airplane ditchings and the majority of helicopter ditchings involved no fatalities, and that most nonditching water-contact airplane accidents involved one or more fatalities.

In airplane ditchings for which the number of fatalities is known, 18.20 percent of the accidents resulted in one or more fatalities, compared with 64.78 percent of airplane nonditching accidents. In water-contact accidents for which airplane damage was reported, ditchings resulted in 52.45 percent of the airplanes being destroyed; nonditching accidents resulted in 65.55 percent of the airplanes being destroyed.

Of the total number of known occupants in the airplane-ditching accidents, 24.92 percent were killed. In airplane-nonditching accidents, 62.09 percent were killed.

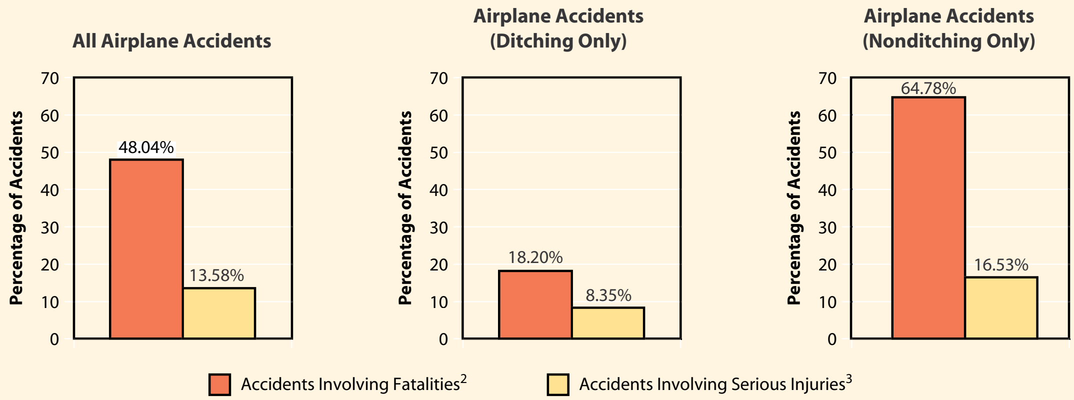
In helicopter ditchings for which the number of fatalities is known, 19.29 percent resulted in one or more fatalities, compared with 46.03 percent of nonditching accidents. In water-contact accidents for which helicopter damage was reported, the helicopter was destroyed in 53.62 percent

Continued on page 472

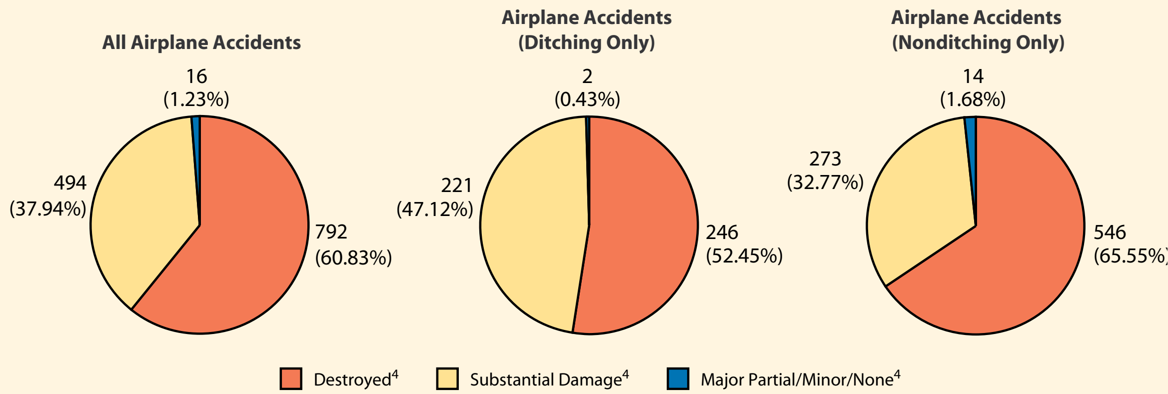
...Ditchings resulted in 52.45 percent of airplanes being destroyed.

Figure 1
Airplane Water-contact Accidents, 1976–July 8, 2003[1]

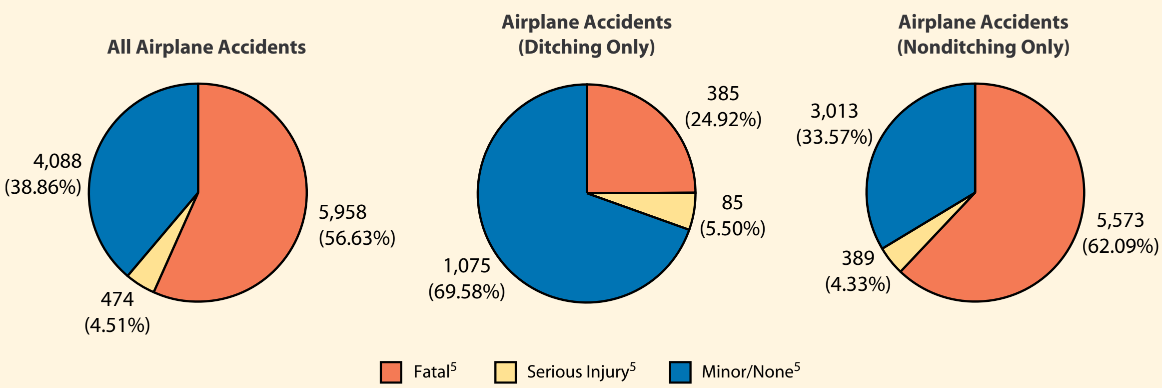
Percentage of Accidents Involving Fatalities and Serious Injuries



Damage to Aircraft



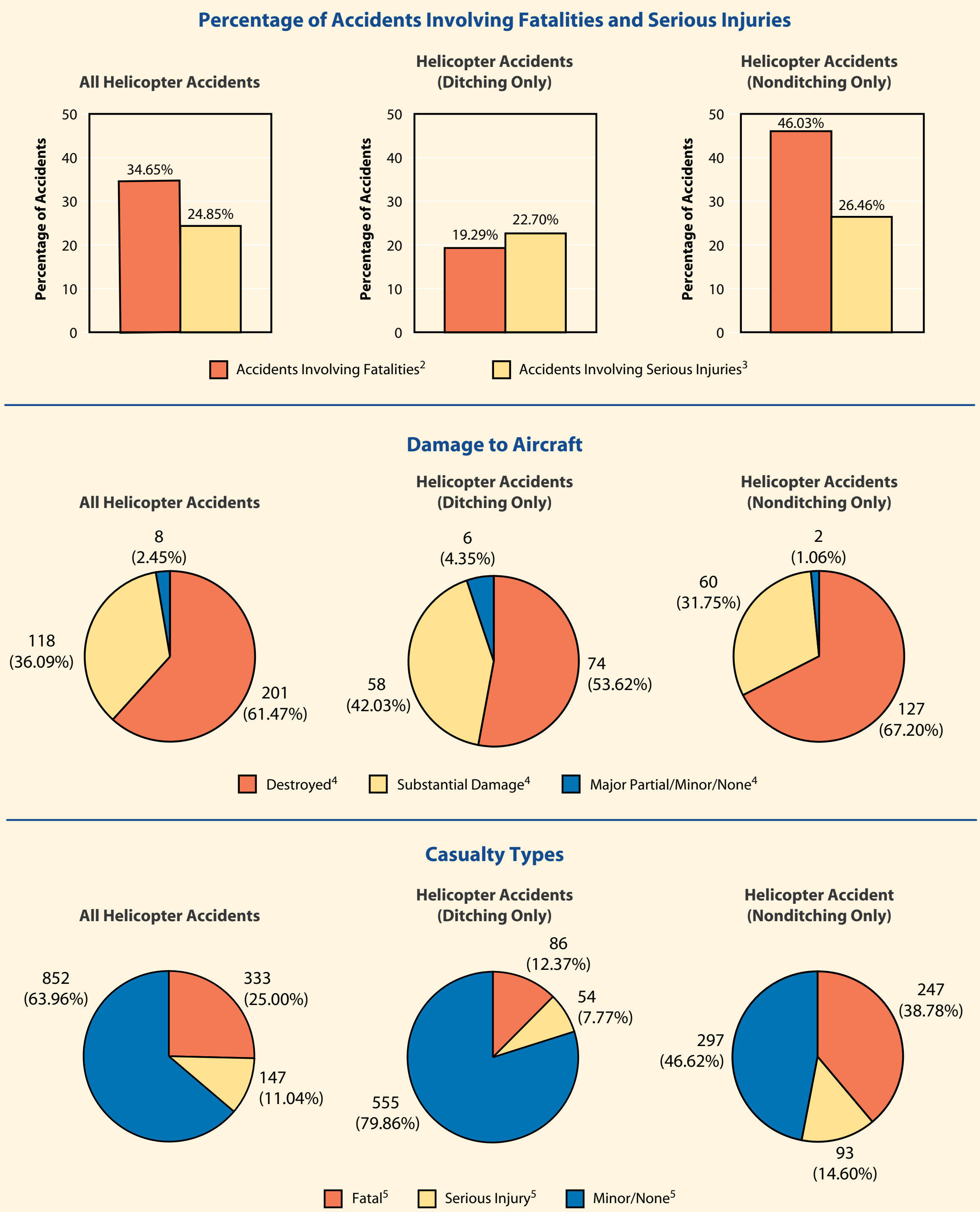
Casualty Types



[1]This summary is derived from the airplane water-contact accident database in Table 1.
[2]Percentage refers to accidents in which the number of fatalities is known.
[3]Percentage refers to accidents in which the number of serious injuries is known.
[4]Percentage refers to accidents in which the damage to the aircraft is known.
[5]Percentage refers to accidents in which the distribution of casualty types is known.

Source: Flight Safety Foundation

Figure 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003[1]



[1]This summary is derived from the helicopter water-contact accident database in Table 2.
[2]Percentage refers to accidents in which the number of fatalities is known.
[3]Percentage refers to accidents in which the number of serious injuries is known.
[4]Percentage refers to accidents in which the damage to the aircraft is known.
[5]Percentage refers to accidents in which the distribution of casualty types is known.

Source: Flight Safety Foundation

of the ditchings and in 67.20 percent of the nonditching accidents.

Of the total number of known occupants in helicopter-ditching accidents, 12.37 percent were killed; 38.78 percent were killed in helicopter-nonditching accidents.

Jet transport water-contact accidents represent a special category. Analysis of data from various sources about 57 jet transport water-contact accidents (in 28 of which there were survivors), including some accidents that predated the time frame of Table 1, yielded the following observations:

- With one exception, the water-contact accidents with survivors occurred within 5.2 nautical miles (9.6 kilometers) of shore. The exception was a ditching that occurred 26 nautical miles (48 kilometers) from shore; and,

- Life rafts were not used in most of the jet transport water-contact accidents with survivors.

In six of the 28 jet transport water-contact accidents in which there were survivors, life rafts were used; in five of these six accidents, the airplane was resting in very shallow water or remained afloat while all occupants were rescued. In two of the 28 accidents, the airplane was so close to shore that occupants were evacuated without life rafts. In 11 of the 28 accidents, the airplane was less than 100 feet (30 meters) from shore.

In two accidents, the airplane sank while survivors were using or attempting to use life rafts:

- In the accident that occurred 26 nautical miles from shore, while crewmembers tried to deploy one of the five life rafts, the raft inflated inside the airplane and blocked the galley-door exit. Most occupants did, however, use flotation devices, primarily life vests; and,

- In a water-contact accident during approach, one of two 26-person life rafts aboard the airplane was deployed and was used by some of the occupants while awaiting rescue. There were 56 survivors and 24 fatalities among the crew and passengers.

Data in Table 1 and Table 2 included 1,304 airplane accidents and 332 helicopter accidents. For a few accidents, information about the number of people killed, seriously injured or incurring minor injury or no injury was partial; in those accidents, any numbers provided by the source were used in the calculations. Percentages were calculated using only accidents for which the required data were available.

No claim is made that the tables represent every water-contact accident during the periods studied. Moreover, the sample is likely skewed in favor of accidents investigated by authorities whose reports were published in English (and were readily available for analysis). Although the sources are considered reliable, total accuracy cannot be established. Nevertheless, the numbers of accidents in the tables are large enough to be reasonably representative of water-contact accidents in their respective categories.

Sources include Airclaims *World Aircraft Accident Summary*; Australian Transport Safety Bureau (ATSB); The Boeing Co.; Civil Aviation Authority of New Zealand; New Zealand Transport Accident Investigation Commission; Robert E. Breiling Associates; Transportation Safety Board of Canada (TSB); U.K. Civil Aviation Authority (CAA); U.S. Federal Aviation Administration (FAA) National Aviation Safety Data Analysis Center (NASDAC); and the U.S. National Transportation Safety Board (NTSB).

As used in this publication, *water-contact accident* means any occurrence in which an aircraft struck or came to rest in a body of water such as an ocean, bay, river, lake, shore, reservoir or swamp. Accidents in which runway-surface condition was a causal factor but the aircraft did not become immersed in water were excluded from the database. In a few instances, an occurrence could be considered an incident rather than an accident, according to some definitions.

A water-contact accident was classified as a ditching if the accident was so described in the source. An accident also was classified as a ditching if the narrative said or implied that the pilot intended or attempted to conduct a controlled water landing, even if the resulting water impact appeared to have been uncontrolled. ■

STATS

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003

					Injury to Occupants			
Date: Month/Day/ Year	**Aircraft**	**Operator**	**Location**	**Nature of Flight**	**Fatal**	**Serious**	**Minor/ None**	**Damage to Aircraft**
1/14/76*	Sabreliner	FAA	Recife, Brazil	Government ferry	1	0	2	Destroyed
The airplane was ditched in the South Atlantic Ocean after fuel exhaustion resulting from a navigational error.								
2/4/76	Douglas DC-6	Lineas Aereas del Caribe	Santa Marta, Colombia	Cargo	3	0	0	Destroyed
The airplane struck the sea shortly after takeoff for a flight to Curacao.								
4/2/76	Douglas DC-3	SATENA	Puerto Asis, Colombia	Passenger	5	11	0	Destroyed
The airplane struck a lake while approaching to land following a flight from Florencia.								
6/6/76	A.S.T.A. (GAF) Nomad N22B	Sabah Air	Kota Kinabulu, Malaysia	NA	11	0	0	Destroyed
At a late stage in the approach, the pilot was reportedly instructed to conduct a go-around because of an obstruction on the runway. The pilot began to conduct the missed approach but apparently lost control and the aircraft struck the sea about three kilometers from the airport.								
7/28/76	Ilyushin IL-18	CSA	Bratislava, Czechoslovakia	Scheduled passenger	76	3	0	Destroyed
During the final approach, the aircraft speed was greater than normal, and reverse thrust was applied on the no. 2 and no. 3 engines below 3,281 feet AGL. As a result, the no. 3 engine failed and, by mistake, the no. 4 propeller was feathered. At 164 feet above the threshold, above the centerline, instead of continuing the landing on two engines, the pilot decided to overshoot; the no. 4 engine was restarted at 131 feet AGL. The aircraft's right bank increased, control of the aircraft could not be maintained, and the aircraft struck the water in a 60-degree right bank and 60-degree nose-down attitude.								
9/16/76	Curtiss C-46	NA	Caribbean	Scheduled cargo	2	0	0	Destroyed
Takeoff was at 1025 hours, with the pilot estimating Aruba at 1230 hours. At 1047, the pilot notified Tiburon that the flight would reach Riohacha, Colombia, at 1120 hours. There were no further communications. An extensive search-and-rescue operation by 23 aircraft covered 28,000 square miles without success.								
10/6/76	Douglas DC-8-40	Cubana	Bridgetown, Barbados	Scheduled passenger	73	0	0	Destroyed
Nine minutes after departure, the crew advised ATC that there had been an explosion onboard and shortly afterward requested clearance to return to the airport. The aircraft apparently began a right turn toward land but struck the sea before arriving at the airport.								

Note: The water-accident data in this table were compiled from several sources, but completeness cannot be claimed. Information has been transcribed faithfully from the sources, but some information may not be accurate. Military accidents have been excluded.

***Ditching accident**

AGL = above ground level ARTCC = air route traffic control center ATC = air traffic control ATR = Avions de Transport Regional
EGT = exhaust-gas temperature ELT = emergency locator transmitter FAA = U.S. Federal Aviation Administration
FARs = U.S. Federal Aviation Regulations FL = flight level fpm = feet per minute GAF = Government Aircraft Factory
IFR = instrument flight rules ILS = instrument landing system IMC = instrument meteorological conditions
MBB HFB = Messerschmitt-Bolkow-Blohm Hamburger Flugzeugbau MD = McDonnell Douglas MDA = minimum descent altitude
MEL = minimum equipment list mph = miles per hour MSL = mean sea level NDB = nondirectional beacon PIC = pilot-in-command
rpm = revolutions per minute SAR = search and rescue VFR = visual flight rules VMC = visual meteorological conditions
VOR-DME = very high frequency omnidirectional radio–distance-measuring equipment

Source: Airclaims *World Aircraft Accident Summary*; Australian Transport Safety Bureau; The Boeing Co.; Civil Aviation Authority of New Zealand; New Zealand Transport Accident Investigation Commission; Robert E. Breiling Associates; Transportation Safety Board of Canada; U.K. Civil Aviation Authority; U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center; U.S. National Transportation Safety Board.

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
11/5/76*	Douglas DC-3	NA	En route, Curacao to Port-au-Prince, Haiti	NA	2	0	0	Destroyed
The aircraft was reported missing while flying between Curacao and Port-au-Prince and was believed to have been ditched.								
11/12/76	Cessna 500 Citation I	Taxi Aéreo Jaragua	Rio de Janeiro, Brazil	Nonscheduled cargo	0	0	8	Destroyed
During the landing roll, the aircraft began to aquaplane on the wet runway and could not be stopped before the runway end. The aircraft fell into Guanabara Bay.								
11/22/76*	Shorts Skyvan	Gulfair	Da Island	Unscheduled passenger	0	0	2	Destroyed
The airplane was ditched in the sea after a reported engine malfunction. Both occupants evacuated safely.								
12/16/76*	De Havilland DHC-6 Twin Otter	Airwest Airlines	Strait of Juan de Fuca, Canada	Scheduled passenger	0	0	16	Destroyed
On arrival at the destination, the pilot found the area blanketed by a low fog layer. While in descent to get below the fog bank, the aircraft struck the water heavily, damaging both floats. The pilot conducted a successful landing, but the aircraft capsized and sank after the occupants had evacuated.								
2/8/77*	Curtiss C-46	Argo SA	San Juan, Puerto Rico, U.S.	Unscheduled cargo	0	0	2	Destroyed
Shortly after takeoff, an engine failure occurred. The pilot depressed the affected propeller-feathering button. Nevertheless, the propeller continued to rotate, and the aircraft began to lose altitude and airspeed. The pilot attempted to return to the airport; then, seeing that the airplane's altitude and airspeed were too low to make a safe return, he ditched the aircraft in about 15 feet of water about one mile north of the airport.								
3/1/77	Douglas DC-3	Alyemda	Aden	Scheduled passenger	19	0	0	Destroyed
The airplane struck the sea shortly after takeoff for a flight to the Ghuraf airport in Yemen.								
5/6/77*	Curtiss C-46	Inter Air	Hollywood, Florida, U.S.	NA	0	0	2	Destroyed
Two previous attempts to fly the aircraft to San Juan, Puerto Rico, had been canceled due to a malfunction in the right engine. Shortly after takeoff, at about 300 feet, the right engine began to overheat and power was lost. The pilot attempted to feather the right propeller but could not keep it feathered. Being unable to maintain altitude, he elected to ditch the aircraft at sea rather than fly over heavily populated areas to return to the airport. The aircraft was ditched in 15 feet of water, about 900 feet east of the shore at Hollywood, Florida. It floated for about 20 minutes, and the pilots exited safely.								
5/28/77	Yakovlev Yak-40	Avioligure	Genoa, Italy	NA	0	0	4	Substantial
During the landing roll, the aircraft reportedly began to veer to the left and ran off the side of the runway, eventually coming to rest partly in the sea.								
6/30/77	Lockheed 188CF Electra	Aero Servicios Punterarenas	East of Panama Canal Zone	Unscheduled cargo	4	0	0	Destroyed
The aircraft disappeared from radar shortly after the pilot had requested vectoring out of an area of "extreme turbulence." There was no further contact with the flight and the aircraft was assumed to have broken up and fallen into the sea.								
7/6/77	Let 410A Turbolet	Air Service Hungary	Veszprem, Hungary	NA	1	0	3	Destroyed
The aircraft crew had departed Budaors, Hungary, with the intention of taking photographs in the vicinity of Lake Balaton. On arrival, the crew found that the weather was not suitable. The pilot elected to return and decided to fly along the lake at an altitude of about 1,000 feet AGL. It appears that, unrecognized by the crew, the aircraft descended gradually and eventually struck the water. The aircraft immediately inverted and sank.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/8/77	Antonov An-24	Aeroflot	Korovgrad, Ukraine, USSR	Crew training	6	0	1	Destroyed
After takeoff, the pilot's attention was distracted, and the aircraft descended into the sea.								
7/17/77*	Nikkon Aeroplane YS-11A	Philippine Air Lines	Cebu, Philippines	Scheduled passenger	0	0	25	Destroyed
While on approach, the left engine apparently began to fail. The pilot attempted to apply power but this proved ineffective. Attempts to feather the left propeller were also unsuccessful, and with the aircraft yawing to the left, descending and becoming uncontrollable, the pilot elected to ditch the aircraft.								
8/8/77	Cessna 404	NA	Christchurch, New Zealand	Cargo	1	0	NA	Destroyed
Immediately after receiving clearance to descend from 10,000 feet, the pilot reported that he had lost control of the aircraft. It struck the sea 45 miles north of Christchurch.								
8/24/77*	Curtiss C-46	Societe Quarterwinds	Goyave, Guadeloupe	Unscheduled Cargo	0	0	4	Destroyed
The port engine was heard to misfire and had to be throttled back, while power was increased on the starboard engine. The port engine stopped a few minutes later, and a drop in oil pressure on the starboard engine forced the pilot to reduce power. As the aircraft could no longer maintain its cruising speed, the pilot ditched in the sea as near the coast as possible. The aircraft floated for a few minutes, and the occupants were rescued by boat.								
9/2/77	Canadair CL44-D4	Transmeridian Air Cargo	Waglan Island, Hong Kong	Unscheduled cargo	4	0	0	Destroyed
Shortly after takeoff from Hong Kong, the aircraft's no. 4 propeller was feathered. The crew reported that an engine had failed and had been shut down. Five minutes after takeoff, the crew reported an engine on fire, and three minutes later, there was an interrupted transmission "We're going in — the engine's come off." There were no further transmissions from the aircraft. Witnesses said that the aircraft was on fire when it struck the sea about eight minutes after takeoff.								
10/31/77*	NA	NA	Wanganui, New Zealand	Cargo	1	0	NA	Destroyed
The pilot reported that the aircraft's engine had failed. The aircraft was ditched in darkness in rough sea conditions. The main aircraft wreckage was not located.								
11/7/77	Rockwell Sabre 40	Mechanical Equipment Co.	New Orleans, Louisiana, U.S.	Business	3	0	1	Destroyed
Following a night takeoff from Runway 35, the aircraft was flown to approximately 300 feet, then began a left turn and a slow descent to the Lake Pontchartrain surface. Upon contact with the water, an explosion was heard and a brief fire was observed. The wreckage was located 1.5 miles from the runway and 500 feet left of the runway centerline. The pilot survived with minor injuries.								
11/19/77	Learjet 25B	Taxi Aero Matila	Rio de Janeiro, Brazil	Unscheduled passenger	0	0	2	Destroyed
There were several puddles of water on the runway. During the takeoff run, the left engine flamed out because of water ingestion. The pilot discontinued the takeoff 300 meters before the runway end. The aircraft aquaplaned, overran the runway and went into the sea.								
12/18/77	Aerospatiale SE.210 Caravelle 10R	Societe de Transport Aerien	Funchal, Madeira, Portugal	Unscheduled passenger	36	21	0	Destroyed
During an NDB approach at night, the aircraft apparently descended below a safe altitude and struck the sea shortly after turning onto base leg. The impact with the sea apparently was relatively gentle, but the aircraft broke up and sank rapidly.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

<table>
<tr><th rowspan="2">Date: Month/Day/ Year</th><th rowspan="2">Aircraft</th><th rowspan="2">Operator</th><th rowspan="2">Location</th><th rowspan="2">Nature of Flight</th><th colspan="3">Injury to Occupants</th><th rowspan="2">Damage to Aircraft</th></tr>
<tr><th>Fatal</th><th>Serious</th><th>Minor/ None</th></tr>
<tr><td>1/1/78</td><td>Boeing 747</td><td>Air India</td><td>Bombay, India</td><td>Scheduled passenger</td><td>213</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">After takeoff, the aircraft was identified by approach radar, and the crew was instructed to climb on track to FL 310 and report leaving FL 80. The crew acknowledged this message. The last message recorded on ATC tape was from the pilot to the approach radar controller: "Happy New Year to you, Sir. Will report leaving 80; 855." The aircraft was observed on radar up to 4.5 nautical miles; thereafter, the radar echo disappeared. There was no further contact with the aircraft. The aircraft had struck the sea off the Bombay coast 5.3 nautical miles from Bombay Airport reference point about 20 seconds after the last transmission.</td></tr>
<tr><td>1/2/78*</td><td>Douglas DC-3</td><td>NA</td><td>Rio Grande, Puerto Rico, U.S.</td><td>Scheduled passenger</td><td>0</td><td>0</td><td>5</td><td>Substantial</td></tr>
<tr><td colspan="9">While cruising at 2,000 feet on an air taxi flight, a power loss on the no. 1 engine occurred about 12 miles east of San Juan. The pilot identified the engine and conducted the engine-out procedure. While securing the no. 1 engine, the crew observed a loss of power on the no. 2 engine. The pilot attempted unsuccessfully to restore power on the no. 1 engine while advising San Juan Approach Control about the impending ditching.

The aircraft was ditched about 1,000 feet offshore from Rio Grande, Puerto Rico. There was no fire and all occupants were evacuated safely in accordance with the airline operating manual.</td></tr>
<tr><td>2/22/78</td><td>Learjet 35</td><td>NA</td><td>Palermo, Sicily, Italy</td><td>NA</td><td>3</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">The airplane was reported missing while approaching to land at Palermo.</td></tr>
<tr><td>3/3/78</td><td>Hawker Siddeley HS 748</td><td>Linea Aeropostal Venezolana</td><td>Macuto, Venezuela</td><td>Scheduled passenger</td><td>47</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">Two minutes after takeoff, the pilot declared an emergency and informed approach that he was returning to the airport because of difficulties with the artificial horizon. The aircraft struck the sea 2.8 nautical miles from Punta Mulatoa. The depth of the water at the accident site made it impossible to recover major parts of the aircraft.</td></tr>
<tr><td>3/25/78</td><td>Douglas DC-3</td><td>Dominica Air Services</td><td>Grand Turk, Turks and Caicos Islands</td><td>NA</td><td>1</td><td>0</td><td>2</td><td>Destroyed</td></tr>
<tr><td colspan="9">The airplane struck the sea shortly after takeoff. Reports said that immediately after takeoff, there was a fire on board and considerable smoke.</td></tr>
<tr><td>4/1/78*</td><td>DV240</td><td>NA</td><td>Unguia, Colombia</td><td>NA</td><td>0</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">The airplane was ditched in a lagoon. The crew was rescued.</td></tr>
<tr><td>5/8/78</td><td>Boeing 727</td><td>National Airlines</td><td>Pensacola, Florida, U.S.</td><td>Scheduled passenger</td><td>3</td><td>4</td><td>51</td><td>Destroyed</td></tr>
<tr><td colspan="9">The aircraft struck Escambia Bay during a surveillance radar approach to Runway 25 at Pensacola Regional Airport. The accident occurred about three nautical miles from the east end of Runway 25, and the airplane came to rest in about 12 feet of water. There were 52 passengers and a crew of six on board; three passengers drowned.</td></tr>
<tr><td>5/12/78*</td><td>CV440</td><td>NA</td><td>Shippingport, Pennsylvania, U.S.</td><td>Ferry</td><td>0</td><td>0</td><td>3</td><td>Substantial</td></tr>
<tr><td colspan="9">The airplane was ditched following failure of one engine and partial power loss on the other. Improper in-flight decisions were also a factor.</td></tr>
<tr><td>7/22/78*</td><td>Curtiss C-46</td><td>NA</td><td>Opa Locka, Florida, U.S.</td><td>Instructional</td><td>0</td><td>0</td><td>3</td><td>NA</td></tr>
<tr><td colspan="9">Both engines quit during final approach, and the pilot ditched the aircraft.</td></tr>
<tr><td>9/3/78</td><td>De Havilland DHC-6</td><td>Airwest Airlines</td><td>Vancouver Harbour, Canada</td><td>Scheduled</td><td>11</td><td>2</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">A Twin Otter operating as a scheduled VFR flight departed from Victoria Harbour, British Columbia, with Vancouver Harbour water-airport as destination. The estimated time en route was 20 minutes. The flight proceeded normally until landing clearance was given to the flight by the Harbour Tower. The approach continued, and when the aircraft was approximately 175 feet above the surface, the two surviving passengers heard a noise. Power was subsequently applied, and the aircraft yawed left, rolled in the same direction and plunged into the harbor in a left-wing-down and nose-down attitude, 2,500 feet from the intended landing area.</td></tr>
</table>

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
9/21/78	Douglas DC-3	NA	Matanzas, Cuba	Ferry	4	0	0	Destroyed
The aircraft was to pick up 21 passengers to return to the United States. The flight was reported to be routine in good weather at 6,000 feet when the aircraft disappeared from U.S. air traffic radar at the approximate position stated.								
10/1/78*	Douglas DC-3	NA	Ft. Walton, Florida, U.S.	Miscellaneous	1	0	3	Destroyed
The pilot ditched the aircraft after becoming lost/disoriented following an electrical system failure with an unknown cause.								
10/23/78	Antonov An-24	Aeroflot	Gulf of Sivash, Ukraine, USSR	Scheduled passenger	26	0	0	Destroyed
After takeoff, while the aircraft was in a climb through 2,400 meters, the left engine flamed out, followed 14 seconds later by the right engine. The aircraft struck the sea. The engine failures were "probably due to icing."								
11/5/78	Douglas DC-3	WEPCO	Mediterranean	Unscheduled passenger	17	0	0	Destroyed
The aircraft is believed to have struck the sea shortly after takeoff for Alexandria, Egypt.								
11/8/78	De Havilland DHC-6	Air Guadeloupe	Marie Galante, Guadeloupe	Scheduled passenger	15	5	0	Destroyed
The aircraft struck the water with the left wing tip. The wreckage stayed afloat for a very brief period, then sank in 13 meters of water.								
11/18/78	DHC-6 Twin Otter 300	Air Guadeloupe	Marie Galante, Guadeloupe/St. Barthelemy	Scheduled passenger	15	5	0	Destroyed
The aircraft was destroyed when it was flown into the sea while en route from Guadeloupe to Marie Galante. After departure, the weather had apparently deteriorated very rapidly because of approaching storms.								
11/29/78	CV240	NA	Miami, Florida, U.S.	Instructional	1	1	0	Destroyed
While on a local training flight, the pilot in the right seat gave the copilot trainee a simulated single-engine emergency, retarding the left throttle at V2 (takeoff safety speed). The trainee lost directional control, which he failed to regain by reapplying the left throttle. The aircraft touched down, with its landing gear extended, left of the runway pavement and continued 1,000 feet before coming to rest in a canal. Fire erupted immediately. Both occupants evacuated the wreckage successfully, but burning fuel on the water surface impeded their efforts to reach the canal bank.								
12/23/78	McDonnell Douglas DC-9-32	Alitalia	Palermo, Sicily, Italy	Scheduled Passenger	108	0	21	Destroyed
During the final stages of a VOR/DME approach to Punta Raisi Airport, Palermo, the aircraft undershot the runway, striking the surface of the sea some three nautical miles short of the runway threshold. The accident happened in darkness and poor weather.								
1/22/79	Partenavia P68	Business AT	Lydd, England	Passenger	3	0	0	Destroyed
The aircraft struck the sea during a radar approach. The cause was not determined.								
1/30/79	Boeing 707	Varig	Pacific Ocean	Scheduled cargo	5	0	0	Destroyed
The aircraft was reported missing during a flight from Tokyo, Japan, to Rio de Janeiro, Brazil, and was presumed to have struck the sea.								
2/17/79	Fokker F27	Air New Zealand	Manukau Harbour, New Zealand	Unscheduled passenger	2	0	2	Destroyed
The aircraft descended into the sea short of the threshold of Runway 05 at Auckland Airport during a daylight visual approach toward a band of heavy rain.								
3/10/79*	Nord 262	Swift Aire Lines	Los Angeles, California, U.S.	Scheduled passenger	3	0	4	Destroyed
The aircraft was ditched in Santa Monica Bay, near Marina Del Rey, California, shortly after takeoff from Los Angeles International Airport. The aircraft was being flown on a scheduled commuter airline passenger flight from Los Angeles, California, to Santa Maria, California, with four passengers and three crewmembers on board. The crewmembers and one passenger died when they were unable to get out of the aircraft.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
3/17/79	De Havilland DHC-4 Caribou	NA	Barbados	Ferry	2	0	0	Destroyed
During a ferry flight, the pilot radioed that an engine had failed and that the other engine was overheating. He gave his position as 68 nautical miles south of Barbados and said he was diverting to that island. Forty-four minutes later, he made his last transmission and reported that the airplane was at 50 feet. No trace of the aircraft was found, despite an intensive search mounted by Barbados. The only overwater survival equipment on board was four life vests.								
5/17/79*	Douglas DC-4	NA	Gulf of Mexico	NA	0	0	3	Destroyed
The airplane caught fire and was ditched in the Gulf of Mexico.								
6/9/79	Beech 99	Skystream Airlines	Chicago, Illinois, U.S.	Ferry	1	0	0	Destroyed
The aircraft struck Lake Michigan during the final segment of a visual approach to Meigs Field, Chicago. The accident happened in daylight but in poor weather, with low cloud and visibility of one mile or less.								
6/11/79*	Douglas DC-3	NA	Selway River, Idaho, U.S.	NA	9	0	3	Destroyed
One engine caught fire and separated from the aircraft. The pilot conducted a forced landing on the Selway River.								
6/14/79*	Douglas DC-4	NA	Eagle Lake, Maine, U.S.	NA	0	0	NA	Substantial
The pilot reported fire on the flight deck. The aircraft was landed on the lake and was towed to shore.								
6/17/79	De Havilland Tiger Moth	NA	River Trent, England	Demonstration-Racing	0	0	2	Substantial
The aircraft struck a wire across the River Trent and landed in the river.								
7/7/79*	Vega 37 Ventura	NA	Aruba, North Atlantic	Practice	0	0	3	Destroyed
While flying over clouds, all aircraft electrical systems failed and the pilot became lost because of a faulty magnetic compass and integrated flight system. He got one generator functioning and determined his position to be 60 nautical miles northwest of Aruba. The aircraft was ditched because of fuel exhaustion 30 nautical miles west of Aruba.								
7/10/79*	Beagle A61	NA	NA	Practice	0	0	2	Substantial
The engine failed on takeoff, and the aircraft was ditched in four feet of water.								
7/15/79*	Piper PA-25 Pawnee	Harvest	West Cliff Bay, U.K.	Aerial application	0	0	1	Substantial
The aircraft was spraying an oil slick with detergent when the engine failed and the aircraft was ditched.								
7/20/79	Douglas DC-6	Kimex	Kingston, Jamaica	Cargo	2	0	2	Destroyed
The airplane struck the sea while approaching to land.								
7/30/79	Fuji 200	NA	NA	Personal	2	0	2	Minor
The aircraft was being used to film a tall-ship race when the engine failed and the aircraft struck the sea. The pilot and front-seat passenger escaped; one of the two rear-seat passengers was released before the aircraft sank but died later.								
7/31/79	Hawker Siddeley 748	Dan-Air	Sumburgh Airport, U.K.	Unscheduled passenger	17	2	28	Destroyed
The aircraft was being flown on a charter flight from Sumburgh Airport to Aberdeen, Scotland, with 44 passengers and a crew of three. During takeoff on Runway 09, the aircraft failed to become airborne and struck the sea about 50 meters offshore and approximately in line with the end of the runway. The aircraft was destroyed and 17 people, including both pilots, died by drowning.								
8/11/79	Learjet 35	NA	En route Athens, Greece/Jeddah, Saudi Arabia	NA	5	0	0	Destroyed
The airplane was reported missing during a flight from Athens to Jeddah.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
8/12/79	Piper PA-25 Pawnee	Harvest	Bantry Bay, Ireland	Demonstration-Racing	0	0	1	Destroyed
	The pilot was demonstrating spraying for oil pollution over the sea. The engine failed when the airplane was steeply banked. The pilot recovered from a spin, but the aircraft stalled and hit the water.							
8/13/79	Volmer	NA	Dornoch, U.K.	Personal	0	0	1	Substantial
	The amphibian was landed hard in a rough sea. The hull was punctured, and the aircraft sank.							
8/14/79*	Rockwell 112	NA	Cliffy Island, Victoria, Australia	Personal	0	0	1	Destroyed
	The engine ran rough during an overwater crossing at 2,000 feet and failed at 1,200 feet. The pilot ditched the airplane in two-foot waves in Bass Strait with flaps and landing gear retracted. The pilot had difficulty escaping the sinking aircraft and floated for 15 minutes before being rescued.							
9/3/79	Aerospatiale Corvette 601	Sterling Airways	Nice, France	Unscheduled passenger	10	0	0	Destroyed
	About 20 minutes before arrival at Nice, the pilot broadcast a distress call, advised ATC that the right engine had failed and requested a straight-in approach. Intermittent power failure occurred on the left engine and by the time of arrival at Nice, both engines had failed. The pilot began an approach but lost control of the aircraft while attempting to turn onto final, and the aircraft struck the sea about 1,500 meters short of the runway threshold.							
9/11/79	Boeing 707	China Airlines	Taoyuan, Taiwan, China	Training	6	0	0	Destroyed
	The airplane struck the sea shortly after takeoff for a crew training flight.							
11/1/79	De Havilland DHC-6	Austin Airways	Big Trout Lake, Canada	Business	2	0	0	Destroyed
	A witness on the ground said that he heard the aircraft and then saw it heading toward a 150-foot radio beacon tower. He then saw the aircraft bank in an apparent attempt to avoid the tower, but it struck either the supporting wires or the tower, which then collapsed. The aircraft fell into the lake.							
12/3/79*	Cessna U206	NA	Dog Island, New Zealand	Passenger	0	0	NA	Destroyed
	After takeoff, the pilot reduced power, and severe engine vibrations followed. He checked the engine instruments, which indicated normal operation, and then the engine failed. After an unsuccessful attempt to restart the engine, the aircraft was ditched. The pilot evacuated without serious injury after being struck on the head by an unrestrained tin of paint.							
1/30/80	Dassault Falcon 10	Kellogg Co.	Chicago, Illinois, U.S.	Personal	2	4	0	Destroyed
	The aircraft failed to attain takeoff speed, continued off the end of the runway in a nose-high attitude and came to rest in shallow water about 300 feet beyond the departure end of the runway.							
3/6/80*	Piper PA-31	NA	Nice, France	Commercial	0	0	1	Destroyed
	An engine failed, and the aircraft was flown with one engine. The operating engine overheated, and manifold pressure dropped. The pilot declared an emergency and ditched the airplane in the sea while some power remained. He was rescued by helicopter within two minutes of entering the water.							
5/13/80	Ilyushin IL-14	Cubana	Varadero, Cuba	Training	3	0	0	Destroyed
	The airplane struck the sea approximately 1,500 feet offshore during a crew-training flight.							
5/19/80	Learjet 25D	Northeast Jet Co.	Gulf of Mexico	Ferry	2	0	0	Destroyed
	About two and one-half minutes after the aircraft was reported at FL 430, the Jacksonville, Florida, U.S., Air Route Traffic Control Center received an unusual staccato sound transmission over the frequency, followed 18 seconds later by a report from the copilot that said, "Can't get it up. … It's in a spin." About 33 seconds after the first staccato sounds, radio and radar contact were lost about 104 miles west of Sarasota, Florida. Floating debris was located by a search aircraft and later recovered; the flight crew was not found. There were no known witnesses to the accident.							

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/15/80*	Piaggio 149	NA	Tees estuary, England	Private business	1	0	3	Destroyed
The aircraft ran out of fuel and was ditched. Life vests were stored in a compartment beneath four cases and three rifles. Before a signal could be fired, the aircraft sank.								
6/27/80	MD DC-9	Itavia	Palermo, Sicily, Italy	Scheduled passenger	81	0	0	Destroyed
The aircraft flew normally until an unidentified object crossed from west to east, at high speed. The object did not collide with the aircraft. Radar echoes demonstrated that a large part of the aircraft preserved longitudinal stability, confirming the presence of airfoil surfaces. Airport fragment laboratory tests and pathological examinations demonstrated that the aircraft was damaged either by collision with an unidentified object or by explosion and not by airframe failure. The aircraft did not collide with another aircraft.								
8/2/80*	Jodel DR105	NA	Dee estuary, U.K.	Personal	3	0	1	Destroyed
Thirty-nine minutes after takeoff, the pilot declared mayday and said that power was failing. Later, he said that he was ditching the airplane. A ship found the aircraft wreckage and one survivor. Bodies of the pilot and two infants were later recovered. None wore life vests prior to the ditching.								
8/7/80	Tupolev Tu-154	Tarom	Nouadhibou, Mauritania	Scheduled passenger	2	NA	NA	Destroyed
The aircraft was being flown on a scheduled flight from Bucharest, Romania. During the final approach to land, the pilots undershot the runway and the airplane struck the sea 300 meters short. One passenger was killed and one was missing.								
9/12/80	Boeing 727	Olympic Airways	Corfu, Greece	Scheduled passenger	0	0	115	Substantial
During landing roll on Runway 35, the right-main landing gear leg detached, dragged underneath the wing and then hit the no. 3 engine on the lower part of the cowling. This moved the engine 45 degrees upward, and the aircraft veered to the right. The aircraft came to rest to the right of the runway, having run 1,100 meters. The aircraft entered a lake located beside runway, from the nose to the front main door, with the water reaching the height of the nose leg. Evacuation took place within five minutes, by the two left-hand emergency windows, as well as by the aft right-hand and left-hand main doors.								
9/12/80	Douglas DC-3	Florida Commuter Airlines	Freeport, Bahamas	Unscheduled passenger	34	0	0	Destroyed
The airplane departed from West Palm Beach International Airport, Palm Beach, Florida, U.S., for Freeport, Grand Bahama Island, Bahamas, on a passenger flight. The aircraft struck the Atlantic Ocean about 3.5 nautical miles southwest of West End Settlement, Grand Bahama Island. The last radio transmission received was when the first officer said that the aircraft was descending from 3,000 feet and acknowledged clearance for the VOR Runway 24 approach at Freeport. The aircraft was not recovered.								
9/15/80	Douglas DC-6B	NA	Haiti	Other	3	1	0	Destroyed
The aircraft departed from Nassau, Bahamas, on a VFR flight plan to South Caicos, Turks and Caicos Islands. The aircraft experienced high oil consumption en route. The crew shut down the no. 1 engine near the destination and subsequently lost radio contact and diverted. Two more engines were shut down. A Haitian fisherman rescued one of the aircraft's occupants from the ocean.								
9/24/80*	Piper PA-23	NA	English Channel	Personal	0	0	1	Destroyed
The power failed on the port engine, which was shut down. Then power gradually began to fail on the starboard engine. The pilot declared mayday and ditched the aircraft.								
10/13/80*	Fokker F.27-400	Pelita Air Services	Irian Jaya, Indonesia	Unscheduled cargo	0	0	4	Destroyed
A navigational error caused the captain to assume wrongly that an island in sight was the flight's destination. A descent in preparation for landing was commenced, but the crew was unable to see the destination airport. The crew elected to circle in an attempt to find the airport, but without success, and after one hour, 40 minutes, with fuel running low, the captain decided to conduct a forced landing in shallow water just off the island. The ditching took place some 80 nautical miles from the intended destination.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
11/28/80	Douglas DC-6A	NA	Bimini, Bahamas	NA	4	0	0	Destroyed
The aircraft flew into the sea for unknown reasons. The aircraft broke up on impact with the water. Identity of the wreckage was confirmed.								
12/3/80*	Piper PA-23	Intra	Exmouth, England	Private business	0	0	1	Destroyed
The pilot declared pan-pan and said that one engine had failed and the other was running roughly. The aircraft was ditched in 10 feet of water near a beach with the landing gear and flaps retracted and both propellers feathered.								
2/24/81	Embraer EMB-110 Bandeirante	Vortec Taxi Aereo	Belem, Brazil	Scheduled passenger	12	2	0	Destroyed
During a visual approach, the pilot allowed the aircraft to descend below a safe altitude and it collided with the mast of a ship in dry dock 1.6 kilometers short of the runway threshold. After the initial impact, the aircraft struck a second vessel and fell into the river. The accident was attributed to the pilot's continued flight into adverse weather.								
3/28/81*	Douglas DC-4	Tuky Air Transport	St. Croix, Virgin Islands	Unscheduled cargo	1	0	1	Destroyed
En route, the no. 3 engine caught fire. Efforts to feather the propeller and extinguish the fire were successful. Control difficulties led to the pilot's decision to ditch the aircraft. The crew evacuated the aircraft. When a rescue boat arrived several minutes later, the copilot had drowned. The aircraft floated 45 minutes before sinking.								
4/21/81	Douglas DC-3	NA	Mediterranean	Unscheduled Passenger	4	0	0	Destroyed
Radar contact was lost 15 miles north of Andraitx, Spain, and communication with the aircraft could not be restored. A six-day search of a large area of the Mediterranean was unsuccessful. The only indication of what happened is from radar recordings that indicate that the aircraft lost speed and altitude and disappeared from radar screens.								
5/7/81	BAC 1-11	Austral Lineas Aereas	River Plate Estuary, Argentina	Scheduled passenger	30	0	0	Destroyed
The aircraft, on a scheduled passenger flight from Tucuman, Argentina, struck the River Plate near the Emilio Mitre canal about 15.2 kilometers east-southeast of Buenos Aires' Jorge Newbery Airport. There were no survivors among the 30 occupants, and only about 55 percent to 65 percent of the aircraft was salvaged from the river. The flight and voice recorders were not found after 42 days of searching.								
6/10/81	Swearingen SA226T	NA	Cameron, Louisiana, U.S.	Other	2	0	0	Destroyed
The crew conducted an uncontrolled descent into the sea during flight in severe thunderstorms. The aircraft was loaded with marijuana.								
6/17/81	Douglas DC-3	NA	Miraflores, Colombia	Scheduled passenger	2	7	3	Destroyed
Shortly before landing, the pilot advised ATC that he had feathered one propeller. He then made a general broadcast to other aircraft to clear the area because of the emergency. Another aircraft landed at Miraflores ahead of the Douglas DC-3, forcing it to overshoot and reposition to land in the opposite direction. Control was lost during this maneuver, and the aircraft struck a lake.								
8/15/81	De Havilland Chipmunk	NA	Ancona, Italy	Demonstration-Racing	1	0	0	Destroyed
The aircraft struck the sea during an air display.								
10/3/81*	Rockwell 112	Eastern Air Executive	Floddaymore, U.K.	Private business	1	0	1	Destroyed
A rough-running engine, which the investigation attributed to fuel starvation, led to the ditching. The aircraft floated on the water at first, but the port door would not open because the left wing was distorted. The aircraft sank. The pilot climbed onto a rock and was rescued, but the passenger was washed back into the water by a wave and drowned.								
10/26/81*	American Aircraft AA-1C	NA	Bateau Bay, New South Wales, Australia	Personal	0	0	2	Destroyed
While the airplane was in cruise flight 600 feet over the sea, the engine failed. Unable to restore power, the pilot decided to ditch in the sea rather than attempt a landing on the rocky shore. The pilot and passenger were rescued by a surfboard rider.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
10/26/81	Constellation HI-328	Argo	St. Thomas, U.S. Virgin Islands	Unscheduled cargo	3	2	0	Destroyed
The crew received clearance for a landing on Runway 09. Approaching the centerline, the pilot reported, "Runway in sight." On radar, the aircraft was seen to enter a right turn. Radio contact was then lost. The aircraft struck the water about three kilometers south of the airport. The wreckage sank the following day while being towed to shore.								
11/8/81	Aero Commander 500-S	NA	Merimbula, New South Wales, Australia	Other aerial work	1	0	0	Substantial
The pilot was returning the airplane to the point of origin because of an engine malfunction. The aircraft was incorrectly positioned on final approach. A go-around was initiated from a low altitude. The pilot misjudged the height above the water, and the wing struck the water surface. The airplane cartwheeled and sank.								
11/15/81*	Piper PA-24-250	NA	Coolangatta, Queensland, Australia	Personal	0	0	1	Substantial
The engine failed during the climbout, and the pilot conducted an emergency landing in the sea.								
12/3/81*	Piper PA-24 Comanche	NA	English Channel	Personal	0	0	2	Destroyed
The aircraft was ditched and sank following a power failure. The pilot and passenger were rescued by helicopter.								
1/13/82	Boeing 737	Air Florida	Washington, D.C., U.S.	Scheduled passenger	74	5	0	Destroyed
The aircraft stalled following takeoff, with snow/ice on airfoil surfaces. The aircraft then struck a bridge 0.75 miles from takeoff and fell into the Potomac River.								
1/17/82*	Convair 440	Island Airlines Hawaii	Honolulu, Hawaii, U.S.	Scheduled cargo	0	0	3	Destroyed
After liftoff, the pilot called for the landing gear to be raised. As the pilot flew the airplane through about 100 feet AGL, there was a loss of power in the right engine. The pilot observed a fire. Ground witnesses heard a muffled explosion and saw smoke and fire trailing from the right engine. The right engine was feathered, and the pilot attempted to return to the airport, but was unable to maintain altitude. The airplane was ditched near Pearl Harbor.								
1/23/82	MD DC-10-30CF	World Airways	Boston, Massachusetts, U.S.	Scheduled passenger	2	4	206	Destroyed
Following a nonprecision instrument approach to Runway 15R at Boston Logan International Airport, the aircraft touched down about 2,800 feet beyond the displaced threshold of the 9,191-foot usable part of the runway. The aircraft veered to avoid the approach light pier at the departure end of the runway and slid into the shallow water of Boston Harbor. The nose section separated from the fuselage in the impact after the aircraft dropped from the shore embankment. Of the 212 persons on board, two persons were missing and presumed dead. The other persons on board evacuated the aircraft, some with injuries.								
1/24/82*	Falcon 10	NA	South America	Corporate/ Executive	0	0	5	Substantial
Fuel exhaustion occurred during a flight from Houston, Texas, U.S., to South America. The crew conducted an emergency landing in a swamp. The three passengers and two crewmembers were not injured, and the aircraft was recovered.								
1/26/82*	Cessna 175 Skylark	NA	Portsmouth, England	Ferry	0	0	1	Destroyed
The aircraft was over the Solent River when the engine ran roughly and then failed. The pilot declared mayday and ditched the aircraft. He was rescued by helicopter.								
2/8/82	Douglas DC-8-61	Japan Airlines	Tokyo, Japan	Scheduled passenger	24	95	63	Destroyed
During the final stage of an approach, the aircraft suddenly descended and struck Tokyo Bay 510 meters short of the runway threshold. It was reported that the pilot had disengaged the autopilot, pushed the control wheel forward and attempted to reduce power to the engines. The copilot attempted a recovery but without success. The pilot's actions apparently resulted from a "mental abnormality."								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
2/20/82*	Grumman G-21A	NA	North Cape Yakataga, Alaska, U.S.	Unscheduled passenger	0	0	2	Destroyed
Both engines failed while the aircraft was being flown at 6,500 feet about 10 miles offshore. The crew was unable to restart the engines, and the aircraft was ditched into 12-foot to 15-foot waves with a 40-knot surface wind. The right float was torn off, and both engine mounts broke. The aircraft sank and was not recovered.								
2/25/82	Cessna 210L	NA	Hilton Head, South Carolina, U.S.	Unscheduled passenger	4	0	0	Destroyed
The pilot requested and received vectors to the Hilton Head airport. The pilot was told that his gyro might be about 30 degrees off and was given a revised heading. About two minutes later, the controller transmitted, "Turn right now, heading two five zero." The pilot's acknowledgement was the last transmission received. A search ensued, but no major pieces of wreckage were recovered. Three pieces of wreckage washed up on shore.								
2/27/82*	Cessna 152	NA	Miami Beach, Florida, U.S.	Personal	0	0	1	Destroyed
While the pilot was flying the airplane over the ocean, the engine began to vibrate. The pilot decided to return to the airport. The engine-oil pressure decreased to zero, and the aircraft was ditched in the ocean.								
3/2/82	Cessna 182E	NA	Forster, New South Wales, Australia	Business	1	0	0	Destroyed
The pilot did not obtain a weather forecast prior to departure. He was advised by pilots of other aircraft of poor weather at the destination but continued with the flight. The pilot reported heavy rain at the destination. The aircraft wing apparently hit the water during a turn. The pilot was not rated for IMC.								
3/8/82*	Cessna T188C	NA	Block Island, Rhode Island, U.S.	Ferry	0	0	1	Destroyed
The engine began to run roughly. After the airplane was turned back toward Block Island, the fuel pressure began to fluctuate and decrease, along with the manifold pressure. The pilot performed an emergency-system fuel check, but the engine lost all power, and the aircraft was ditched.								
3/11/82	De Havilland DHC-6	Wideroe	Ganvik, Norway	Scheduled passenger	15	0	0	Destroyed
While being flown at 2,000 feet in VMC along the coastline in moderate turbulence, the aircraft struck the sea. The fin and rudder separated in flight because of overload forces. The reason for breakup in flight could not be determined, but it was suggested that the overload resulted from a combination of clear air turbulence and pilot control input.								
3/17/82	Cessna 150	Pilot/owner	Tilghman Island, Maryland, U.S.	Instructional	1	0	0	Destroyed
The student pilot conducted a takeoff from his farm to fly the aircraft to a meeting with an instructor. Heavy fog moved in. Crewmembers of an oyster boat near the island heard an aircraft being flown low overhead. Shortly afterward, they saw the airplane emerge from the overcast in a right bank, then level just before striking the water. A blood-alcohol level of 0.14 percent was found in the pilot's body.								
3/18/82*	Hawker Siddeley 748 Srs. 2A	Calm Air	Churchill, Manitoba, Canada	Scheduled passenger	0	0	21	Destroyed
During takeoff, the starboard engine failed at rotation. As the crew prepared to land on another runway, the port engine also failed. A gear-up landing was conducted in the Churchill River.								
4/3/82*	Piper PA-18	NA	Hollywood, Florida, U.S.	Banner towing	0	0	1	Destroyed
The pilot was towing a banner along a beach when the aircraft engine failed. The pilot landed the airplane in the water just offshore and escaped without injury. The aircraft was destroyed by the surf.								
4/17/82	Beech B19	NA	College Park, Maryland, U.S.	Personal	0	0	2	Minor
The stall warning was sounding during the takeoff. The pilot turned the aircraft into the wind, but because of buildings in the flight path, he turned the airplane 360 degrees. The aircraft would not climb, so the pilot lowered the nose to gain airspeed. The aircraft collided with trees and landed in a creek.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
4/20/82*	Cessna 150K	NA	Santa Barbara, California, U.S.	Fish spotting	0	0	1	Destroyed
The engine failed while the pilot was spotting fish at night. He was unable to restart the engine or glide the airplane to shore. The airplane was ditched about 3.5 miles from shore and was not recovered.								
4/21/82	Cessna 172	NA	English Channel	Personal	4	0	0	Destroyed
The pilot declared mayday while the aircraft was over the English Channel when the engine failed because of fuel exhaustion. A full search-and-rescue effort was maintained for two days, but the aircraft and its occupants were not found.								
5/6/82	Learjet 23	Ibex Corp.	Savannah, Georgia, U.S.	Business	4	0	0	Destroyed
While in cruise flight en route to Orlando, Florida, U.S., from Teterboro, New Jersey, the flight crew was cleared by the Jacksonville Air Route Traffic Control Center to descend from FL 410 to FL 390. The flight crew acknowledged the clearance, and ATC observed the radar target descend. About two minutes later, the aircraft struck the Atlantic Ocean from a steep, high-speed descent about 12 miles from Savannah, Georgia. The air traffic controller made several unsuccessful attempts to contact the pilots, who had reported no difficulties in any of their radio transmissions.								
5/9/82	De Havilland DHC-7	Alyemda	Aden, Yemen	Scheduled passenger	23	0	26	Destroyed
The pilot reported the runway in sight at a distance of nine nautical miles and was cleared to report on final for Runway 26. The pilot reported the airplane on short final, the airplane was observed by the tower, and the pilot was cleared to land. The aircraft then was seen losing altitude. It struck the sea one nautical mile from the runway threshold.								
5/10/82	Piper PA-12	NA	Dunbar, West Virginia, U.S.	Personal	2	0	0	Substantial
The pilot conducted a takeoff toward power lines that crossed a river. The aircraft was at about 100 feet and was being turned left, away from the power lines, when it nosed over and struck the river.								
5/13/82	Cessna A185F	NA	Houma, Louisiana, U.S.	Business	0	0	1	Substantial
The pilot was distracted during the approach and did not use the checklist. He landed the aircraft wheels-down in water, and the aircraft nosed down.								
5/13/82	Volmer Aircraft Amphibian	NA	Muskegon, Michigan, U.S.	Personal	0	0	1	Substantial
The pilot returned to land on a lake after conducting touch-and-go landings at an airport. He said that he conducted a water landing with the landing gear extended. During touchdown, the amphibious aircraft nosed over.								
5/15/82	DHC-6 Twin Otter 300	Kenn Borek Air	Nanisivik, Northwest Territories, Canada	Unscheduled passenger	0	0	9	Destroyed
After landing on snow-covered sea ice, the landing gear broke through the surface and the aircraft began to sink. The crew and passengers evacuated safely but the aircraft was lost.								
5/23/82	Cessna 180	NA	North Cordova, Alaska, U.S.	Personal	4	0	0	Destroyed
The pilot was conducting a landing diagonally into a strong headwind. After touchdown, the left wing lifted up and the aircraft began a gentle turn to the right. Witnesses heard the engine power increase and observed an attempted go-around. The main landing gear struck two waves, and the airplane struck the water in a nose-down pitch attitude.								
5/30/82	Thurston Teal TSC-1A	NA	Methuen, Massachusetts, U.S.	Personal	1	0	1	Substantial
The pilot was practicing takeoffs and landings on a river in an amphibious aircraft. After a landing in rough water, the pilot began a high-speed taxi takeoff. When violent shaking began, the pilot reduced power, pulled back the stick and landed. The aircraft nosed over. The landing gear was found in the down position.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/7/82	Cessna 172M	NA	Thomasville, Georgia, U.S.	Business	2	0	0	Destroyed
The aircraft was being flown for a survey of farm crops. Reports said that as the aircraft passed along the side of a 20-acre farm lake, it circled and descended, then came out of the turn. Witnesses saw the aircraft at an altitude of 10 feet to 30 feet, after which it struck the water with no change in engine sound. Divers found no bodies in the cockpit. The seat belts and shoulder harnesses were found hanging loose with no damage and no evidence that they had been latched during impact.								
6/8/82	Cessna 150	Sherburn	Flamborough, England	Instructional	1	0	0	Destroyed
The aircraft struck the sea during a cross-country exercise. The pilot's body was later recovered.								
6/16/82*	Cessna 152	NA	Tulsa, Oklahoma, U.S.	Personal	0	0	2	Destroyed
The engine failed during climb at 1,300 feet and would not restart. The pilot conducted an emergency landing in the Arkansas River.								
6/18/82	Cessna 185F	NA	Chinitna B, Alaska, U.S.	Unscheduled cargo	1	0	2	Destroyed
The pilot began a takeoff, but the aircraft would not get on the step. Examination of the right float revealed that the second compartment from the front was full of water. While taxiing to a sand beach three miles to five miles away, the nose of the aircraft sank. The occupants exited with difficulty. A short time later, the aircraft rolled over, and a hole was observed in the no. 2 compartment next to the keel. One passenger stayed with the airplane until rescued. The other passenger is presumed to have drowned as he and the pilot swam toward shore.								
6/21/82*	Cessna 310	NA	Horseshoe, Florida, U.S.	Business	0	0	1	Destroyed
The pilot said that during an overwater flight, he observed that the right engine fuel flow indication was fluctuating, the engine was cutting in and out and intense white smoke was coming out of the louvers on top of the engine cowling. The pilot saw a fishing boat in the vicinity and ditched the aircraft near the vessel. The aircraft sank in deep water, and the pilot was rescued by the crew of the fishing boat.								
6/26/82*	Downer Republic RC-3	NA	Llano, Texas, U.S.	Test flight	0	0	1	Substantial
As the landing gear was being lowered to land at the airport, a "pop" was heard. Reportedly, the noise occurred when the clevis on the rod end of the retract/extend cylinder failed. The pilot reported that the landing gear would not retract or extend but swung freely in a trailing position. He decided to conduct a water landing, believing that the gear would trail behind. The aircraft bounced on its first touchdown. The wheels were knocked back hard, then bounced fully forward and locked. Subsequently, the aircraft flipped forward onto its back.								
7/4/82*	Cessna 182	NA	Madison, Indiana, U.S.	Personal	0	0	3	Destroyed
The pilot said that the airplane's engine gradually failed on a dark night. The pilot landed the airplane upwind on the Ohio River. After ditching, the occupants egressed and swam to shore, but the airplane sank and was not recovered.								
7/5/82*	Beech 60	NA	Santa Monica, California, U.S.	Personal	0	0	1	Destroyed
At 700 feet, the pilot said that his left engine had failed. He immediately feathered the left propeller and continued to climb, planning to restart the engine before returning to land. At 1,000 feet, the pilot determined that the aircraft was no longer climbing. His airspeed was below the single-engine best-rate-of-climb speed, and he felt a power loss in the right engine. He put the airplane's nose down and feathered the right propeller. The aircraft struck the water 6,000 feet from the Santa Monica Pier. Lifeguards were on the scene with a rescue boat when the pilot surfaced.								
7/5/82*	Beech B23	NA	North Castle, New York, U.S.	Personal	0	0	2	Substantial
The aircraft was ditched and sank in a reservoir in 20 feet of water after the engine failed in flight.								
7/16/82*	Republic RC-3	NA	Southwick, Massachusetts, U.S.	Personal	0	0	2	Substantial
After the engine began running roughly during flight, the pilot decided to land the amphibious airplane in a field, and he extended the landing gear. When he saw that the aircraft would not clear trees, he decided to land on a nearby lake. There was no time to retract the gear, and during the landing, the airplane flipped over.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/18/82*	Cessna 150	NA	Englewood, Florida, U.S.	Personal	0	0	2	Substantial
The pilot initiated a descent to wave to someone on a beach, then initiated a climb. As he advanced the throttle, the engine responded momentarily, then failed. He maneuvered to land on the beach, but the beach was crowded, so he ditched the airplane in the ocean.								
7/20/82*	Cessna 150M	NA	Orinda, California, U.S.	Personal	0	0	1	Substantial
The pilot reported a loss of climb power at 2,000 feet near the San Pablo Reservoir. Witnesses said that they observed the aircraft gliding toward the east end of the reservoir at 200 feet, entering a sharp 180-degree right turn and landing in the reservoir.								
7/26/82	Ercoupe 415C	NA	Port Sheldon, Michigan, U.S.	Personal	0	0	2	Destroyed
During a VFR flight along the Lake Michigan shoreline, the pilot encountered a lowering ceiling. The pilot attempted to conduct a 180-degree turn to return to the airport, but during the turn, he encountered a fog bank. The pilot descended to avoid the fog bank, and the airplane struck the lake.								
8/1/82	Cessna A185F	NA	Friday Harbor, Washington, U.S.	Executive/ Corporate	0	0	1	Substantial
The pilot said that while he was conducting a water landing, everything was normal until after touchdown. As the aircraft decelerated, the right float rose off the water as if it had traveled over a swell or had encountered an object. When the float contacted the water again, the right front wheel dug into the water, the right wing tip contacted the water, and the aircraft pivoted 180 degrees before coming to rest. The aircraft then overturned as the pilot exited.								
8/3/82	Cessna 150H	NA	Anchorage, Alaska, U.S.	Instructional	0	2	0	Substantial
While conducting a takeoff from a lake, the instructor reduced the power at 200 feet AGL to simulate a forced landing. The student turned the aircraft 180 degrees and raised the nose; the aircraft entered a stall and spin and struck the water.								
8/6/82*	Beech 65	NA	Andros Island, Bahamas	Personal	0	0	3	Destroyed
The right engine failed and was feathered. The pilot said that the left engine partially failed and the aircraft would not maintain altitude. Communication was maintained until the pilot reported ditching about 40 miles south of Nassau, Bahamas. A U.S. Navy vessel rescued the pilot and two passengers.								
8/6/82	Aeronca 11BC	NA	Long Lake, New York, U.S.	Personal	0	0	2	Substantial
The pilot flew his airplane in a 360-degree turn to survey a lake landing area when airspeed decreased and the airplane stalled. The aircraft sank in 15 feet of water.								
8/21/82*	Piper PA-30	NA	Santa Catalina, California, U.S.	Personal	0	0	2	Destroyed
The aircraft's right-engine power failed following departure from Santa Catalina. Unable to fly the aircraft to airport altitude, the pilot decided to proceed over the open sea to San Clemente. About 19 miles from the island, the pilot switched fuel tanks and the left engine stopped. The pilot ditched the aircraft.								
8/22/82*	Piper PA-22	NA	Houston, Minnesota, U.S.	Personal	0	0	1	Substantial
During a go-around, the pilot applied power and retracted the flaps. The aircraft's ability to climb and accelerate was negligible. To avoid hitting trees, the pilot landed the airplane in a river near the end of the field.								
8/22/82	Cessna 150L	NA	Kalispell, Wyoming, U.S.	NA	1	0	1	Substantial
The aircraft struck Little Bitterroot Lake during a night flight. The pilot exited the airplane, but the passenger was incapacitated after impact and drowned when the airplane sank. The pilot left the accident site and was not located, but he made telephone calls from New York and Texas to a friend in Canada and indicated the location of the accident site.								
8/27/82	De Havilland Tiger Moth	Tiger C	Camber, U.K.	Flight club	0	0	1	Destroyed
The floatplane pilot was practicing turns, completing one to the right and entering one to the left, when the aircraft's nose dropped rapidly and the aircraft plunged into the sea.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/2/82	Champion 7EC	NA	Isleton, California, U.S.	Observation	2	0	0	Destroyed
The aircraft was being used to observe and photograph the passenger's boat. Witnesses said that the aircraft was circling the area when it struck unmarked power lines that crossed the river. After impact, the aircraft struck the water and sank.								
9/8/82*	Cessna T210N	NA	St. Petersburg, Florida, U.S.	Business	0	0	2	Destroyed
The pilot contacted the tower for landing and advised that the airplane was low on fuel. Shortly thereafter, the engine failed. The aircraft was ditched in shallow water at night in an inland waterway.								
9/9/82*	Cessna 172M	NA	Cheboygan, Michigan, U.S.	Personal	0	0	3	Substantial
The engine stopped during a flight over Lake Huron. Unable to glide to the airport, the pilot ditched the aircraft at the shoreline.								
9/10/82	Boeing 707	Sudan Airways	Khartoum, Sudan	Positioning	0	0	11	Substantial
The aircraft was being returned empty from a flight to Jeddah, Saudi Arabia, when it was landed in the River Nile three miles short of the runway at Khartoum. The aircraft was substantially damaged, and three of the 11 crewmembers were slightly injured.								
9/11/82	Piper PA-18-150	NA	Wasilla, Alaska, U.S.	Personal	0	0	1	Substantial
On takeoff, after reaching about 100 feet AGL, the airplane would not climb. Subsequently, the airplane struck power lines along a road that divided Anderson Lake and King Lake. The aircraft then struck King Lake.								
9/16/82*	Wassmer 41	Alderney	Alderney, Channel Islands, U.K.	Private business	0	0	1	Destroyed
The pilot reported a loss of oil pressure. The engine failed, and the pilot declared mayday. The aircraft was ditched, and the pilot was rescued from his life raft.								
9/17/82	Cessna U206F	NA	Nondalton, Alaska, U.S.	NA	3	1	1	Destroyed
Shortly after takeoff from Hudson Lake, the left wing tip contacted the water, causing the aircraft to cartwheel. The aircraft came to rest inverted and floated for a short time before sinking. A witness said that the waves on the lake were at least four feet high and were breaking over the floats.								
9/18/82*	Piper PA-28-140	NA	Gisborne, New Zealand	Personal	0	0	NA	Substantial
The aircraft's engine failed as the pilot was turning onto final for Runway 32. The pilot ditched the aircraft 180 meters offshore and was picked up by a jet rescue boat crew 12 minutes later.								
10/5/82*	Piper PA-23-250	NA	Lake Placid, Florida, U.S.	NA	2	0	0	Substantial
The aircraft was transporting marijuana and, during an attempted landing on a road at Lake Placid, collided with wires, damaging the landing assembly. The pilot flew the aircraft north about four miles and ditched in a lake. The aircraft sank with both occupants and cargo.								
10/10/82	Bellanca 7GCBC	NA	Peo, Oregon, U.S.	Personal	1	0	1	Substantial
During a pleasure flight over the Willamette River, the aircraft began to climb and turn east. After a sudden jolt, the airplane began to spin and struck the water.								
10/12/82	Lake LA-4-200	NA	Coeur d'Alene, Idaho, U.S.	Personal	0	0	1	Substantial
At dusk, under glassy water conditions, the airplane was flown on a final approach. After touchdown, the aircraft bounced back into the air and a go-around was initiated. During the go-around, the aircraft drifted left. The left wing struck a boom piling, and the airplane struck the water and sank.								
11/20/82*	Cessna 337	NA	Andros, Bahamas	Business	0	0	2	Substantial
Sixty miles from its destination, the flight was diverted to Nassau because of approaching darkness and the lack of an IFR flight plan. The pilot said he was not IFR rated and did not have enough fuel for the flight to Nassau. The accident report said that ATC in Nassau "insisted until it was dark and then relented" by giving the pilot clearance to land anywhere. No land was in sight, so the pilot landed near the light of a ship and was rescued by the Coast Guard. The aircraft sank in 4,000 feet of water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
12/9/82	Piper PA-31-350	NA	500 nautical miles east of Honolulu, Hawaii, U.S.	Ferry	2	0	0	Destroyed
The pilot told ATC that the left engine was slowly losing oil pressure, that he had shut down the engine and that the airplane was unable to maintain 6,000 feet. A descent was begun. In his last transmission, the pilot said that the airplane was at 500 feet, barely maintaining altitude. Radio contact then was lost. The crew of a search aircraft observed floating debris and a body. A marker buoy was deployed, but no recovery was accomplished. The aircraft was presumed to have been destroyed and both occupants were presumed to have been killed. The aircraft struck the ocean in moderate sea conditions with wave heights estimated at three feet to five feet.								
12/14/82*	Cessna 185A	NA	Sawmill Bay, Alaska, U.S.	Personal	0	0	3	Destroyed
The aircraft encountered gusty wind, and power was lost during takeoff. The aircraft landed hard on the water and nosed over but did not sink.								
12/18/82	Cessna 182N	NA	Ringwood, New Jersey, U.S.	Personal	1	0	0	Substantial
The pilot declared an emergency because of power loss, and the aircraft struck a reservoir.								
1/6/83*	Teal TSC-1A	NA	Port Sulphur, Louisiana, U.S.	Personal	1	0	1	Destroyed
The engine failed during a pull-up from a low pass over the airport. The pilot conducted an emergency landing in the icy Mississippi River with the landing gear down. The amphibian struck a submerged object in the river and flipped over. The pilot and passenger attempted to swim to shore, but because of the exceedingly cold water temperature, only the pilot reached the shore.								
1/15/83*	Cessna 336	NA	Key Largo, Florida, U.S.	Personal	0	0	2	Substantial
The pilot requested vectors to the nearest airport because of fuel problems. The aircraft was ditched 0.5 mile south of Key Largo, Florida.								
1/21/83*	BE-90	NA	Aruba	Business	0	0	2	Substantial
During a flight from Haiti to Aruba, the aircraft ran out of fuel. A successful ditching was accomplished in the harbor three miles north of the airport. The aircraft was towed in and salvaged. There were no injuries to the businessman pilot or passenger.								
2/13/83	Learjet 35A	Upali USA	Strait of Malacca	Business	6	0	0	Destroyed
The crew reported that the airplane was climbing through FL 270 for FL 390. This was the last radio communication from the aircraft. Some small pieces of the aircraft were found by fishermen in the Strait of Malacca.								
2/18/83*	Cessna C-182P	NA	Bahia Honda, Florida, U.S.	Personal	0	0	2	Substantial
The aircraft was ditched in the Bay of Florida after the engine failed at 1,000 feet. The pilot and passenger swam to shore without injury.								
2/21/83	Lake LA-4-200	NA	Renmark, South Australia, Australia	Unscheduled passenger	0	0	4	Substantial
Takeoff and climb were normal until the aircraft reached riverside treetop height of 50 feet AGL. Climb attitude was maintained while the aircraft was banked 25 degrees, turning right at a sharp bend. Speed decayed, altitude was lost and the starboard float hit water, causing a yaw.								
3/6/83	Cessna 182Q	NA	Lake Powell, Utah, U.S.	Personal	1	0	0	Destroyed
The aircraft was seen being flown erratically before plunging into the lake during a landing attempt.								
3/18/83*	American Aircraft AA-5B	NA	Nambucca Heads, New South Wales, Australia	Personal	0	0	4	Substantial
The pilot began the takeoff run on a wet and boggy strip. The aircraft failed to accelerate normally and was ditched in a river about 50 meters off the end of the strip.								
3/27/83	Cessna 185F	NA	Int. Coastal City, Louisiana, U.S.	Unscheduled passenger	0	0	2	Substantial
The landing gear was not retracted after takeoff from the airport. When the pilot attempted to land on water, the aircraft flipped over and sank. The landing gear is built into the floats, and during the retraction cycle, the landing gear retracts into the floats.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
3/30/83*	Cessna 182RG	NA	Palm Beach, Florida, U.S.	Personal	0	0	1	Destroyed
The aircraft was ditched in the Atlantic Ocean five miles east of Palm Beach, Florida, after an electrical fire and engine failure.								
4/19/83	Grumman G-44	NA	Fond du Lac, Wisconsin, U.S.	Personal	0	0	1	Substantial
The pilot became preoccupied with a minor electrical problem and did not retract the landing gear before making a landing on water. On water contact, the landing gear created enough drag to push the aircraft, nose first, into the water.								
5/1/83	Cessna 177B	NA	Port Aransas, Texas, U.S.	Personal	2	0	0	Destroyed
The non-instrument-rated pilot found himself in instrument meteorological conditions. Radar contact was lost when the aircraft was about two miles from the airport. Both occupants and aircraft debris were found near the Gulf of Mexico shore.								
5/18/83	Learjet	ATE Jet Service	North Atlantic Ocean	Commercial training	3	0	0	Destroyed
The aircraft was on a crew-training flight from Vienna, Austria, to Hamburg, Germany. The aircraft was observed by radar on a track across Germany, the Netherlands, the North Sea and Scotland; the aircraft disappeared from radar after its fuel was exhausted. Military aircraft sent to intercept the flight reported no sign of the three crewmembers.								
5/23/83	Piper PA-18-150	NA	Anchorage, Alaska, U.S.	Personal	0	0	2	Substantial
While being landed on a lake, the aircraft suddenly veered right, submerging the right float tip and inverting the aircraft.								
5/25/83	Lake LA-4-200	NA	Vinalhaven, Maine, U.S.	Personal	0	1	0	Destroyed
Before departure, an attempt was made to remove water from the tail section of the aircraft. The water had accumulated because of a missing rear plug in the fuselage. Witnesses said that after several unsuccessful takeoff attempts, the aircraft took off but climbed slowly and appeared to be out of control. The aircraft struck a lake.								
5/29/83*	Embraer EMB-110 Bandeirante	Tavina	Barranquilla, Colombia	Scheduled passenger	0	0	7	Destroyed
The aircraft collided with a Colombian Air Force T-33 shortly after takeoff. The pilot of the Bandeirante elected to conduct an immediate forced landing in a saltwater marsh some three miles from the airfield.								
6/4/83	Mooney M20B	NA	Lakeville, Massachusetts, U.S.	Personal	0	0	1	Substantial
The aircraft struck the smooth water of a reservoir while flying low, about 1,000 feet offshore. The aircraft sank in 15 feet to 20 feet of water.								
6/6/83	Fairchild Packet	NA	Taiwan Strait	Unscheduled passenger	38	NA	NA	Destroyed
The aircraft crew reported an engine fire after takeoff, and the airplane struck the sea.								
6/16/83*	Cessna 182H	NA	Petersburg, Alaska, U.S.	Personal	0	0	1	Destroyed
The inexperienced student pilot was on a night flight when the weather deteriorated and the pilot became unsure of his position. He spent several hours trying to determine his position. When fuel was nearly depleted, he ditched the aircraft near a ship whose lights he had spotted. He was rescued by ship personnel.								
6/19/83	Cessna 172PII	NA	Richmond Beach, California, U.S.	Personal	0	0	2	Substantial
During the pilot's attempt to land, the aircraft contacted the water in a nose-low attitude and twisted clockwise. The right float filled with water, and the pilot and passenger donned life vests. Both occupants exited the left door of the aircraft. The aircraft rolled inverted and filled with water.								
7/8/83	Grumman AA-1	NA	Manitowoc, Wisconsin, U.S.	Personal	1	0	0	Destroyed
The aircraft disappeared from radar contact while over Lake Michigan. Part of the aircraft with the data plate containing the serial number was found on a beach of the lake.								
7/11/83*	Piper PA 32R-300	NA	Islamorada, Florida, U.S.	Personal	0	2	0	Destroyed
The aircraft was ditched in a bay after the engine malfunctioned.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/12/83	Cessna 305A	NA	North Myrtle Beach, South Carolina, U.S.	Banner towing	0	0	1	Substantial
The aircraft stalled and struck an inland waterway shortly after takeoff.								
7/17/83*	Rockwell 685	NA	Bass Strait, Victoria, Australia	Personal	2	0	0	Destroyed
Because of a low-fuel warning, the pilot conducted an emergency descent. The aircraft continued on track toward the Victoria coast. The ditching may have been conducted with the engines operating.								
7/23/83	Bellanca Citabria 7GCBC	NA	Seward, Alaska, U.S.	Aerial observation	0	0	1	Substantial
The pilot said that he was flying the aircraft 200 feet AGL, about 65 miles per hour in a left turn, spotting fish for a fishing vessel when a map that was on his lap fell to the floor. When he reached for it, his left hand hit the throttle, reducing power. Before he could recover, the aircraft struck the water.								
8/7/83*	Piper PA-23	NA	Tangier, Morocco	Personal	0	0	2	Destroyed
The aircraft was ditched off the coast following a double engine failure. The crew had difficulty leaving the aircraft, which sank in 90 seconds. The crew swam three miles to shore, then walked for five hours to civilization.								
8/9/83*	Aerostar 600	NA	Pahokee, Florida, U.S.	Personal	0	0	6	Substantial
While the pilot was flying the aircraft in a climb through 5,000 feet, the left engine failed and began surging, the oil-temperature gauge failed, and smoke came from under the instrument panel. The pilot reduced power to the left engine and requested vectors to the nearest airport. When he realized the airplane could not reach the airport, the pilot ditched the airplane in Lake Okeechobee.								
8/13/83	Pierce GS-1	NA	Sand Springs, Oklahoma, U.S.	Personal	0	0	1	Substantial
The pilot initiated a 30-degree to 40-degree bank and the aircraft stalled, and then struck the lake and sank in 37 feet of water. The aircraft was recovered the following day.								
9/4/83	Cessna U206F	NA	Lake Taupo, New Zealand	Unscheduled passenger	0	0	NA	Substantial
The aircraft was departing on a scenic flight from Lake Taupo. During the takeoff run, the aircraft struck a large swell and become airborne prematurely at too low an airspeed to continue flying. The aircraft descended in a nose-high attitude and struck another large swell. The pilot closed the throttle and discontinued the takeoff.								
9/8/83*	Beech H18S	NA	Kailua-Kona, Hawaii, U.S.	Scheduled passenger	0	1	9	Destroyed
About one minute after takeoff, between 400 feet and 500 feet and during the first power reduction, the right engine backfired. Following more violent backfires, the rpm decreased to zero. The right engine was restarted, but the problem recurred. The pilot attempted to feather the right propeller but to no avail. The aircraft was then deliberately ditched to avoid an outcropping of lava and came to rest in about 25 feet to 30 feet of water.								
9/10/83	Cessna 180A	NA	Stake Island, Gulf of Mexico	Personal	0	0	1	Substantial
While flying over the Gulf, the pilot forgot to set his altimeter and believed that the aircraft was at 200 feet when it contacted the water. The floats were ripped off, and the aircraft sank. The pilot and passenger held onto a float until morning and then swam to shore.								
9/10/83	Piper PA-28-140	NA	Big Bear, California, U.S.	Personal	1	0	3	Substantial
After takeoff, the airplane climbed only 150 feet to 250 feet above the lake, then descended and struck the water at 60 knots. Investigation revealed that the aircraft was at least 294 pounds over maximum gross weight.								
9/14/83	De Havilland B-206	NA	Davenport, California, U.S.	NA	1	0	0	Destroyed
The aircraft struck the water while attempting to evade U.S. Customs officials, who had been following the aircraft from Mexico. Three days after the accident, two bags of marijuana washed ashore, and a week after the accident, the pilot's body washed ashore.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/17/83*	Cessna U-206FG	NA	Jones Beach, New York, U.S.	Personal	4	0	0	None
The aircraft was ditched in the ocean after an engine failure caused by misjudgment of the fuel supply.								
9/18/83*	Piper PA-32R-300	NA	Kieta, Papua New Guinea	Personal	0	0	4	Destroyed
The engine failed after takeoff, and the pilot ditched the airplane. Investigation revealed that takeoff had been attempted with the aircraft loaded in excess of the maximum weight recommended for the length of strip available.								
9/21/83	Cessna 185	NA	Valdez, Alaska, U.S.	Unscheduled passenger	2	0	0	Substantial
During a descending left turn with 15 degrees to 20 degrees of left bank, the aircraft struck the water with the left float, then bounced high above the water. The aircraft pitched down abruptly and struck the water. Witnesses saw the two occupants climb onto the floating wreckage. The witnesses began building a log raft to rescue the occupants, but before the raft was completed, the occupants had drifted out of sight in fog and rain. The occupants were not found and were presumed to have drowned.								
9/23/83	Lake LA-4-200	NA	Eastsound, Washington, U.S.	Personal	2	1	0	Destroyed
The aircraft struck the glassy water during a low-altitude maneuver. The occupants were recovered by a sailboat, but only one of the three survived. There were considerable feathers among the wreckage.								
10/6/83	Cessna U206G	NA	Meyers Chuck, Alaska, U.S.	Personal	0	0	4	Substantial
During takeoff, the aircraft struck a large wave, which broke the front struts. The right wing then struck the water, and the aircraft nosed over.								
10/21/83*	Piper PA-23	NA	Gulf of Mexico	Personal	0	0	2	Destroyed
The pilot said that the compass had malfunctioned and that, fearing fuel exhaustion, he had made two passes around a freighter before ditching across the ship's bow.								
11/4/83	Cessna A185F	NA	Freemason Island, Louisiana, U.S.	Personal	1	0	3	Destroyed
The aircraft was at 200 feet AGL and was being flown at 90 knots when the pilot initiated a 10-degree to 15-degree right bank. The aircraft then struck the water and sank in about 15 feet of water. The passenger in the right front seat was not found after the accident and was presumed to have drowned.								
11/8/83	Lake LA-4-200	NA	St. Michaels, Maryland, U.S.	Personal	1	1	0	Destroyed
The water was glassy at the time of the landing, and the pilot believed that his approach was perfect and that he was about five feet above the water. As he began the flare, the amphibious aircraft struck the water. Both occupants were pulled from the water, but the passenger, who had gone through the windshield, died later.								
11/9/83	Gazelle	Specialist Flight Training	Talkin Tarn, U.K.	Commercial training	0	0	1	Destroyed
At the end of a third low-level pass over a lake, the aircraft was pulled up, apparently to avoid trees, before descending and striking the water in a level attitude. The aircraft broke up and was destroyed.								
11/26/83*	Cessna 172P	NA	Jackson, Mississippi, U.S.	Personal	0	0	3	Substantial
The aircraft was ditched in a reservoir at night following a loss of power. The occupants exited and swam to shore without injury.								
12/8/83	Cessna C-500 Citation	Transeurch	Stornoway, Scotland	Personal	10	0	0	Destroyed
The aircraft was seen on radar descending from FL 330. The radar return disappeared as the aircraft struck the sea near Stornoway. Seven bodies and some small pieces of wreckage were recovered.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
12/14/83	Cessna 310R	NA	Buffalo, New York, U.S.	Unscheduled, purpose unknown	1	0	0	Destroyed
The aircraft struck Lake Erie during an ILS approach to Runway 05 at Buffalo. The Coast Guard located wreckage associated with the aircraft about two hours later, 12 miles from the airport.								
12/17/83	Cessna C-172M	NA	Chesapeake, Virginia, U.S.	Personal	1	1	0	Destroyed
The pilot was distracted by a passenger door that would not stay latched. The pilot said that he was trying to help the passenger close the door and was distracted by reflections in the water when the aircraft struck the water. The pilot's next conscious moment occurred in the water, still strapped to the seat. The passenger was unconscious and drowned.								
12/23/83*	Cessna 210	NA	Ft. Myers, Florida, U.S.	Personal	0	0	4	Destroyed
During the takeoff roll, about half way along the runway, the pilot observed that the aircraft was not accelerating normally. After liftoff, he attempted to return to the airport but was forced to ditch the aircraft in the Caloosahatchee River because of power loss.								
12/26/83*	King Air BE-90	Airmore	Copenhagen, Denmark	Cargo	0	0	1	Destroyed
The airplane was ditched two nautical miles short of the runway after both engines failed. The pilot left the airplane and was rescued by helicopter.								
1/8/84	Cessna 182Q	NA	Hana, Hawaii, U.S.	Personal	3	0	0	Destroyed
The aircraft disappeared from radar about eight miles north of Hana, Hawaii, while on an overwater flight. The aircraft was not found in the ensuing search. The pilot and passengers, who were reported to have been drinking at a bar before the flight, were presumed to have died from injuries and/or drowning.								
2/16/84*	Cessna 150F	NA	Folsom Lake, California, U.S.	Personal	0	0	2	Substantial
A power loss occurred because of fuel exhaustion. To avoid rough, unsuitable terrain, the pilot decided to ditch the aircraft in a nearby lake.								
2/28/84	DC-10-30	SAS	New York, New York, U.S.	Scheduled passenger	0	0	177	Substantial
The aircraft touched down about 4,700 feet beyond the threshold of the 8,400-foot runway and could not be stopped on the runway. The crew steered the aircraft to the right to avoid the approach light pier at the departure end of the runway, and the aircraft came to rest in a tidal waterway about 600 feet from the departure end of the runway. The 163 passengers and 14 crewmembers evacuated the aircraft safely, but a few received minor injuries.								
3/1/84	Cessna U206	NA	Stevenson, Washington, U.S.	Business	2	0	0	Destroyed
While the pilot was maneuvering at low altitude, the aircraft struck a river, whose water was reported to have been "glassy smooth." The aircraft sank in 65 feet of water and was not recovered.								
3/3/84*	Cessna C-172F	NA	Pascagoula, Mississippi, U.S.	Personal	0	0	1	Substantial
The pilot ditched the aircraft after a complete loss of power.								
3/11/84	Cessna 150G	NA	Kingsville, Texas, U.S.	Personal	0	0	2	Destroyed
The pilot and passenger said that, while flying over a water basin, they felt an updraft. They said that the next thing they remembered was climbing out of the aircraft, which was inverted and under water.								
4/7/84*	Beech BE-18D	NA	Egegik, Alaska, U.S.	Business	0	0	2	Destroyed
The pilot said that the engines failed as a result of snow ingestion and carburetor icing upon entering clouds at 9,000 feet. The airplane remained in IMC until approximately 100 feet to 300 feet AGL, then entered VMC. After ditching the aircraft, the pilot and passenger swam to shore. The aircraft washed out to sea and was not recovered.								
4/22/84	Piper-28-140	NA	Panacea, Florida, U.S.	Personal	1	0	0	Destroyed
The aircraft struck water shortly after takeoff. One witness said that the aircraft entered the water in a steep left bank at a high rate of descent.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
4/24/84*	Piper PA-32R-300	NA	Venice, Florida, U.S.	NA	0	0	1	Destroyed
The aircraft was ditched in the Gulf of Mexico after being followed by U.S. Customs. The pilot did not tell authorities his departure point or destination.								
5/4/84*	Cessna 180B	NA	Galveston, Texas, U.S.	Aerial observation	0	0	2	Destroyed
The aircraft was being flown about 300 feet over the bay when the pilot made a turn to fly downwind and the aircraft began to stall. The pilot said that he advanced the throttle, but the engine did not respond. He lowered the aircraft's nose to regain flying speed, then flared so that touchdown in the water was in a normal landing attitude.								
5/7/84	Colonial C-2	NA	Stone Lake, Wisconsin, U.S.	Personal	1	0	0	Minor
A witness saw the aircraft in a wide, gradually descending left turn around an island. The aircraft was later found inverted in 15 feet of water, 300 feet from shore. The pilot was found 150 feet from the shore. He had drowned.								
5/15/84	Learjet 35	Argentine Government	Near Ushuaia, Argentina	Public use	12	0	0	Destroyed
The aircraft disappeared from radar while on approach to its destination in low visibility and a snowstorm. The wreckage was located two days later in the Bay of Ushuaia.								
5/15/84*	Cessna 182P	NA	Douglas Island, Alaska, U.S.	Personal	0	0	1	Destroyed
The pilot reported a complete loss of power, with oil visible on the left side of the windscreen. The pilot was unable to glide the airplane to land, and the airplane was ditched in deep water about 100 yards from shore.								
5/23/84	Piper PA-38-112	NA	St. Petersburg, Florida, U.S.	Personal	2	0	0	Destroyed
Witnesses said that the aircraft appeared to bank very steeply to the left, then pitch down into the water.								
5/28/84	Cessna U-206-GII	NA	Kenmore, Washington, U.S.	Personal	0	0	4	Substantial
The pilot said that he was attempting a landing, with a left quartering crosswind, in water made rough by considerable boat activity. The left float dug into the water, and the aircraft sank.								
6/14/84	Lake 250	NA	Key Largo, Florida, U.S.	Personal	0	0	4	Destroyed
As the pilot flew the approach over the ocean, a big wave appeared. The pilot pulled the nose of the aircraft up and added power. The aircraft nevertheless struck the wave crest and was catapulted upward in a nose-high attitude. The aircraft then struck the water with its left wing, which separated from the aircraft. The aircraft sank in 12 feet of water after about 35 minutes.								
6/16/84	Cessna 152	NA	Houston, Texas, U.S.	Instructional	0	0	1	Substantial
Shortly after touchdown during a touch-and-go landing, directional control was lost. The aircraft veered off the left side of the runway and came to rest in a waterway used by seaplanes.								
6/16/84*	Cessna 172	NA	Boulogne, France	Flight club	0	0	4	Destroyed
The aircraft was ditched in the sea after the engine failed.								
6/19/84*	Cessna 206	NA	Barbers Point, Hawaii, U.S.	Ferry	0	0	1	Destroyed
Fuel exhaustion forced the pilot to ditch about 10 miles from the Hawaiian coast. The pilot was rescued by the Coast Guard.								
6/24/84	Lake LA-4-200	NA	Mears, Michigan, U.S.	Personal	0	0	3	Substantial
The pilot said that after the amphibious aircraft reached eight feet to 10 feet AGL during takeoff, a crosswind gust caused the left sponson to contact the water surface. This caused a loss of control, and the airplane struck the lake inverted.								
6/25/84	Lake LA-4-200	NA	Levenworth, Washington, U.S.	Personal	0	0	1	Substantial
The amphibious aircraft started to "porpoise" in the air after takeoff and stalled about 25 feet above the water. The aircraft dragged a wing, struck the water and sank. The pilot said that water in the hull had caused the unstable condition.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
6/25/84	Champion 7KCAB	NA	Egg Harbor Town, New Jersey, U.S.	Personal	0	0	2	Destroyed
At 350 feet to 400 feet AGL and about 85 knots, the aircraft abruptly pitched nose-down. Impact occurred in 30-foot-deep water.								
6/25/84	Cessna 206	NA	Montauk, New York, U.S.	Positioning	0	0	1	Substantial
The float-equipped airplane had approached nose-high, and upon initial touchdown on the lake, the airplane skipped and bounced. The aircraft nosed over and sank.								
6/30/84	Lake LA-4-200	NA	Marathon, Florida, U.S.	Personal	0	1	1	Destroyed
The pilot said that he was flying the airplane low and in level flight over the ocean when the airplane struck the wake from a large boat and flipped over. Witnesses said that the aircraft began a right turn while flying low, then the right wing hit the water, and the aircraft cartwheeled and struck the ocean. A check of the pilot's blood showed an alcohol level of 0.16 percent.								
6/30/84	Maule M-5-235C	NA	Millinocket Lake, Maine, U.S.	Personal	0	0	2	Destroyed
The aircraft was landed hard on the glassy-smooth surface of a lake. After touchdown, the left float split open, and the aircraft sank in 40 feet of water.								
7/4/84	Cessna 172P	NA	St. Joseph, Missouri, U.S.	Personal	1	0	0	Destroyed
Pieces of wreckage and the body of the pilot were recovered from Lake Michigan about four miles southwest of St. Joseph. Weather conditions had deteriorated into IMC along the route of flight.								
7/4/84	Cessna 172M	NA	St. Croix, U.S. Virgin Islands	Personal	2	0	0	Destroyed
Shortly after takeoff, the aircraft struck the water about 200 yards off the northwest shore of St. Croix. Witnesses said that the aircraft appeared to be in straight and level flight with the engine running until it suddenly pitched straight down into the ocean.								
7/6/84	Champion 7ECA	NA	Juneau, Alaska, U.S.	Personal	0	1	0	Destroyed
The cowling of the aircraft came loose, and the pilot reduced power because of the vibration. An emergency was declared, and the pilot attempted a 180-degree turn at an altitude of 400 feet AGL. The aircraft stalled and hit a channel where the water was about 10 feet deep.								
7/17/84*	Beech H18S	NA	Honolulu, Hawaii, U.S.	Unscheduled, otherwise unknown	0	0	1	Destroyed
During takeoff, about 50 feet AGL and 4,000 feet down Runway 4R, the right engine failed. The aircraft banked right, and the pilot maintained control of the aircraft until impact with the water.								
7/21/84	Grumman G-21A	NA	Ouzinkie, Alaska, U.S.	Unscheduled, otherwise unknown	4	0	0	Destroyed
The pilot obtained a special VFR clearance for departure, then circled the airplane over Monashka Bay while waiting for the weather over the narrow strait to improve. Eventually, the pilot radioed that the weather appeared to be getting better and that he was going to take a look. The aircraft struck the waters of a narrow strait northwest of Monashka Bay. Witnesses said that the weather was IFR. The accident aircraft was not equipped for instrument flight, nor was the pilot current to conduct IFR operations.								
8/1/84	Aeronca 7CCM	NA	Kotzebue, Alaska, U.S.	Personal	2	0	0	Destroyed
Witnesses said that they saw the aircraft being flown in an erratic manner and buzzing the shoreline. On Aug. 6, 1984, the aircraft was located in a small lake near the Noatak River. An examination of the wreckage revealed damage that was typical of impacting in a stall or spin. Toxicology checks of the pilot's and passenger's blood revealed alcohol levels of 0.15 percent and 0.21 percent, respectively.								
8/4/84	BAC1-11	PAL	Tacloban Airport, Philippines	Scheduled passenger	0	0	80	Destroyed
The aircraft overran the runway on landing and came to rest in the sea.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/5/84	F27	Bangladesh Biman	Zia, Dhaka, Bangladesh	Scheduled passenger	49	0	0	Destroyed
The pilot conducted a VOR approach to Runway 32 but did not have visual contact and conducted a missed approach. The pilot received clearance for an ILS approach to Runway 14, and again no visual contact was established. On the second ILS approach to Runway 14, the aircraft struck water 550 meters west of the runway threshold.								
8/7/84	F27	Rio Sul Servicos Aereos Regionais	Rio de Janeiro, Brazil	Training	0	0	7	Substantial
The airplane overran the runway on landing and was partially submerged in Guanabara Bay.								
8/18/84*	De Havilland DHC-6 Twin Otter	Unknown	Tuktoyaktuk, Canada	Survey	0	0	6	Substantial
When the pilot switched from the main fuel tanks to wing tip fuel tanks, both engines failed. The pilot ditched the aircraft.								
8/18/84	Starduster Too	NA	Whidbey Island, Washington, U.S.	Personal	0	0	1	Destroyed
Witnesses said that the aircraft was being flown on an aerobatic flight before it struck the water and was destroyed.								
8/19/84	Piper PA-28-235	NA	Put In Bay, Ohio, U.S.	Personal	1	1	0	Destroyed
The pilot attempted a go-around, making a sharp right turn described as a 90-degree bank. The aircraft struck the water in a right-wing-low attitude.								
8/22/84	Cessna 206	NA	Viekoda Bay, Alaska, U.S.	Unscheduled passenger	0	0	2	Destroyed
The aircraft had been flown to about 30 feet AGL when the pilot saw the silhouette of a fishing vessel's rigging through the glare of the sun. The aircraft hit a mast on the vessel and struck the bay.								
8/29/84*	Cessna 210M	NA	Howell, Michigan, U.S.	Unscheduled Cargo	0	0	1	Destroyed
The pilot said that about 10 minutes after takeoff, the fuel flow fluctuated and slowly decreased to zero. He conducted a forced landing in a lake, exited the aircraft and swam to shore.								
9/3/84	Aero Commander 680V	NA	Bridgeport, Connecticut, U.S.	Personal	1	0	0	Destroyed
The aircraft descended into the water 6.5 miles southwest of Bridgeport. The aircraft was on an ILS approach to Runway 6. The controller was giving the final approach instructions to the pilot, after having issued instructions for some turns and changes in airspeed for spacing behind landing traffic, when radar contact and radio contact were lost. Post-accident fuel calculations showed about six gallons of fuel remaining; the typical amount of unusable fuel for this aircraft is 13 gallons.								
9/6/84*	Piper PA-31-350	NA	Marathon, Florida, U.S.	NA	0	0	2	Destroyed
The Coast Guard was alerted to a ditched aircraft in the Atlantic Ocean and found the wreckage of a PA-31, with 27 bales of marijuana in and around the wreckage. Two men in a life raft were arrested.								
9/7/84*	Beech J35	NA	Hyannis, Massachusetts, U.S.	Personal	0	0	1	Substantial
The engine ran roughly and then stopped. The landing-gear-down forced landing was made in salt water about six minutes' flying time from the destination airport.								
9/18/84	Piper PA-12	NA	Dadina Lake, Alaska, U.S.	Personal	1	0	0	Substantial
The pilot had been hunting moose. After takeoff, the pilot lost control of the aircraft, which struck the water in a right-wing-down attitude. The pilot drowned. Divers found moose horns that had been tied to the float lift struts. The pilot did not have a seaplane rating.								
9/20/84	Cessna A185F	NA	Fort Peck, Montana, U.S.	Personal	1	0	2	Substantial
The aircraft struck several waves during the takeoff run from a reservoir. The right wing tip dragged in the water, causing the aircraft to invert and to become partially submerged. The pilot pulled his son and daughter from the aircraft before he drowned.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/26/84	Cessna 172P	NA	Webbers Falls, Oklahoma, U.S.	Public use	2	0	0	Destroyed
The aircraft's left wing tip struck an electrical transmission line 80 feet above water during a wildlife survey. The aircraft struck the river 0.13 mile downstream from the wire.								
9/27/84	Robin 100	NA	North Sea	NA	1	0	0	Destroyed
The aircraft struck water following loss of oil pressure. No wreckage was found.								
10/3/84	Cessna A185E	NA	Morgan City, Louisiana, U.S.	Personal	0	0	1	Substantial
After 100 yards to 150 yards of landing roll, the right float struck a submerged object. The float filled with water and the aircraft rolled inverted before sinking.								
10/5/84*	Citation	NA	Skiathos, Greece	NA	0	0	10	Destroyed
The aircraft was ditched in the sea shortly after takeoff. All occupants were rescued.								
10/7/84	Grumman American AA5A	NA	Corinth, New York, U.S.	Personal	0	0	2	Substantial
The pilot became disoriented and flew an approach to an area that he mistakenly identified as his planned destination. During the approach, the aircraft struck wires and descended out of control into a river.								
10/7/84	Lake LA-4-200	NA	Waurika, Oklahoma, U.S.	Personal	0	1	2	Destroyed
Witnesses said that the aircraft's nose was too low at touchdown, and the nose and right pontoon dug into the water. The aircraft swerved abruptly to the right, inverted and sank.								
10/13/84	Catalina PBY-6A	NA	Port Isabel, Texas, U.S.	Demonstration	6	4	0	Destroyed
The pilot of the aircraft, which was being photographed by individuals in another aircraft, conducted a simulated water landing. The aircraft struck a fishing net supported by metal stakes. The stakes ripped through the fuselage and the aircraft nosed over into shallow water. The aircraft broke apart on impact.								
10/16/84*	Cessna 210	NA	San Pedro, California, U.S.	Personal	0	0	2	Substantial
The aircraft was on a 3.5-mile final approach to Torrance Airport when an engine failed. The pilot ditched the aircraft in the Los Angeles West Basin Harbor.								
10/23/84*	De Havilland DHC-4	Newcal Aviation	Sable Island, North Atlantic Ocean	Ferry	1	1	0	Destroyed
Navigational aids failed, the fuel supply was exhausted and the aircraft was ditched 150 miles south of Sable Island. The aircraft sank. The pilot was missing, and the copilot was rescued from a raft.								
10/26/84	Cessna 150M	NA	Providence, Rhode Island, U.S.	Personal	2	0	0	Destroyed
The aircraft struck the waters of Narragansett Bay. When the aircraft was located the next morning, divers from the Coast Guard found a woman's body in the aircraft. The drowned pilot's body was found on a beach about two weeks later.								
10/31/84	Douglas DC-3	NA	Davao/Manila, Philippines	Unscheduled cargo	4	0	0	Destroyed
The aircraft was reported missing on a flight from Davao to Manila.								
11/6/84	Piper PA-18-150	NA	Omaha, Arkansas, U.S.	Personal	1	0	0	Substantial
The aircraft struck an unmarked power line about 85 feet above a lake. The aircraft then struck the water and sank. The pilot drowned.								
11/10/84	Cessna C337	NA	Taunton, Massachusetts, U.S.	Personal	1	0	3	Minor
The pilot said that during a go-around, the aircraft began to descend because of wind shear, turbulence and downdrafts. The aircraft descended into a pond beyond the end of the runway. One passenger drowned.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
11/10/84	Gates Learjet 24F	NA	St. Thomas, U.S. Virgin Islands	Business	2	1	1	Destroyed
While conducting a night visual approach to Runway 9 in VMC, the aircraft descended and struck water two miles short of the runway. The pilot was not familiar with the airport and did not use a full ILS or the visual approach slope indicator, which were operational for Runway 9. The aircraft was equipped with a radar altimeter system that also was not used by the pilot. Neither the pilot-in-command nor the copilot was properly certificated for the flight.								
11/16/84*	Piper J3C-65	NA	Stuart, Florida, U.S.	Aerial observation	0	0	2	Substantial
The aircraft was being flown low over water to film a television commercial. The pilot said that the engine did not respond when he advanced the throttle lever for additional power. There was insufficient power to maintain level flight, and the pilot ditched the aircraft, which sank.								
11/16/84	Piper PA-28-236	NA	Atlantic City, New Jersey, U.S.	Personal	4	0	0	Destroyed
During the approach, the pilot suffered a disabling heart attack and the aircraft descended, entering the water at a nose-down angle of about 80 degrees.								
11/19/84	Cessna 180J	NA	Ketchikan, Alaska, U.S.	Personal	0	0	2	Substantial
The aircraft sank after a hard landing on water. The pilot said that the aircraft bounced during landing and that wind beneath the upwind wing caused the aircraft to roll.								
12/1/84	Cessna 182H	NA	Provo, Utah, U.S.	Instructional	2	0	0	Destroyed
The left-seat noninstrument private pilot was being checked out in a flying club aircraft by a commercial pilot. The aircraft was being flown over a Utah lake on a dark night, on final approach to the Provo airport. The private pilot maneuvered the aircraft for spacing from a second aircraft. A witness said that two aircraft were over the lake and that one turned toward the airport and went straight down. Investigation revealed that the aircraft struck the water in a left-wing-down, nose-low attitude.								
2/3/85	Piper PA-23-250	NA	Key Largo, Florida, U.S.	NA	2	0	0	Substantial
The aircraft struck the Atlantic Ocean and sank nose-first into 15 feet of water. On impact, the 25 bales of marijuana located in the cabin of the aircraft shifted forward and pinned the pilot and passenger in the aircraft.								
2/10/85*	Cessna 172	NA	Alderney, Channel Islands, U.K.	Personal	1	0	0	Destroyed
The pilot had just reported being 12 miles from Alderney when he declared mayday and said that he would ditch the aircraft within two minutes to three minutes because of an engine problem. A full air and sea search failed to find the wreckage, but more than a year later, the aircraft's engine and propeller were netted by a trawler.								
2/11/85*	Cessna 210N	NA	Georges River, New South Wales, Australia	Instructional	0	0	2	Substantial
The engine surged and then failed. The pilot moved the fuel selector to all fuel-tank positions, but power was not restored. The pilot ditched the aircraft in a river. Neither pilot had visually checked the fuel tanks, and there was no fuel in the starboard tank.								
2/24/85	Grumman GA-7 Cougar	NA	Ventnor, Isle of Wight, England	Personal	1	2	1	Destroyed
The pilot intended to fly VFR around the Isle of Wight. He flew the airplane to 100 feet above the sea and followed the coastline offshore. The pilot asked the passenger in the right seat to find a radio frequency printed on an aeronautical chart. When the pilot glanced briefly at the chart, the aircraft struck the sea. The aircraft sank with life vests stowed in the rear cabin.								
3/1/85*	Rockwell 680E	NA	Key West, Florida, U.S.	Personal	2	0	0	Destroyed
A Coast Guard Falcon aircraft was on the scene when the aircraft was ditched in the Atlantic Ocean because of fuel exhaustion. A life raft and marker were dropped by the Coast Guard aircraft. A search was conducted all day March 1 and was called off at sunset March 2. The occupants were presumed to have been fatally injured or drowned. The aircraft was presumed to have been destroyed.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
4/8/85	Cessna P210N	NA	Santa Barbara, California, U.S.	Personal	1	0	0	Destroyed
A controller observed the aircraft's radar target climb to 600 feet, then descend to 500 feet before disappearing from the radar scope about one mile south of the airport. Two ground witnesses observed the aircraft strike the water after descending out of the clouds.								
4/13/85*	Cessna 152	NA	Franklin, Louisiana, U.S.	Personal	1	0	0	Destroyed
The aircraft struck a crawfish pond during a ditching at night following a power loss caused by fuel exhaustion.								
4/14/85*	Mitsubishi MU2J	NA	Patterson, Louisiana, U.S.	Business	0	0	4	Substantial
On visual final approach to the airport at night, the aircraft entered ground fog. Reflection of the landing lights in the fog was distracting to the pilot, who landed the aircraft in the adjacent seaplane-landing area instead of on the hard-surface runway.								
4/14/85	Cessna 150G	NA	Stevens Point, Wisconsin, U.S.	Personal	0	0	2	Substantial
During flight over a river at 300 feet AGL, the pilot initiated a turn to reverse direction. The aircraft struck the water during the descending turn and nosed over.								
4/14/85*	Cessna 150G	NA	Daytona Beach, Florida, U.S.	Banner towing	0	0	1	Destroyed
The aircraft was ditched as a result of a loss of power. During landing, the aircraft nosed over and sank.								
4/19/85	Cessna 140	NA	Hawesville, Kentucky, U.S.	Personal	2	0	0	Destroyed
The aircraft struck the Ohio River and sank following a wing separation caused by a wire strike.								
4/19/85	Bellanca 8KCAB	NA	Clearwater, Florida, U.S.	Personal	2	0	0	Destroyed
The pilot was observed performing low-level aerobatics. In an inverted dive over water, he attempted to fly the airplane in an outside loop. The aircraft struck the water inverted after the onset of a stall.								
4/25/85*	Beech A-36	NA	Afton, Oklahoma, U.S.	Personal	0	0	1	Substantial
The aircraft was ditched in 60-foot-deep to 80-foot-deep water following a loss of power after takeoff. The pilot was rescued by a bass boat before the aircraft sank.								
5/7/85	Cessna 310H	NA	Avinger, Texas, U.S.	Personal	1	1	0	Destroyed
Witnesses saw the aircraft over the lake at a low altitude. They said that the right wing struck the water and the aircraft cartwheeled to the right and sank.								
5/18/85*	Cessna 172F	NA	Curl Beach, New South Wales, Australia	Personal	0	0	4	Substantial
When engine power was applied, the engine ran roughly. The pilot failed to apply carburetor heat because of insufficient knowledge of carburetor icing. The pilot positioned the aircraft over the sea and ditched in shallow water five meters from shore. The aircraft came to rest inverted.								
5/21/85	Cessna TR-182	NA	Grand Island, New York, U.S.	Sightseeing	3	1	0	Destroyed
The flight had been a local sightseeing tour over Niagara Falls. The pilot said that he would demonstrate to his passengers how fast the aircraft appeared to be traveling when near the water. The pilot then began a left descending turn over the Niagara River. The right-seat passenger said that he turned in his seat to speak to his wife, and the next thing he knew, he was in the water.								
5/24/85*	Cessna U206F	NA	Piney Point, Maryland, U.S.	Business	0	0	1	Substantial
When the engine failed at an altitude of 3,800 feet to 4,000 feet, the pilot requested vectors toward land and the nearest airport. When the aircraft emerged from clouds at about 1,000 feet AGL, the aircraft was still over water. Unable to reach land, the pilot ditched the aircraft in the mouth of the Potomac River about 0.75 mile from shore.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
5/31/85*	Cessna 172	NA	Columbia, South Carolina, U.S.	Business	0	0	1	Substantial
A power loss occurred over a dense forest, and the pilot ditched the aircraft in a lake. The aircraft sank in 14 feet of water.								
6/8/85	Ercoupe 415-C	NA	Daytona Beach, Florida, U.S.	Personal	1	0	1	Destroyed
During a low-altitude turn, the aircraft's left wing struck water, and the aircraft sank in less than one minute. The pilot received a head injury and drowned. Toxicology tests showed that the alcohol level in the pilot's blood was 0.128 percent.								
6/13/85*	Cessna T210J	NA	Moab, Utah, U.S.	Personal	0	1	1	Destroyed
The pilot and a passenger conducted a low-level pass over the Colorado River to drop a package to friends, who were rafting on the river. The pilot said that the engine failed when the aircraft was in the canyon, and he ditched the airplane in the river.								
6/20/85	Grumman G-44	NA	Dillingham, Alaska, U.S.	Business	0	0	3	Substantial
The amphibious aircraft struck water as the pilot was landing on glassy water at the inlet of Nerka Lake. Subsequently, the aircraft sank and came to rest inverted at the bottom of Wood River								
6/22/85	Anderson Skybolt	NA	Escanaba, Michigan, U.S.	Personal	0	0	2	Substantial
Witnesses reported that during a turning maneuver over water, the aircraft struck the surface. A toxicology check of the pilot's blood showed an alcohol level of 0.225 percent.								
6/23/85	Boeing 747	Air India	Atlantic Ocean, off Ireland	Scheduled Passenger	329	0	0	Destroyed
During the flight from Montreal, Quebec, Canada, to London, England, the aircraft disappeared from radar and struck the Atlantic Ocean southwest of Ireland. The incident has been attributed to an explosion in the forward cargo hold, caused by sabotage.								
6/24/85*	Piper PA-23-250	NA	Atlantic Ocean	Personal	0	0	2	Destroyed
During an overwater flight at 10,500 feet, a fire began in the forward section of the aircraft. The pilot ditched the aircraft in the Atlantic Ocean and was rescued by the Coast Guard about four hours later.								
6/27/85	McDonnell Douglas DC-10	American Airlines	San Juan, Puerto Rico, U.S.	Scheduled passenger	0	3	267	Substantial
During takeoff, at about the V_1 speed of 141 knots, the captain rejected the takeoff using maximum braking. (V_1 is the maximum speed in the takeoff at which the pilot must take the first action to stop the airplane within the accelerate-stop distance.) Unable to stop the aircraft on the remaining runway, he angled the aircraft to the safest area. The aircraft stopped with its nose in a lagoon.								
6/30/85	Beech 65-A90	NA	Apalachicola, Florida, U.S.	Personal	0	0	2	Destroyed
The pilot flying, who was being checked out by another pilot, was conducting a takeoff after a touch-and-go landing. The aircraft lost altitude and struck water. The pilot flying said that he was looking for the flap control when the accident occurred.								
7/2/85	Pitts Special	NA	Bognor Regis, England	Aerobatic display	1	0	0	Destroyed
The pilot was performing aerobatic maneuvers about 0.5 mile offshore. The pilot appeared to have attempted a stall while in a turn, during which a decrease in engine noise was heard. Witnesses said that the aircraft entered a rotational descent and flew into the sea.								
7/14/85*	Cessna 177B	NA	Cedar Key, Florida, U.S.	Personal	0	0	4	Substantial
While the aircraft was being flown at 1,400 feet, there was a strong odor of fuel in the cabin, and the engine failed. The pilot was unable to restart the engine and subsequently ditched the aircraft in the Gulf of Mexico. The aircraft was recovered from 20 feet of water.								
7/17/85	Piper PA-28-235	NA	Monterey, California, U.S.	Personal	1	0	0	Destroyed
On a training flight, 12 miles offshore and about 12 minutes after takeoff, the pilot declared "mayday, rough engine." The aircraft's radar target vanished from the controller's screen at an altitude of 1,300 feet. The Coast Guard recovered a few pieces of debris from the aircraft.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/None	Damage to Aircraft
7/19/85	Aerostar 601	NA	Erie, Pennsylvania, U.S.	Unscheduled passenger	2	0	0	Destroyed
During a normal IFR cruise flight, the pilot did not respond to ATC instructions. The flight continued for 40 minutes with no reply and without deviation in altitude or heading until the discrete target disappeared from radar over Lake Erie. The pilot had not slept for about 30 hours before the loss of communication.								
7/21/85	Piper PA-11	NA	Moultonboro, New Hampshire, U.S.	Personal	0	3	0	Destroyed
During a turn at 150 feet AGL, the aircraft nosed down after rolling right. The aircraft struck water in a steep nose-down attitude.								
7/21/85	Lake LA-4	NA	Snowpond, Maine, U.S.	Personal	0	0	4	Substantial
The aircraft was on step with indicated airspeed of about 45 knots. The aircraft then encountered a boat wake and began flying. The aircraft "porpoised" two or three times and then struck the water in an estimated 10-degree to 15-degree nose-down attitude.								
7/27/85	Cessna TU206G	NA	Taohoma, California, U.S.	Personal	0	0	3	Substantial
The float-equipped Cessna landed on choppy water, nosed over and sank at the seaplane base.								
8/3/85*	Cessna 152	NA	Hilton Head, South Carolina, U.S.	Personal	0	0	2	Destroyed
The commercial pilot and a passenger were flying the aircraft just offshore at about 700 feet when the engine failed. The pilot landed the aircraft in the ocean, and both occupants swam to shore. The aircraft was located but was not recovered.								
8/13/85	Taylorcraft BL-65	NA	Ottumwa, Iowa, U.S.	Personal	0	0	2	Substantial
The aircraft collided with utility wires that crossed the Des Moines River and struck the river.								
8/16/85*	Cessna R182RG	NA	Hilo, Hawaii, U.S.	Ferry	0	0	1	Destroyed
The aircraft was ditched at sea about 200 miles from Hawaii following fuel starvation.								
8/17/85	Cessna C-305A	NA	Brooklyn, New York, U.S.	Banner towing	1	0	0	Destroyed
Witnesses heard the engine sputtering, then observed the airplane in a steep right bank and diving into the water.								
8/19/85	Cessna 172M	NA	St. Thomas, U.S. Virgin Islands	Business	4	0	0	Destroyed
The aircraft was being flown slowly at 200 feet to allow passengers to photograph a group of sailboats. As the pilot began a left turn to reverse course, the aircraft stalled and nosed down, striking the water in a near-vertical attitude.								
8/21/85	Piper PA-18-95	NA	Millinocket, Maine, U.S.	Personal	0	0	1	Substantial
Departing from South Twin Lake in 12-knot winds gusting to 20 knots, the pilot began a slight turn as the aircraft lifted off from the water. A gust of wind simultaneously lifted the nose and a wing, causing the aircraft to stall. It touched down on the lake and was damaged.								
8/23/85	Cessna 150	NA	Newport Beach, California, U.S.	Personal	0	0	2	Destroyed
The aircraft was being flown in circles to photograph a sailboat race. The accident report said that when the pilot attempted to roll out of the turn, the "aircraft flight controls did not respond." To prevent a stall, the pilot applied full power and pushed the nose down. The aircraft struck the ocean and sank.								
8/31/85*	Cessna A150K	NA	Avalon, California, U.S.	Aerial observation	0	0	2	Destroyed
During a commercial fish-spotting flight, the engine began to run roughly, then quit. The pilot could not restart the engine and conducted a power-off ditching at sea. After ditching, the aircraft sank in 300 feet to 400 feet of water and was not recovered.								
9/13/85	Mooney M20F	NA	Aripeka, Florida, U.S.	Personal	0	1	0	Destroyed
The student pilot became lost and disoriented in darkness. Flying low to try to identify a familiar landmark, the pilot flew the aircraft over the shore of the Gulf of Mexico and inadvertently descended into the water.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
9/16/85	Pitts S-2A	NA	Carlsbad, California, U.S.	Aerial photography	1	0	0	Destroyed
After completing a spin over the Pacific Ocean during the filming of a movie, the pilot flew his aircraft back to the entry altitude and initiated a flat inverted spin. The spin continued through the recovery altitude, at which time the pilot radioed, "I have a problem, I have a real problem." Neither the pilot nor the aircraft was recovered.								
9/17/85*	Metro II	Duke Leasing	Gulf of Mexico	Personal	1	0	0	Destroyed
The aircraft presumably was ditched in the Gulf of Mexico, 145 miles South of Grand Isle, Louisiana, U.S. The pilot made at least two distress calls. He first reported an engine problem and then reported the aircraft at 1,500 feet and said that he was preparing to ditch. Aircraft in the vicinity heard both distress calls. No wreckage was found.								
9/23/85	Piper PA-28-140	NA	Gulfport, Mississippi, U.S.	Personal	3	0	0	Destroyed
Approach control told the pilot that lines of rain showers existed across the flight path. The pilot said that he believed that could avoid the bad weather. Later, the pilot said that the ride was bouncy and that he was in rain. The aircraft disappeared from radar, and radio contact was lost. The bodies of the pilot and passengers were recovered from the Gulf of Mexico.								
9/28/85*	Grumman AA-5B	NA	Manchester, Massachusetts, U.S.	Personal	0	0	4	Substantial
During cruise flight at 1,200 feet over water, the engine power decreased and the pilot was unable to maintain altitude. He began a descent toward land, but had insufficient altitude to glide to land and ditched the aircraft.								
10/3/85*	Cessna 152	NA	Lake Charles, Louisiana, U.S.	Banner towing	0	0	1	Substantial
An engine failure occurred because of fuel exhaustion, and the pilot ditched the aircraft in a lake.								
10/6/85	Cessna 500 Citation I	Air Charter (Austria)	Skiathos, Greece	Unscheduled passenger	0	0	10	Destroyed
The aircraft reportedly failed to gain altitude after takeoff from Skiathos and struck the sea just beyond the runway end.								
10/10/85	Cessna C-182N	NA	Winterport, Maine, U.S.	Personal	2	0	0	Destroyed
A witness saw the aircraft being flown under power lines that crossed a river. There was no indication of an accident. Twenty-two days later, the aircraft was located 150 feet south of the power lines at the bottom of the river. The landing gear and propeller had been gouged and scraped.								
10/10/85	Israel Aircraft Industries IAI 1124 Westwind	Pel-Air	Sydney, Australia	Cargo	2	0	0	Destroyed
After an evidently normal takeoff, the crew contacted ATC, advised that they were flying the aircraft to FL 370 and requested to fly the aircraft direct to Brisbane, Australia. Approximately two minutes later, the crew did not respond to ATC calls, and the aircraft disappeared from radar. The aircraft was seen diving steeply toward the water.								
10/23/85*	Cessna 185	NA	Block Island, Rhode Island, U.S.	Personal	0	0	1	Destroyed
The floatplane's engine failed, and the pilot tried unsuccessfully to restart the engine. The pilot contacted the control towers at three airports and advised them of his location and that he would be ditching the aircraft. The aircraft sank and was not recovered.								
11/1/85*	Piper PA-32-300	NA	New York, New York, U.S.	Instructional	0	0	2	Substantial
A pilot was giving a student pilot night-flight instruction. The pilot smelled an odor associated with a hot engine and observed an engine-oil-pressure-gauge reading of zero. He contacted Newark (New Jersey) International Airport to advise them of the emergency. During the flight to Newark, the engine seized, and the pilot decided to ditch the airplane. After the ditching, the Coast Guard rescued the two occupants, who had exited the aircraft and were standing on the wings.								
11/4/85*	Cessna T188C	NA	Hilo, Hawaii, U.S.	Ferry	0	0	1	Destroyed
The engine failed while the aircraft was over the Pacific Ocean, about 900 miles from its destination. The pilot restarted the engine but estimated that there was not enough fuel remaining to reach the destination. He sought assistance from Navy and Coast Guard aircraft to locate a ship near which he might ditch. A ship was located, and the pilot ditched his aircraft about 700 miles short of his destination.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
11/6/85	Piper PA-32R-301T	NA	San Diego, California, U.S.	Personal	3	0	0	Destroyed
When the flight was on a two-mile final at 2,000 feet, the controller initiated a missed approach. The pilot responded and then said that he would prefer to return to the departure airport. A clearance was issued, and then radio contact and radar contact were lost.								
11/14/85	Cessna 182Q	NA	Edenton, North Carolina, U.S.	Business	1	1	0	Substantial
Witnesses said that visibility was 15 feet in fog. The pilot was reportedly flying the airplane on an NDB approach and descended below MDA. The aircraft flew into the Albemarle Sound and sank in 18 feet of water. The pilot was en route to a business meeting with company executives.								
11/19/85	Cessna 182R	NA	Bryson City, North Carolina, U.S.	Personal	3	0	0	Destroyed
On landing, the aircraft veered to the left of the runway centerline. The aircraft was spun around after the left wing contacted a tree. The aircraft fell into the river about 200 feet below.								
12/11/85*	Cessna 150K	NA	Honolulu, Hawaii, U.S.	Personal	0	0	1	Substantial
Five minutes after takeoff, the engine went into uncommanded idle-power operation, and attempts to restore full power were unsuccessful. The pilot was unable to maintain altitude and ditched the airplane about 75 feet from shore.								
12/25/85*	Douglas DC-3	Aero Ejecutivos	Cumana, Venezuela	NA	NA	NA	NA	Destroyed
The aircraft was believed to have been ditched following a loss of power in both engines and to have sunk.								
1/29/86*	Cessna P210N	NA	Keflavik, Reykjavik, Iceland	Business	2	0	0	Destroyed
There was adverse weather at the intended destination in Greenland and at the alternate. The pilot continued the flight to Reykjavik. He extended the estimated arrival time by more than one hour and indicated that the aircraft was low on fuel and in icing conditions. U.S. Air Force and Icelandic aircraft and ships were dispatched in search-and-rescue procedures before the aircraft ran out of fuel. Fuel exhaustion occurred as the pilot was flying a descent from 15,000 feet. A U.S. Air Force C-130 flew to the aircraft location, lighted the ocean with flares and gave ditching advice. The pilot ditched his aircraft in high seas about 36 miles from Keflavik, Iceland, with winds gusting to 35 knots. An Air Force helicopter arrived three minutes later, but the airplane occupants were never observed to emerge from the aircraft.								
2/1/86	Cessna 152	NA	Berthoud, Colorado, U.S.	Personal	2	0	0	Substantial
The student pilot had rented the aircraft from a flying club. The aircraft was observed by witnesses approaching the lake from the southern end at a low altitude and striking water with the right-main landing gear and right wing tip. The aircraft nosed over. The water was glassy, and the sun had set.								
2/9/86*	Piper PA-23-250	NA	San Francisco, California, U.S.	Ferry	0	0	2	Destroyed
The flight originated in Honolulu, Hawaii, U.S. A fuel leak was discovered after seven hours of flight. The pilot attempted to isolate the leak but could not. The fuel cross-feed selector and aircraft fuel selector became difficult to move. The aircraft was ditched after nine hours, 45 minutes of flight because of fuel exhaustion.								
2/16/86	Boeing 737	China Airlines	Pescadores Islands, Taiwan, China	Scheduled passenger	13	0	0	Destroyed
Contact with the aircraft was lost three and one-half minutes after the crew conducted a go-around while attempting to land at Makung, an island off the coast of Taiwan, China. The aircraft was presumed to have struck the sea.								
2/19/86*	Lake LA-4-200	NA	Auburndale, Florida, U.S.	Personal	0	1	0	Destroyed
The pilot said that the engine rpm began to fluctuate. He selected auxiliary fuel tanks, but the rpm continued fluctuating. He decided to ditch the aircraft on a small lake. Not having enough altitude to turn the airplane for a landing into the wind, he conducted a downwind landing. On touchdown, the aircraft flipped and sank in 14 feet of water.								
2/20/86	Cessna 172N	NA	Andover, New Jersey, U.S.	Instructional	1	0	0	Destroyed
The student pilot attempted a go-around, and the aircraft entered a departure stall and spin off the departure end of the runway. The aircraft collided vertically with a frozen lake bed. The student had been working steadily for three days before the accident, and the toxicology report indicated positive for cocaine.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
3/2/86	Piper PA-28-181	NA	Newport Beach, California, U.S.	Instructional	2	0	0	Destroyed
Witnesses observed the aircraft being flown low over a pier at Newport Beach, then entering a right climbing turn. As the turn continued, the aircraft descended to the ocean, cartwheeled and sank.								
3/5/86	Learjet 35	Flight International	Pacific Ocean	NA	2	0	0	Destroyed
The crew lost control and the aircraft struck the sea after colliding with a second Flight International Learjet, 27 nautical miles southeast of San Clemente Island, off southern California, ,U.S.								
3/5/86	Learjet 35	Flight International	Pacific Ocean	NA	2	0	0	Destroyed
The aircraft collided with the other Learjet in the accident listed above and struck the sea at the same location.								
3/12/86*	Cessna A150K	NA	Hanakuli, Hawaii, U.S.	Personal	0	0	2	Destroyed
The aircraft was ditched in the Pacific Ocean after the engine failed. The ditching occurred one mile from shore, and the occupants were rescued after 20 minutes in the water.								
3/17/86	Jodel DR1050	NA	Orkney, U.K.	Private business	0	1	0	Destroyed
The aircraft was approaching 300 feet when the oil-filler-inspection cover began flapping in the slipstream. A witness said that the aircraft entered a steep turn and then dived into the sea. The pilot received serious injuries and could not remember the descent.								
3/29/86	Cessna 150L	NA	Kailua Kona, Hawaii, U.S.	Instructional	1	0	0	Destroyed
Witnesses observed the aircraft's spiral into the Pacific Ocean. Neither the pilot nor the aircraft was recovered.								
4/16/86	Cessna 172D	NA	Garden Grove, Louisiana, U.S.	Personal	0	0	3	Substantial
During a rejected takeoff, the aircraft continued past the end of the runway into a pond.								
5/6/86*	Piper PA-28-181	NA	Madison, Connecticut, U.S.	Personal	0	0	1	Substantial
The engine failed during takeoff, and the pilot conducted a forced landing in the river.								
5/22/86	Cessna 180	NA	Iliamna, Alaska, U.S.	Personal	1	1	0	Substantial
The pilot said that at the time of the accident, the wind was 30 knots, gusting to 35 knots. After touchdown on the water, the pilot lost control of the aircraft, which flipped onto its back and sank.								
6/1/86	Grumman G21A	Channel Flying	Hobart Bay, Alaska, U.S.	Unscheduled passenger	0	0	5	Substantial
The pilot did not retract the landing gear after departure from the airport. During a landing on water with the landing gear still extended, the aircraft's nose separated, and the aircraft flipped over and sank.								
6/3/86	Beech A-23	NA	Charlotte, Vermont, U.S.	Personal	0	0	3	Substantial
On takeoff, the aircraft was at the end of the runway and over water at an altitude of 15 feet to 20 feet. At about 30 feet, the aircraft stopped climbing. A 20-degree change of direction was made to avoid a collision with a sailboat. The aircraft lost lift and struck the water.								
6/3/86	Cessna 152	NA	Middletown, Connecticut, U.S.	Instructional	0	0	1	Substantial
The aircraft ran out of fuel about 15 miles short of the destination, and the pilot conducted a forced landing on the Connecticut River.								
6/7/86	Taylorcraft BCM-12D-85	NA	Ketchikan, Alaska, U.S.	Business	0	0	1	Destroyed
The pilot felt a sudden hard jolt while in cruise flight. Power inputs and control inputs did not correct the aircraft's nose-low, left-wing-down attitude. The aircraft struck the water shortly after the loss of control.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/19/86	Cessna A185F	NA	New Orleans, Louisiana, U.S.	Business	0	0	1	Substantial
The pilot decided to land because of rain shortly after departure. He had forgotten to retract the landing gear after takeoff and made a water landing with the gear down, causing the aircraft to invert and sink.								
7/14/86*	Piper PA-28R-200	NA	Marathon, Florida, U.S.	Personal	0	0	2	Substantial
After a loss of engine oil and subsequent seizing of the engine, the pilot ditched the aircraft in the Gulf of Mexico.								
7/20/86*	Cessna 177RG	NA	Dania, Florida, U.S.	Personal	0	0	4	Substantial
While flying the airplane along a beach, the pilot observed that the engine was steadily losing power. The pilot then ditched the aircraft.								
7/22/86	Douglas DC-3	Borinquen Air	Isla Verde, Puerto Rico, U.S.	Unscheduled cargo	1	1	0	Destroyed
Shortly after takeoff, the pilot told ATC that he was returning to the airport on a right downwind for Runway 10; he received clearance to land. The right propeller was stopped. The pilot flew a descent and turned the airplane onto a base leg at low altitude in a right vertical bank. The airplane struck a lagoon.								
7/26/86*	Grob G109	NA	Isles of Scilly, U.K.	Personal	0	0	2	Substantial
The aircraft's engine failed at 2,500 feet. At about 200 feet, a final ditching call was transmitted, the aircraft was turned into the wind, the systems were shut down, and the propeller was feathered. A gentle water contact was achieved, with the aircraft remaining upright and settling only slightly in the water.								
7/29/86*	Beech BE-35 Bonanza	NA	Frejus, France	NA	0	0	2	Destroyed
The aircraft was ditched in the sea shortly after takeoff because of engine failure.								
8/3/86	De Havilland DHC-6	LIAT	Kingstown, St. Vincent	Passenger	13	0	0	Destroyed
The aircraft struck the sea while approaching to land in poor weather.								
8/17/86	Piper PA-30	NA	Bowley's Quarters, Maryland, U.S.	Personal	3	0	0	Destroyed
The pilot said that he was having trouble controlling the aircraft during the approach. The pilot's last transmission was to acknowledge that he would turn the aircraft 180 degrees to abandon the approach. Witnesses saw the aircraft emerge from clouds in a steep dive and strike water that was 10 feet to 15 feet deep one mile from the airport.								
8/23/86	De Havilland DHC-3 Otter	Lindbergh's Air Service	Sangster Lake, Ontario, Canada	Unscheduled passenger	0	0	5	Substantial
While landing, the pilot misjudged the height of the aircraft above the water because of the dark-night visual conditions. The force of the water strike separated the floats and their attachments from the aircraft. The passengers had not been briefed before the flight on emergency-evacuation procedures or on the use of life vests.								
8/18/86	Cessna 172	NA	Oroville, California, U.S.	Personal	0	0	1	Substantial
The pilot flew the airplane low over a reservoir with the engine stopped. The aircraft was observed to make a right turn, stall and descend into the water. The uninjured pilot exited the sinking aircraft and was rescued by nearby fishermen. The aircraft sank in 300 feet of water.								
8/20/86	Republic RC-3	NA	Keego Harbor, Michigan, U.S.	Personal	0	0	1	Substantial
Preparing to land on a lake at an altitude of 100 feet, the pilot noticed that he did not have full flaps extended. He then reached down and, by error, extended the landing gear instead of the flaps. During touchdown, the aircraft immediately flipped over. The wings and hull were substantially damaged.								
8/27/86*	Piper PA-25	NA	Myrtle Beach, South Carolina, U.S.	Banner towing	0	0	1	Destroyed
At 500 feet AGL, the engine failed. The pilot turned the aircraft out to sea and ditched in the ocean. The pilot swam to shore, and the aircraft sank.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/30/86*	Cessna 182B	NA	La Jolla, California, U.S.	Personal	0	0	1	Destroyed
The airplane was ditched in the ocean after a loss of engine power.								
8/31/86*	Piper PA-22-150	NA	Dennis Port, Massachusetts, U.S.	NA	0	0	1	Substantial
The pilot said that he was flying the airplane at 800 feet along the coastline and was switching from the right fuel tank to the left fuel tank when the engine failed. The aircraft was then ditched in 14-foot-deep water.								
9/1/86	BN-2A Trislander	Kondair	North Sea	Cargo	0	0	1	Substantial
The pilot, having had two hours of sleep, was en route to Stansted Airport, England. He fell asleep, and the airplane hit the sea in a level attitude, sustaining considerable damage to the landing gear. The airplane became airborne again and was flown to Stansted, where the pilot conducted a normal landing.								
9/8/86	MU-2F	Private	Inagua Island, Bahamas	NA	1	0	0	Destroyed
The aircraft was discovered floating in the ocean by a passing ship. One occupant was observed protruding through the windscreen. The aircraft subsequently sank in 230 meters of water.								
9/9/86	Merlin 3	ORD	McLainstown, Grand Bahama	NA	NA	NA	NA	Destroyed
The aircraft was reported to have struck a swampy area eight miles from McLainstown.								
9/24/86*	Cessna 152	NA	Deltona, Florida, U.S.	Personal	0	0	2	Substantial
While in cruise flight, the engine failed, and the pilot ditched the airplane on a lake.								
9/26/86*	De Havilland Chipmunk	NA	Harwich, U.K.	Aerobatic display	0	0	1	Destroyed
The engine failed while the pilot was practicing aerobatics over the sea. The pilot declared mayday before ditching the aircraft. The pilot was rescued by personnel of a sailing craft.								
10/9/86*	McDonnell Douglas DC-7	U.S. Agency for International Development	Dakar, Senegal	Aerial application	3	1	0	Destroyed
During the takeoff roll, smoke was seen from the no. 3 engine. After gear retraction, the no. 4 engine fire alarm sounded, but no fire was observed. The engine was stopped, and the propeller was feathered. The aircraft was ditched shortly afterward.								
10/10/86*	Piper PA-30	NA	Oceanside, California, U.S.	Positioning	0	0	1	Destroyed
Just south of Los Angeles International Airport, the aircraft's right engine ran roughly. Power in the left engine began decreasing and the propeller automatically feathered. The pilot attempted a restart with no success. Unable to maintain altitude, the pilot ditched the aircraft about two miles offshore.								
10/11/86*	Cessna C-152	NA	Port Jefferson, New York, U.S.	Personal	0	0	1	Substantial
While the aircraft was being leveled at 1,800 feet, there was a power loss. The student pilot escaped without injury after the aircraft was ditched in Long Island Sound.								
10/14/86	Let 410M Turbolet	Aeroflot	Ust-Maya, Russia, USSR	Scheduled passenger	14	0	0	Destroyed
The aircraft's left engine failed during a left turn shortly after takeoff, and the aircraft struck a river.								
10/18/86	Lake LA4-180	NA	Folsom, California, U.S.	Personal	0	2	2	Substantial
The pilot attempted a landing on Lake Folsom. On touchdown, the aircraft began settling in the water and nosed over and sank.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/None	Damage to Aircraft
10/28/86	G73 Mallard	Virgin Islands Seaplane Shuttle	St. Croix, Virgin Islands	Scheduled passenger	1	5	9	Substantial
Shortly after takeoff from the water, the aircraft rolled left and could not be leveled with full right aileron. The aircraft then stalled, and the wings leveled. After stall recovery, the aircraft again rolled left and descended, striking the water.								
11/3/86	Cessna 150J	NA	Memphis, Tennessee, U.S.	Personal	1	0	0	Destroyed
Before its discovery on May 20, 1987, this aircraft had last been seen on the crosswind leg on climb-out after a touch-and-go at DeWitt Spain Airport. Parts of the aircraft were recovered from the Mississippi River northwest of the airport.								
11/25/86	Piper PA-34-200T	NA	Isabela, Puerto Rico, U.S.	Personal	2	0	0	Destroyed
The aircraft was reported missing while on a personal flight from San Juan, Puerto Rico, to Aguadilla, Puerto Rico. The pilot's last radio contact was with Aguadilla tower, requesting an alternate airport to land because the aircraft was in heavy rain. The Coast Guard initiated a search and found two seats, four seat cushions and other debris that was identified as being from the missing aircraft.								
11/27/86*	Navion H	NA	Fort Pierce, Florida, U.S.	Personal	0	1	1	Substantial
Electrical failure was followed by engine failure. The pilot ditched the aircraft in the Indian River.								
11/29/86	Cessna 182L	NA	Oceano, Florida, U.S.	Personal	2	0	0	Destroyed
The aircraft made a sharp descending turn and struck the ocean. The reason for the occurrence could not be determined.								
12/5/86*	Cessna T210L	NA	Miami, Florida, U.S.	Business	0	0	1	Destroyed
The engine failed while the aircraft was in cruise flight at 6,000 feet over the Atlantic Ocean. When the engine could not be restarted, the aircraft was ditched. The pilot was rescued by the Coast Guard about 2.5 hours after the accident.								
12/11/86	Piper PA-28R-200	NA	North Manitou Island, Michigan, U.S.	Instructional	2	0	0	Substantial
The pilot had received a weather briefing that included a sigmet on in-flight icing. En route, during flight over a large body of water, he experienced an aircraft power loss. The airplane's altitude was too low for the pilot to glide the airplane to shore. The pilot tried to land on an island but struck a lake.								
12/17/86*	CASA 212-200	Latin Air Services	Punta Patuca, Honduras	NA	0	0	3	Destroyed
According to unconfirmed reports, the aircraft was ditched for unreported reasons in the Caribbean Sea while en route from Key West, Florida, U.S., to Panama. The occupants were rescued by an ocean vessel.								
12/23/86*	Douglas DC-4	NA	Pacific Ocean	Training	0	0	2	Destroyed
The pilot said that he ditched his DC-4 in the Pacific Ocean after experiencing an uncontrollable no. 3 engine fire at the conclusion of a training flight. The ditching occurred in dark-night conditions with minimal 10-foot swells approximately every 10 seconds. The aircraft was reported to have remained afloat approximately 10 minutes after the ditching.								
12/27/86	Piper PA-34	NA	Fort Lauderdale, Florida, U.S.	Personal	2	0	0	Destroyed
While on approach, the aircraft disappeared from radar and struck the Atlantic Ocean in 800 feet of water. The accident occurred in night IMC with rain, thunderstorms and heavy turbulence.								
1/10/87	Aerostar 601	NA	Pahokee, Florida, U.S.	Personal	0	0	2	Substantial
During an overwater approach, the pilot observed an abnormal loss of altitude and airspeed, which he attributed to failure of the right engine, although the rudder pedals did not feel as though the engine had malfunctioned. He added power to maintain correct airspeed, then full power when he did not get the expected response in thrust or airspeed. The flaps were then retracted, and the aircraft struck the lake.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/12/87*	Britten-Norman BN2A-20 Islander	Trillium Air	Toronto Island Airport, Ontario, Canada	Unscheduled passenger	1	1	0	Substantial
The aircraft was being flown on a day VFR flight when both engines failed. The pilot ditched the aircraft in Lake Ontario, 3.5 miles from the Toronto Island Airport. Both occupants were recovered from the water, suffering from hypothermia. The passenger survived, but the pilot died. Rescue was delayed because the aircraft occupants did not have effective signaling devices and authorities had difficulty locating the survivors on the rough water surface.								
1/26/87*	Cessna 337D	NA	Savannah, Georgia, U.S.	Aerial observation	0	0	5	Destroyed
The airplane had fuel in the auxiliary fuel tanks at takeoff, and the pilot switched to the auxiliary tanks about 20 miles offshore. He flew several legs of a whale-search pattern before the engine quit. The pilot turned the airplane toward the shore and switched to the main fuel tank; the front engine also quit. The aircraft was ditched in the ocean and sank about two minutes after impact. It was not recovered.								
2/6/87	Embraer Bandeirante	Talair	East Coast of Papua New Guinea	Scheduled Passenger	15	0	3	Destroyed
The aircraft struck the sea in bad weather en route from Rabaul to Hoskins Airport in the province of West New Britain.								
2/7/87	DHC-6 Twin Otter 300	Inter Atoll Air	Lhaviyani Atoll, Maldives	Unscheduled passenger	0	0	16	Destroyed
During a landing in "moderate seas" the aircraft's right float was lost and the aircraft came to rest in a right-wing-low attitude. The passengers and crew evacuated safely. The aircraft was blown out to sea and sank in deep water.								
2/20/87	Cessna 172M	NA	Cedar Key, Florida, U.S.	Personal	0	0	2	Substantial
In an attempted go-around after an encounter with an unexpectedly strong tailwind, the aircraft was blown off the runway, collided with trees and came to rest in the Gulf of Mexico.								
3/2/87	Cessna 150M	NA	Porter, Texas, U.S.	Personal	0	1	0	Substantial
The pilot was flying the airplane at about 50 feet AGL over the San Jacinto River. During a descending right turn, the aircraft struck a power line and then the river.								
3/8/87	Beech C24R	NA	Milton, Florida, U.S.	Personal	0	0	3	Substantial
The aircraft struck a river about one mile west of the pilot's alternate landing location after the engine failed because of fuel exhaustion during the descent for the approach.								
3/10/87*	Cessna TR182	NA	North Atlantic Ocean	Ferry	0	0	1	Destroyed
The pilot departed from Canada on a North Atlantic ferry flight to Shannon, Ireland, after jump-starting the aircraft because he had left the master switch on overnight. About 750 miles west of the Irish coast, the electrical system failed, and he could not transfer fuel from the ferry tanks. The engine failed, and the aircraft was ditched and sank. The pilot was rescued.								
3/11/87*	Piper PA-24-250	NA	Navarre, Florida, U.S.	Personal	0	0	1	Substantial
Shortly after takeoff at an altitude of about 250 feet with the fuel selector positioned to the right tank, the engine quit. The pilot ditched the aircraft in an intercoastal waterway with the landing gear extended.								
3/13/87	Cessna P210R	NA	Block Island, Rhode Island, U.S.	Business	1	0	0	Destroyed
The aircraft disappeared from radar while the pilot was receiving radar vectors. The aircraft was missing until March 20, 1987, when fishermen pulled part of the wreckage out of ocean waters near Block Island.								
3/25/87	Cessna 310Q	NA	Half Moon Bay, California, U.S.	Personal	2	0	0	Destroyed
The controller observed that the aircraft was losing altitude rapidly and gave the pilot vectors toward the shoreline. The pilot responded, "We're going in." No further transmissions were received from the pilot. Coast Guard helicopters arrived over the area of the accident, and the helicopter aircrews found an oil slick, a landing gear and other remnants of the aircraft, but the major portion of the aircraft sank and was not recovered.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
3/28/87	Piper PA-32-300	NA	Many, Louisiana, U.S.	Personal	0	0	4	Substantial
The pilot said that he landed long and fast over trees at the runway threshold and delayed initiating a go-around until it was too late. The aircraft subsequently departed the end of the runway into a lake.								
4/5/87*	Piper PA-18-125	NA	Fort Lauderdale, Florida, U.S.	Banner towing	0	0	1	Substantial
The pilot said that while the aircraft was towing a banner 200 yards to 300 yards offshore at 500 feet, the engine sputtered, then quit. Attempts to restart it were unsuccessful. The pilot released the banner and ditched the aircraft in the ocean.								
4/9/87	Piper PA-28-161	NA	Malibu, California, U.S.	Personal	2	2	0	Destroyed
The pilot and his three passengers met at a bar and decided to go on a local night scenic flight. Subsequently, the aircraft struck the ocean as the pilot was demonstrating low flight over the water. The pilot and one passenger were hospitalized and treated for injuries and hypothermia. The other two passengers died from drowning.								
4/10/87*	Piper PA-18	NA	Dinard, France	Personal	2	0	0	Destroyed
The pilot declared mayday before the ditching. Two bodies in life vests were recovered.								
4/12/87	Grumman G-44A	NA	Ventura, California, U.S.	Personal	0	2	1	Destroyed
During a descent, the aircraft stalled. The pilot lowered the nose and abruptly added power. The engines did not respond in time to regain altitude and airspeed. The aircraft then struck the water left-wing first.								
4/25/87*	Cessna 182G	NA	Groote Eylandt, Northern Australia, Australia	Unscheduled passenger	0	0	5	Destroyed
Shortly after takeoff, the engine sound changed. The pilot attempted to return to the landing strip, but the engine failed. The aircraft was ditched at low speed and floated in a 60-degree nose-down attitude. The pilot and passengers exited the aircraft, which sank and was not recovered.								
4/25/87	Piper PA-28-181	NA	Valley, Nebraska, U.S.	Personal	2	0	0	Destroyed
The aircraft struck power lines, then struck the Platte River. The wreckage came to rest in the main channel of the river in about 25 feet of water.								
4/28/87	Piper PA-18-135	NA	Greenville, Maine, U.S.	Personal	0	0	2	Destroyed
The pilot was conducting a takeoff from a lake in windy conditions. The aircraft stalled shortly after takeoff about 60 feet above the surface and struck the water.								
5/8/87	Cessna 337E	NA	San Juan, Puerto Rico, U.S.	Instructional	0	1	0	Substantial
During the base leg with flaps two-thirds extended, the aircraft entered an uncontrolled left bank, spun to the left, struck the ocean and sank in about 23 feet of water.								
6/5/87*	Piper PA-32-300	NA	Santa Barbara, California, U.S.	Instructional	0	0	3	Destroyed
During an ILS approach that was partially over water, the engine failed just after the final approach fix. The pilot ditched the airplane in the ocean about four miles west of the airport.								
6/6/87*	Lake LA-4-200	NA	Fife Lake, Michigan, U.S.	Personal	0	0	2	Substantial
The pilot said that the engine started to run roughly during cruise flight. Efforts to restore normal operation failed, and the pilot decided to conduct a precautionary ditching on Fife Lake. The aircraft landed normally, but the landing was followed by a loud noise, and water began to enter the cockpit. The aircraft sank in 25 feet to 30 feet of water. The pilot did not have a seaplane rating.								
6/12/87	Taylorcraft BC12-D	NA	Ketchikan, Alaska, U.S.	Personal	0	0	2	Destroyed
The pilot made a hard landing while attempting to land on smooth, glassy water. The landing-gear float rigging broke on impact, which allowed the aircraft to enter the water. The aircraft filled with water and sank.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
6/15/87*	Cessna 152	NA	Long Beach, California, U.S.	Instructional	0	0	2	Destroyed
The aircraft was ditched in the Pacific Ocean during a VFR instructional flight. The student pilot said that she was unable to open her door or unfasten her seat belt, although she was not injured. The instructor and the student pilot treaded water for about 15 minutes before they were rescued by a boat. Both pilots said that there were no flotation devices aboard the aircraft at the time of the accident.								
6/20/87*	Stinson 108-1	NA	Big Sandy Lake, Minnesota, U.S.	Personal	0	0	2	Substantial
The engine failed for undetermined reasons after the pilot made a wide-circle turn. During a ditching on a lake, the aircraft nosed over.								
6/22/87*	Cessna 310R	NA	Kailua, Hawaii, U.S.	Ferry	0	0	2	Destroyed
The no. 2 engine failed during cruise flight at 8,000 feet. The aircraft was unable to maintain altitude and was ditched in the ocean about 45 minutes later, about 500 nautical miles southwest of Hawaii.								
6/25/87*	De Havilland DHC-2	NA	Ketchikan, Alaska, U.S.	Positioning	0	0	1	Substantial
During the approach, the pilot advanced the throttle lever but the engine did not respond. The pilot could not see the runway and conducted a water landing with the landing gear down. During the landing, the aircraft flipped over.								
6/27/87	Cessna 180	NA	Bull Shoals, Arkansas, U.S.	Personal	0	0	4	Substantial
The pilot landed his airplane in a smooth-water cove and was taxiing across the lake when a strong wind lifted the right wing, and the left wing struck the water. The airplane capsized and sank.								
7/13/87	Champion 7EC	NA	Lake Monroe, Indiana, U.S.	Personal	0	0	2	Substantial
The copilot began a right turn at 200 feet to 250 feet. Then, he said, he "was not able to get the wing up, and by the time I realized we had a problem, there was not enough time or altitude to try to do anything." Reportedly, the aircraft settled and struck the water with its right wing, then sank. An investigation revealed that the aircraft had a history of leaking floats.								
7/13/87	De Havilland DHC-2 Beaver	Harbour Air	Witherby Point, British Columbia, Canada	Unscheduled passenger	0	0	5	Substantial
The aircraft was being turned onto final approach when it struck the water and nosed over. Life vests were available to the passengers but were not being worn at the time of the accident. The occupants could not remember how they got out of the aircraft, but recalled kicking and pushing the doors and windows. They were rescued by people in a nearby boat. The ELT activated when the aircraft struck the water but did not transmit because it was submerged in the water.								
7/18/87	Consolidated Vultee PBY5-A Canso	Government of Quebec	Lac Cache, Quebec, Canada	Training	1	0	1	Destroyed
The crew of the Canso water bomber was practicing touch-and-go landings as part of a periodic-training requirement. On the third landing, with the captain at the controls, the aircraft nosed down. The captain was ejected without serious injury as the aircraft broke up and sank. The copilot drowned.								
7/24/87*	Davis Starship Alpha	NA	Burley, Idaho, U.S.	Personal	0	0	1	Substantial
Engine power was lost after takeoff, at 100 feet AGL. Because of obstacles in the flight path, the pilot ditched the airplane in a river.								
7/29/87*	Piper PA-23-160	NA	St. Petersburg, Florida, U.S.	Instructional	0	0	2	Substantial
As part of the instruction, the instructor turned off fuel to the left engine. The student followed the correct procedures but could not restart the left engine, and the aircraft descended. The pilots could not reach the airport, so they ditched the aircraft in a bay.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/31/87	Lake LA-4-250	NA	Westport, New York, U.S.	Personal	0	1	2	Substantial
During the takeoff run on a lake, the amphibian encountered rough water and became airborne prematurely. The aircraft then settled onto the water in a slightly nose-high attitude and touched down in front of a large wave. The aircraft's nose encountered the wave head-on. Within seconds, the aircraft became inverted. The occupants exited through a window that had come out during the impact. The aircraft continued to float, although the cabin area was completely submerged.								
8/1/87	Piper PA-23-250	NA	Imperial, Texas, U.S.	Personal	1	2	3	Destroyed
Witnesses observed the aircraft being flown at a very low altitude over a reservoir before the aircraft struck the water. As the aircraft began to sink, five occupants exited. The sixth occupant had been killed.								
8/1/87	Piper PA-18S	NA	Brewster, Massachusetts, U.S.	Instructional	0	0	2	Substantial
The airplane stalled during an instructional flight, and there was insufficient altitude to recover airspeed. The aircraft struck the water in a wings-level attitude.								
8/2/87	Piper J3	NA	Vermillion Lake, Minnesota, U.S.	Personal	0	0	2	Substantial
While the pilot was attempting to return for landing after a loss of power, the right wing tip struck the water and the aircraft flipped upside down into the lake.								
8/7/87	Cessna 150M	NA	Newport Beach, California, U.S.	Personal	1	0	0	Substantial
On a dark night, the pilot conducted a low-altitude pleasure flight 0.25 mile offshore. The aircraft entered a gradual descent and struck the ocean, and the pilot drowned.								
8/14/87*	Piper PA-28-235	NA	Knoxville, Tennessee, U.S.	Personal	0	1	0	Substantial
The pilot reported that the engine failed during takeoff. He switched fuel tanks and tried to restart the engine but could not. The aircraft was ditched and sank in a river.								
8/18/87	Bellanca 8GCBC	NA	Martha's Vineyard, Massachusetts, U.S.	Commercial fishing	1	0	0	Destroyed
Attempting to herd fish into a net, the pilot placed his airplane in a dive, then pulled up abruptly. Witnesses heard a loud crack and observed the left wing collapse rearward. The airplane spun into the ocean.								
8/18/87*	Piper PA-28-140	NA	Aurora, North Carolina, U.S.	Personal	1	0	2	Destroyed
The pilot ditched the aircraft after the fuel supply was depleted. The pilot's failure to file a flight plan resulted in a delay of several hours in the search for the aircraft. There was no record that the pilot had declared mayday. The two passengers were rescued by a ferry boat about 13 hours after the accident.								
8/20/87*	Cessna 182P	NA	Highland Beach, Florida, U.S.	Personal	0	0	3	Substantial
The pilot said that the aircraft was at 1,000 feet about two miles offshore when the engine failed. He ditched the aircraft in the ocean about 40 feet from the beach.								
8/30/87*	Cessna 152	NA	Kapiti Island, New Zealand	Personal	NA	NA	NA	Destroyed
The engine failed after a negative-g pitch-over maneuver. The aircraft was ditched at sea but was not recovered.								
8/30/87*	Piper PA-25	NA	Myrtle Beach, South Carolina, U.S.	Business	0	0	1	Substantial
The pilot ditched the aircraft after the cabin filled with smoke and the engine began to lose power.								
8/31/87	Boeing 737	Thai Airways	Phuket, Thailand	Scheduled passenger	83	0	0	Destroyed
The aircraft was being flown on approach to Phuket at 3,000 feet. At the same time, another B-737 was on approach at 2,500 feet. The first aircraft suddenly pitched nose down and dived into the sea.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
9/11/87*	Piper PA-28-180	Newair Flight	Riverhead, New York, U.S.	Personal	1	0	1	Destroyed
Fuel exhaustion occurred while the aircraft was flown over the Long Island Sound. The pilot successfully ditched the aircraft, and both occupants exited the aircraft without injury. After some time in the water, they voluntarily separated, and one was rescued after being in the water for three hours. The other drowned.								
9/11/87	Partenavia P68C	NA	New Orleans, Louisiana, U.S.	Executive/ Corporate	0	1	0	Destroyed
While flying the airplane on a night ILS approach, the pilot perceived that the aircraft was over the end of the runway and he prepared to flare. About that time, the aircraft struck water, well short of the runway. As the aircraft sank, the pilot escaped through a hole in the windshield. He was found by passing fishermen. The pilot believed that he had a false perception of the runway location because of the reflection of lights off the calm lake water.								
9/19/87	Commonwealth 185/Beech 23	NA	St. Petersburg, Florida, U.S.	Personal	3	0	0	Destroyed
The pilot of the Commonwealth erroneously reported his position to the tower for landing instructions. He then failed to follow the instructions, and his airplane collided with the Beech 23 that was on downwind to land. Both aircraft fell into Tampa Bay about one mile east of the airport.								
9/26/87	Beech B35	NA	Kissimmee, Florida, U.S.	Personal	1	1	1	Destroyed
On takeoff, the left wing of the aircraft hit the top of a tree about 50 feet AGL. Subsequently, the aircraft struck a lake near the end of the runway.								
9/26/87*	Cessna 411	NA	North Atlantic Ocean	NA	0	0	2	Destroyed
The aircraft was ditched for unknown reasons 35 miles southeast of Cat Island on a flight to Freeport, Bahamas. The aircraft was not recovered, and attempts to contact the pilot and registered owner were unsuccessful.								
9/30/87	Beech 95-B55	NA	Manteo, North Carolina, U.S.	Personal	5	0	0	Destroyed
Witnesses observed the aircraft settle into the ocean during low-level cruise flight near a beach. An IFR flight plan had been filed, but no contact was made with ATC.								
10/11/87*	Falcon 20D	Drenair Jet Aviation	45 miles west of Iceland	Passenger/ferry	0	0	6	Destroyed
The aircraft was low on fuel, and the crew declared an emergency. After a loss of power, the aircraft was ditched in heavy seas as the aircraft disappeared in troughs behind waves. The passengers and crew launched and boarded a life raft and were rescued by a ship in less than two hours.								
10/12/87*	Piper PA-23-250	NA	St. Thomas, U.S. Virgin Islands	Personal	1	1	4	Substantial
After departure, the pilot reported to the tower that the airplane was returning because of a loss of left-engine power. He secured the engine and returned the airplane to land. On short final, the pilot was unable to extend the landing gear normally; instead, he conducted manual extension procedures and pumped the gear until it had extended. While on base leg and turning to final approach, the pilot told the tower that he was ditching the aircraft.								
10/30/87	Cessna 150E	NA	Aguadilla, Puerto Rico, U.S.	Personal	2	0	0	Destroyed
Witnesses saw the aircraft being maneuvered at low altitude over the ocean near a shoreline. They saw a pull-up over a boat dock, and then the aircraft struck the water in a nose-low, right-wing-low attitude. The aircraft sank in 30 feet of water.								
10/31/87*	Piper J5A	NA	Devil's Lake, North Dakota, U.S.	Instructional	0	0	2	Substantial
Witnesses saw the aircraft about 100 feet over a waterfowl-production lake. The pilot said that during a turn and pull-up, the engine failed, and the aircraft was ditched in the lake.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
11/4/87	Piper PA-32-260	NA	Fulton, Texas, U.S.	Business	2	0	0	Destroyed
The aircraft was flown from the airport in conditions of low ceiling and visibility with a student pilot and a passenger on board. Witnesses on the beach, about 0.5 mile from the airport, saw the aircraft strike the water in a right bank and disappear.								
11/9/87	Piper PA-28-161	NA	St. Petersburg, Florida, U.S.	Personal	0	0	2	Substantial
The aircraft touched down about 528 feet from the departure end of the runway, and as it approached the seawall, the pilot applied full-up elevator. The aircraft became airborne momentarily, flew over the seawall and landed in Tampa Bay in about 18 feet of water.								
11/12/87*	Mooney M20A	NA	Southport, North Carolina, U.S.	Personal	0	0	1	Substantial
The airplane lost engine power shortly after takeoff. The pilot ditched the airplane in a nearby waterway.								
11/12/87*	Cessna 172B	NA	Jamestown, California, U.S.	Sightseeing	0	0	2	Substantial
During a sightseeing flight over a lake, the pilot said that the engine failed. The pilot conducted an emergency landing on the lake, where the aircraft sank.								
11/15/87*	Cessna 172A	NA	Dayton, Ohio, U.S.	Personal	0	0	2	Substantial
The pilot said that the engine began to sputter and lose power shortly after takeoff. The pilot subsequently conducted a forced landing in a nearby river. The aircraft nosed over on landing and came to rest partially submerged in about four feet of water.								
11/17/87*	Cessna 150M	NA	Honolulu, Hawaii, U.S.	Aerial observation	0	0	1	Destroyed
The pilot said that the engine failed while he was flying the airplane low over the ocean on a fish-spotting flight. Subsequently, he ditched the airplane in the ocean.								
11/20/87	Cessna A185F	NA	Silvan Reservoir, Victoria, Australia	Personal	2	0	1	Substantial
Lacking low-level flight training, the pilot made an unauthorized low-level flight and misjudged the altitude over a glassy-water surface. The aircraft struck the water. The pilot was fatigued and impaired by alcohol.								
11/22/87*	Bellanca 8GCBC	NA	San Diego, California, U.S.	Towing	0	0	1	Destroyed
As the pilot was completing a banner-towing flight, the aircraft's engine failed, and the cockpit filled with smoke. The pilot released the banner, and ditched the aircraft in rough water.								
11/25/87	Beech H35	NA	Port Mansfield, Texas, U.S.	Personal	3	0	0	Destroyed
The aircraft struck Laguna Madre in about a 10-degree nose-down attitude.								
11/27/87	Cessna 208A	NA	Haumuri Bluffs, New Zealand	Scheduled cargo	2	0	0	Destroyed
The aircraft, on a scheduled night flight from Christchurch, New Zealand, to Wellington, New Zealand, continued to fly in icing conditions at 11,000 feet until it stalled and spun into the sea.								
11/28/87	Boeing 747	South African Airways	Mauritius	Scheduled passenger	159	0	0	Destroyed
A Boeing 747-244B Combi of South African Airways departed from Taipei (Taiwan, China) Chiang Kai-Shek Airport for Mauritius' Plaisance Airport. In the main deck cargo hold, six pallets of cargo had been loaded. Some nine hours out and some 46 minutes before the estimated time of arrival at Plaisance, the flight deck informed the approach control at Plaisance that there was a smoke problem in the airplane and that an emergency descent to FL 140 had begun. The last radio communication was at 00:04. About 00:07, the airplane struck the sea. A fire in the right hand front pallet in the main deck cargo hold led to the accident.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
11/29/87	Boeing 707	Korean Air	Andaman Sea	Scheduled passenger	115	0	0	Destroyed
The flight crew last reported the aircraft's position while flying over Burma. There was no further contact with the crew. The main wreckage was not found, but one partially inflated life raft was retrieved from the Andaman Sea. The life raft later was identified as the 25-person life raft installed at the no. 2 storage compartment in the forward cabin. The event was a result of an in-flight explosion caused by terrorist sabotage.								
12/8/87	F27	Peruvian Military	Lima, Peru	Unscheduled passenger	42	1	0	Destroyed
The crew of the aircraft, being flown on a civil charter flight, conducted a low fly-by to have a possible landing-gear malfunction inspected from the ground. After ATC said that the landing gear appeared to be extended, the aircraft was being positioned for another landing approach when it struck the sea six miles northwest of Lima.								
12/18/87	Beech 58	NA	Wedron, Illinois, U.S.	Cargo	1	0	0	Destroyed
The airplane struck trees and descended out of control into a river while the crew attempted a night emergency landing after the airplane's fuel supply was depleted. The airplane was found under water on the fifth day of a search, after two boys found debris from the airplane on the river bank.								
12/21/87*	Douglas DC-6	Aeronica	Northern Costa Rica	Unscheduled cargo	0	0	6	Destroyed
During cruise, the crew heard an explosion and saw that the no. 3 engine had separated. Following a fire warning on the no. 4 engine, the crew attempted to extinguish the fire. They tried unsuccessfully to feather the propeller. The pilot decided to unload the cargo and ditch the aircraft in a river. The crew then evacuated the aircraft.								
1/10/88	Nikkon Aeroplane YS-11	Toa	Miho, Japan	Scheduled passenger	0	0	52	Substantial
The copilot, at the controls, found the elevator control too heavy to rotate the aircraft and rejected the takeoff. The aircraft overran Runway 25 and dropped into the sea.								
1/16/88*	Pitts S-2A	NA	Portsea, Victoria, Australia	Personal	1	0	1	Destroyed
The aircraft collided with another aircraft. The pilot was able to gain some control before ditching.								
2/11/88	Fairchild Metro SA226TC Metro II	Air Niagara Express	Hamilton, Ontario, Canada	Ferry	2	0	0	Destroyed
While on a long final approach at Hamilton, the aircraft suddenly disappeared from radar and all contact with the flight was lost. The aircraft was later found to have struck the water of Lake Ontario about 10 miles short of the runway.								
2/18/88	Beech S35	NA	Lake Charles, Louisiana, U.S.	Business	2	0	0	Destroyed
The aircraft struck a lake shortly after being vectored onto the final approach. No evidence of mechanical malfunction or abnormal trim settings was found on the aircraft during the investigation. Local ornithologists said that large flocks of birds were known to be airborne at the time of the accident.								
2/18/88	Piper PA-28-161	NA	Stuart, Florida, U.S.	Personal	3	0	0	Destroyed
The pilot said that he was having a problem with weather and wanted to turn the airplane to the south. The controller gave the pilot a vector and told him to maintain VFR. The pilot replied that he was not in visual conditions and asked if the controller wanted him to climb. The controller told the pilot that he could climb at his discretion. Soon afterward, radar contact with the aircraft was lost and the aircraft struck the ocean.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
2/19/88	Piper PA-34-200T	NA	Stratford, Connecticut, U.S.	Unscheduled	2	0	0	Destroyed
The pilot and pilot-rated passenger received vectors for multiple ILS approaches in deteriorating weather conditions. On the first attempt, the aircraft was off course and not in a position to land. The second attempt was rejected before the aircraft reached the airport. During the third attempt, radar service was terminated, and the pilot was given a frequency change. The aircraft struck water about one mile from the runway.								
2/19/88	Fairchild Metro SA227AC Metro III	AV Air	Raleigh-Durham, North Carolina, U.S.	Scheduled passenger	12	0	0	Destroyed
The aircraft was flown into the waters of a reservoir shortly after takeoff. The accident happened at night in poor weather.								
3/13/88*	Cessna P210N	NA	Outer Harbour, South Australia, Australia	Personal	1	0	4	Destroyed
The pilot declared mayday when the engine failed over open water because of fuel exhaustion. The aircraft was ditched.								
3/27/88	Cessna 172RG	NA	Malibu, California, U.S.	Aerial observation	0	0	2	Destroyed
The flight's purpose was to enable the passenger to photograph yachts sailing off the Malibu coast. The pilot said that he initiated a turn at 300 feet AGL and the aircraft stalled and struck the water.								
4/1/88	Cessna 150J	NA	Guntersville, Alabama, U.S.	Personal	0	0	1	Substantial
The airplane was in a gradual right turn about 100 feet above the water when a large spider dropped in front of the pilot and distracted him. The pilot attempted to swat the spider and inadvertently allowed the airplane to descend into the water. The airplane flipped over and came to rest inverted. The pilot exited the airplane as it sank; he was rescued by a fisherman.								
4/18/88*	Beech 23	NA	Brighton, Michigan, U.S.	Personal	0	0	4	Substantial
During a go-around, engine power decreased and the airplane descended. The aircraft struck the top of a large tree and then contacted a smaller tree before descending into the lake. The pilot and passengers exited the aircraft before it sank.								
4/23/88	Hernandez Thorp T-18	NA	Palos Verdes, California, U.S.	Personal	2	0	0	Destroyed
The aircraft was being demonstrated for a prospective buyer. Witnesses reported observing the aircraft in a dive toward the water. Aircraft debris was found on the beach.								
4/27/88	Champion 7KCAB	NA	Dracut, Massachusetts, U.S.	Personal	0	0	1	Substantial
The pilot said that while he was making a normal approach for a glassy-water landing on a lake, he flared the aircraft high, and it stalled with the right wing low before striking the water.								
5/24/88	Boeing 737-300	TACA International Airlines	Rio de Janeiro, Brazil	Ferry	0	0	2	Destroyed
The aircraft apparently undershot the runway while on approach to Santos Dumont Airport, touching down in Guanabara Bay some 500 meters short of the runway threshold.								
5/24/88	Cessna 320F	NA	San Angelo, Texas, U.S.	Instructional	0	1	1	Substantial
A touch-and-go landing was being performed by the left-seat pilot, who was receiving instruction. As power was added, the aircraft drifted to the right despite the application of full-left rudder. The PIC did not discontinue the takeoff because he believed that the swerve was pilot-induced or a result of mismatched throttle-lever settings. The PIC took control of the airplane at rotation, but the aircraft rolled left. The PIC feathered the left propeller, and the airplane stalled and struck a lake.								
5/27/88	Cessna 150K	NA	Gary, Indiana, U.S.	Personal	0	0	1	Destroyed
The pilot was flying the airplane 150 feet above the water along the shoreline. The pilot's attention was diverted from flying the airplane by navigation duties, and he failed to maintain sufficient visual lookout. The airplane entered an unnoticed gradual descent, struck the water and sank.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

<table>
<tr><th rowspan="2">Date: Month/Day/ Year</th><th rowspan="2">Aircraft</th><th rowspan="2">Operator</th><th rowspan="2">Location</th><th rowspan="2">Nature of Flight</th><th colspan="3">Injury to Occupants</th><th rowspan="2">Damage to Aircraft</th></tr>
<tr><th>Fatal</th><th>Serious</th><th>Minor/ None</th></tr>
<tr><td>5/27/88</td><td>Beech A-23-19</td><td>NA</td><td>Big Island, Arkansas, U.S.</td><td>Personal</td><td>1</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">The pilot suffered an incapacitating medical event that resulted in loss of aircraft control during the initial segment of the takeoff. The aircraft struck the Mississippi River and sank to a depth of about 12 feet. Autopsy findings listed the cause of death as "drowning in association with arteriosclerotic heart disease."</td></tr>
<tr><td>5/28/88</td><td>Cessna 172K</td><td>NA</td><td>Bismark, Missouri, U.S.</td><td>Personal</td><td>0</td><td>1</td><td>0</td><td>Substantial</td></tr>
<tr><td colspan="9">The accident aircraft was observed in several low passes over Lake Bismark. Witnesses said that, following the last pass, the aircraft struck the water and sank. The pilot's blood alcohol content was 0.14 percent.</td></tr>
<tr><td>6/28/88</td><td>Champion 7GCB</td><td>NA</td><td>Fairbanks, Alaska, U.S.</td><td>Personal</td><td>0</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">During takeoff, the 70-hour private pilot conducted the liftoff prematurely. The pilot banked the airplane to the right, then overcorrected by banking to the left. The airplane stalled, pitched down and struck an adjacent seaplane pond.</td></tr>
<tr><td>7/1/88</td><td>Rockwell 112A</td><td>NA</td><td>Sandusky, Ohio, U.S.</td><td>Personal</td><td>0</td><td>1</td><td>0</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot reported that the landing airspeed was fast and that the aircraft bounced on touchdown. Directional control of the aircraft was lost. The pilot attempted a go-around and applied partial power. The aircraft struck a tree during climbout and came to rest in a bay.</td></tr>
<tr><td>7/2/88*</td><td>Cessna 152</td><td>NA</td><td>Marathon, Florida, U.S.</td><td>Instructional</td><td>0</td><td>0</td><td>1</td><td>Substantial</td></tr>
<tr><td colspan="9">The student pilot was on his first solo cross-country flight. While he was flying the airplane over the Gulf of Mexico, the engine failed. The pilot ditched the airplane near a small boat and believed that its occupants had observed the ditching. The boat was sailed away. The pilot had declared mayday before the ditching and was rescued by the Coast Guard shortly afterward.</td></tr>
<tr><td>7/10/88</td><td>Champion 7GCB</td><td>NA</td><td>Staten Island, New York, U.S.</td><td>Banner towing</td><td>0</td><td>0</td><td>1</td><td>Destroyed</td></tr>
<tr><td colspan="9">The pilot said that after flying the airplane into a thunderstorm, he encountered strong turbulence, heavy downdrafts and rain, which forced the airplane into the water.</td></tr>
<tr><td>7/16/88</td><td>Lake LA-4-200</td><td>NA</td><td>Candlewood Lake, Connecticut, U.S.</td><td>Personal</td><td>0</td><td>0</td><td>3</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot said that he discontinued the takeoff because a person on a jet ski was in the way. As the pilot tried to turn the aircraft to the right, a wing dug into the water and the aircraft "water looped." The pilot and two passengers were rescued by boaters, and the aircraft sank within 15 seconds.</td></tr>
<tr><td>7/17/88*</td><td>Cessna 150K</td><td>NA</td><td>Dana Point, California, U.S.</td><td>Aerial observation</td><td>0</td><td>0</td><td>2</td><td>Destroyed</td></tr>
<tr><td colspan="9">During a fish-spotting operation, the engine began to run roughly and to vibrate. The engine then failed completely, and the airplane was ditched in the ocean.</td></tr>
<tr><td>7/17/88</td><td>Beech 95</td><td>NA</td><td>Destin, Florida, U.S.</td><td>Personal</td><td>2</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">The pilot received clearance for a visual approach. Witnesses saw the aircraft on left downwind and said that it was flown into a thundershower. The pilot was not heard from again. The aircraft wreckage was found in the bay 1.25 miles north of the runway. Examination showed that the aircraft had struck the water with its left wing low.</td></tr>
<tr><td>7/20/88</td><td>Cessna 180K</td><td>NA</td><td>Eastsound, Washington, U.S.</td><td>Positioning</td><td>0</td><td>0</td><td>1</td><td>Destroyed</td></tr>
<tr><td colspan="9">While the aircraft was in cruise flight 200 feet over the water, the pilot looked down to get a chart that was under his seat. As he did, the aircraft descended and struck the water.</td></tr>
<tr><td>7/24/88*</td><td>Piper PA-28-151</td><td>NA</td><td>La Grange, Georgia, U.S.</td><td>Personal</td><td>0</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot said that a hardover in the single-axis autopilot caused the aircraft to constantly bank right. Because of the continuous bank, he conducted a precautionary ditching in a lake.</td></tr>
<tr><td>7/25/88</td><td>Cessna U206F</td><td>NA</td><td>Lake Minchumina, Alaska, U.S.</td><td>Personal</td><td>1</td><td>1</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot was taxiing the floatplane from a windy, wavy location to a small protected cover for a final preflight. While he taxied the aircraft, the top cap of the left float was open and the float began filling with water. Subsequently, the floatplane rolled over and sank.</td></tr>
</table>

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
7/28/88	Piper PA-18	NA	Forsyth, Montana, U.S.	Aerial observation	0	0	1	Substantial
Flying the airplane toward the setting sun at low altitude, the pilot did not see the power lines ahead until there was insufficient time to take evasive action. The aircraft struck three cables about 30 feet AGL and fell into a river. The pilot exited and clung to the aircraft until he was rescued.								
7/30/88*	Cessna 172L	NA	North Kingston, Rhode Island, U.S.	Personal	0	0	3	Substantial
After several approaches to different airports, all of which were unsuitable because of weather conditions, the pilot was receiving vectors to Providence, Rhode Island. Fuel exhaustion forced the pilot to ditch the aircraft in Narragansett Bay.								
8/7/88*	Ryan Navion	NA	Cumming, Georgia, U.S.	Personal	0	0	2	Substantial
Because of heavy rain over the destination airport, the pilot diverted to an alternate. On the way to the alternate, the engine failed from fuel starvation, and the pilot ditched the airplane in Lake Lanier.								
8/12/88	Cessna TU206G	NA	White Lake, New York, U.S.	Personal	2	0	0	Substantial
The pilot of the float-equipped aircraft conducted multiple takeoff attempts on a lake. On the final takeoff run, after the aircraft became airborne, the pilot flew it into an inlet with insufficient room to turn around. The pilot began a left turn, and the airplane was observed to strike the water in a nose-low, left-wing-low attitude. Rescuers removed both occupants from the submerged aircraft within 10 minutes after the accident. Both occupants wore seat belts without shoulder harnesses. The aircraft was more than 80 pounds over maximum gross weight at takeoff.								
8/26/88*	Piper PA-28R-200	NA	Gary, Indiana, U.S.	Business	0	0	1	Destroyed
While the aircraft was in cruise flight over Lake Michigan at night, oil pressure was lost, followed by an engine failure. The pilot performed emergency procedures and prepared for a ditching. He was able to glide the aircraft to shore, but because of "industrial terrain" along the shoreline, he decided to ditch the aircraft in Lake Michigan near the shore. After the ditching, the pilot exited the aircraft and swam to a breakwater. He was rescued about five hours later and was treated for hypothermia.								
8/28/88*	American AA-1A	NA	Fairhope, Alabama, U.S.	Personal	0	0	2	Substantial
The pilot said that the engine failed without warning as he and his passenger were flying the airplane over water near the shore at 500 feet. He performed emergency procedures and regained partial power but not enough to continue flight. He maneuvered toward the shore, then ditched the aircraft to avoid obstructions and people on the beach.								
8/31/88	Trident 2E	CAAC	Hong Kong	Scheduled passenger	7	13	69	Destroyed
The aircraft was being flown on an approach in heavy rain when the right outer flap struck an approach light and the right-main landing gear struck the runway lip. A tire burst, and the right-main landing gear was torn away. When the aircraft bounced, the right wing struck the ground, and the aircraft left the runway to the right, slewed and came to rest in water just off the runway. The flight deck area was half detached and submerged. Most passengers evacuated in the first 10 minutes.								
9/4/88	Cessna 172P	NA	Boyne City, Michigan, U.S.	Aerial observation	1	1	0	Destroyed
The pilot and passenger were flying the airplane low over a sailboat regatta to photograph sailboats. Maneuvering the airplane for a photograph, the pilot reduced power and banked the aircraft steeply. The aircraft stalled with insufficient altitude to recover. The aircraft struck the water in a left-wing-low, nose-down attitude and sank almost immediately. The passenger escaped with a serious injury. He tried to help the pilot, but the pilot had received a fatal head injury.								
9/4/88	Cessna 172E	NA	Petersburg, Alaska, U.S.	Personal	4	0	0	Destroyed
The pilot received a weather briefing for marginal VMC. Witnesses to the departure observed a fog bank offshore from the airport. Witnesses near the accident site, 10 miles from the airport, heard the aircraft and sounds of impact. They reported fog on the water and glassy-water conditions.								
9/26/88	B-737	Aerolineas Argentinas	Ushuaia, Argentina	Scheduled passenger	0	0	62	Substantial
The aircraft was landed with excessive speed and touched down three-quarters of the way along the runway. About 200 meters before the end of the runway, the aircraft veered left, overran the runway and descended a five-meter escarpment before coming to rest in the sea, partially submerged.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/30/88	Bellanca 14-13-2	NA	Sodus Bay, New York, U.S.	Personal	0	0	4	Substantial
While on a low-level pleasure flight over water, the pilot failed to maintain adequate terrain clearance, and the left wing contacted the water. The aircraft struck the water and remained upright. The pilot and passengers exited the aircraft and were rescued by occupants of a passing boat.								
10/6/88*	Piper PA-23-250	NA	La Belle, Florida, U.S.	Ferry	0	0	1	Substantial
During the ferry flight, the no. 4 cylinder of the left engine failed, and the airplane began to descend. The pilot ditched the aircraft in a lake.								
10/6/88*	Republic RC-3	NA	Miami, Florida, U.S.	Personal	0	0	4	Substantial
The pilot was having difficulty with the elevator trim and decided to land the amphibious aircraft in the bay. He lowered the landing gear before attempting to land on the water. The aircraft flipped inverted upon touchdown.								
10/28/88	Piper PA-34-200	NA	Ocean City, Maryland, U.S.	Personal	3	0	0	Destroyed
Witnesses observed the aircraft about two miles north of the destination airport at an altitude of about 600 feet AGL. They observed the aircraft as it was flown across the shoreline and over water. Witnesses said that the aircraft began descending after a turn to the south; the descent continued until the aircraft struck the water.								
10/31/88	Piper PA-28-181	NA	Alexander City, Alabama, U.S.	Personal	1	0	0	Substantial
The pilot reported a loss of engine power. He received vectors toward an airport, but radar contact was lost. On Nov. 16, 1990, the aircraft was found in 65 feet of water in Martin Lake.								
11/1/88	Douglas DC-3	Air Ontario	Pikangikum Lake, Ontario, Canada	Cargo	2	1	0	Destroyed
The aircraft was heard as it was flown over the town, then sounds of an accident were heard. The DC-3 was later found to have struck the lake.								
11/1/88	Piper PA-31/A1	NA	Stanwell Park, New South Wales, Australia	Drogue towing	3	0	0	Destroyed
The pilot declared mayday and said that the aircraft had an engine problem. Shortly afterward, the aircraft struck the sea.								
11/12/88*	Cessna 337E	NA	Kahului, Hawaii, U.S.	Ferry	0	0	1	Destroyed
The pilot shut down the rear engine because it was running roughly and oil temperature was too high. Subsequently, the front engine failed. The pilot, unable to restore power to either engine, ditched the airplane in the ocean.								
11/22/88*	Piper PA-28-181	NA	Palmyra, New York, U.S.	Personal	0	0	3	Substantial
The pilot said that the airplane lost power because of fuel exhaustion. He ditched the aircraft in a canal, and the pilot and the two passengers swam to shore.								
11/28/88	Piper PA-28-180	NA	Atlantic Ocean	Personal	1	0	0	Destroyed
The student pilot filed an international flight plan to the Bahamas. He did not request a weather briefing, and none was given. The pilot later contacted ATC, said that the aircraft was in IMC and requested assistance. ATC located the aircraft on radar and attempted to assist the pilot, but the aircraft disappeared from radar over the Atlantic Ocean and there was no further contact with him.								
12/5/88	De Havilland DHC-2	NA	Bundaberg, Queensland, Australia	Instructional	3	0	0	Destroyed
The aircraft sustained severe damage to the right float, wings and cockpit area, consistent with striking the water in a right-wing-low attitude and then overturning. The accident may have been caused by control difficulties in an excessive crosswind.								
12/21/88	Cessna 310L	NA	Cedar Key, Florida, U.S.	Business	2	0	0	Destroyed
An in-flight fire burned through a fuel-crossfeed line that could not be shut off by the pilot. The aircraft struck water in a left-wing-low attitude.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
12/21/88	Piper PA-24-250	NA	Elephant Butte, New Mexico, U.S.	Personal	1	0	0	Destroyed
During a return flight after having maintenance performed on the aircraft, the pilot flew the airplane in a low pass near his home, which was located on a point of land overlooking Elephant Butte Reservoir. During the maneuver, while in a steep turn, the left wing struck the water and separated from the aircraft. The aircraft cartwheeled and sank. Weather was VMC, and the water surface was smooth and glassy.								
12/27/88*	Cessna 172H	NA	Hot Water Beach, New Zealand	Personal	NA	NA	NA	Substantial
During a flight at 250 feet above the sea, the aircraft's engine failed. The aircraft was ditched successfully. The engine was not recovered.								
1/15/89	Mooney M20	NA	Malmo, Minnesota, U.S.	Personal	0	1	1	Destroyed
The non-instrument-rated pilot inadvertently flew the aircraft into IMC in whiteout conditions. He lost control of the aircraft, which struck a frozen lake.								
2/4/89*	Stolp-Adams SA 100	NA	Indian Rocks, Florida, U.S.	Personal	0	0	1	Substantial
While the pilot was performing inverted aerobatic maneuvers near the coastline, the engine (which did not have an inverted fuel system or inverted oil system installed) failed because of fuel starvation. Unable to restart the engine, the pilot ditched the aircraft near the shore.								
2/6/89	Vickers 950 Vanguard	Inter Ciel Service	Marseille, France	Scheduled cargo	3	0	0	Destroyed
On takeoff, the aircraft was flown to about 50 feet before descending and striking the waters of Etang de Berre close to the end of the runway. This was reportedly the aircraft's second takeoff attempt, the first having been rejected for unspecified reasons.								
2/11/89*	Cessna 172M	NA	San Juan, Puerto Rico, U.S.	Personal	0	0	3	Substantial
Shortly after takeoff, about 500 feet above the airport, the pilot reported that the engine failed. Unable to return to the airport for landing, he ditched the aircraft.								
2/14/89*	Piper 31-350	Southern Cross Aviation	Pacific Ocean	Ferry	0	0	1	Destroyed
During cruise flight, the right engine suddenly lost oil pressure. The pilot shut down the engine, but because of high gross weight, the aircraft was unable to maintain altitude on the one remaining engine. The aircraft was ditched in the ocean and was not recovered.								
2/28/89	Mitsubishi MU-2B-20F	NA	San Diego, California, U.S.	Public use	1	0	0	Destroyed
Radar data showed that the aircraft descended from 22,500 feet and struck the ocean. No distress calls were made.								
3/1/89*	Douglas DC-3	NA	Isla Verde, Puerto Rico, U.S.	Unscheduled cargo	0	0	2	Substantial
On base leg, the left engine failed. The pilot retracted the landing gear but did not feather the propeller. The right engine did not respond immediately. The pilot could not maintain altitude and ditched the airplane in a lagoon two miles from the airport.								
3/4/89*	John C. Corby CJ-1	NA	Rottnest Island, Western Australia	Personal	0	0	1	Substantial
While the pilot performed turning stalls, the aircraft's engine failed. The pilot could not restart the engine and ditched the aircraft in the bay.								
3/8/89*	Piper PA-32-300	NA	Atlantic Ocean	Ferry	1	0	0	Destroyed
The pilot was ferrying the airplane from St. Johns, Newfoundland, Canada, to Shannon, Ireland. The area controller received a distress call from the pilot, who reported an engine problem and said that he was preparing to ditch. Eleven aircraft and two surface vessels searched the area, but neither the pilot nor the aircraft was found. The pilot was presumed to have died from injuries or drowning after ditching the aircraft in heavy sea conditions.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
3/12/89	Piper PA-28-161	NA	New Orleans, Louisiana, U.S.	Personal	4	0	0	Destroyed
The aircraft struck water about 4,000 feet beyond the departure end of the runway. The accident report said that the probable cause was that the pilot diverted his attention from flying the aircraft while complying with departure control instructions and allowed the aircraft to descend into the water.								
3/16/89	Beech H35	NA	Knoxville, Tennessee, U.S.	Personal	2	0	0	Substantial
An air-oil separator kit had just been installed on the airplane, reportedly by uncertified maintenance technicians. The airplane was observed to land on the river, short of the airport. Both occupants exited the airplane and swam toward shore. The pilot reached the shore but swam back out to help his passenger. Water temperature was 48 degrees Fahrenheit. Both bodies were recovered later.								
3/24/89	Piper PA-38-112	NA	Mayflower, Arkansas, U.S.	Personal	2	0	0	Substantial
The student pilot and his student-pilot-rated passenger were flying the airplane low over the Arkansas River, as observed by witnesses. The witnesses said that the aircraft was flown directly overhead and was pulled up sharply into a climb. At the top of the climb, the right wing stalled and the aircraft descended rapidly, nose-down, and struck the water. The aircraft rapidly sank in 30 feet of water.								
3/25/89	Bellanca 7KCAB	NA	Daytona Beach, Florida, U.S.	Banner towing	1	0	0	Destroyed
While being flown offshore southbound at 300 feet to 400 feet, the pilot of the banner-towing Bellanca passed another banner-towing aircraft to the right. The pilot initiated a "very tight" right turn to return northbound. While descending eastbound with the banner attached, the main landing gear struck a wave, causing the aircraft to nose into the water.								
3/28/89	Cessna 172	NA	Santa Barbara, California, U.S.	Personal	1	0	0	Substantial
The student pilot said that he was flying the airplane toward the water at 400 feet per minute to 600 feet per minute when the engine backfired. He said that he applied carburetor heat, but the engine continued to run roughly and produced only 1,200 rpm. He flew the airplane at this power setting for a mile or more, just above the water, and struck the tops of waves at times. Then the wheels struck the water and the airplane bounced and nosed into the water.								
4/2/89	Piper 601B	NA	Wollongong, New South Wales, Australia	Unscheduled passenger	1	0	0	Destroyed
The pilot was flying the aircraft in heavy rain and low clouds to Wollongong to pick up charter passengers. The aircraft and pilot were lost at sea and were not recovered.								
4/8/89*	Beech F-33A	NA	Reddington Beach, Florida, U.S.	Instructional	0	0	2	Substantial
The instructor pilot and the rated pilot/owner were flying the aircraft during a dual instrument-training flight when the engine failed. They both attempted engine starts but were unsuccessful. They ditched the airplane.								
4/29/89*	Beech 35	NA	Daytona Beach, Florida, U.S.	Personal	0	0	2	Substantial
During normal cruise flight just offshore, the engine failed. The pilot ditched the aircraft in 10 feet of water.								
5/2/89	Douglas DC-3	NA	Summerland Key, Florida, U.S.	Aerial application	2	0	0	Destroyed
When the aircraft did not return from a routine spraying flight, the Coast Guard initiated a search. The aircraft was located in the water near Summerland Key about nine hours later.								
5/9/89	Piper PA-44-180	FlightSafety International	Fort Pierce, Florida, U.S.	Instructional	3	0	0	Destroyed
The aircraft's ground speed slowed to 37 knots, which resulted in an inadvertent stall and spin and subsequent loss of engine power, possibly because of interruption of fuel supply. The aircraft then struck the ocean.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/None	Damage to Aircraft
5/22/89	Britten Norman BN-2A-26	NA	Derby, Western Australia, Australia	Unscheduled passenger	0	2	1	Substantial
The aircraft was flown in two low passes over a boat. The aircraft was banked right, and the right wing tip struck water. The aircraft cartwheeled and crashed in the water, its fuselage breaking apart on impact. The pilot and passengers surfaced 400 meters from the boat and were rescued by the boat crew.								
5/23/89	Cessna 180	NA	Green Island, Alaska, U.S.	Unscheduled passenger	0	1	2	Substantial
The float-equipped airplane flipped over while landing. The pilot believed that the airplane may have inadvertently encountered a boat's wake. A crewmember from a nearby boat dived into the water and helped the pilot and passengers to escape.								
5/27/89	Mooney M20J	NA	Big Pine Key, Florida, U.S.	Personal	2	0	0	Destroyed
The aircraft was being flown in a normal descent until, according to radar data, the aircraft's heading began to change constantly, and the aircraft began to climb and descend. After these maneuvers had continued for about four minutes, contact with the aircraft was lost, and search-and-rescue effects were begun. An oil slick was found near the aircraft's last known position. A Coast Guard ship recovered debris from the aircraft, but the aircraft's main wreckage and the occupants were not located.								
5/28/89	Cessna 172M	NA	Oakland, Arkansas, U.S.	Personal	0	2	0	Substantial
The accident aircraft was seen at a very low altitude over a lake. Witnesses said that the pilot rocked the wings several times, as if waving to someone on the lake. The aircraft struck wires about 45 feet above the lake surface. Aircraft control was lost, and the aircraft struck the lake.								
5/29/89	De Havilland DHC-2	NA	Angoon, Alaska, U.S.	NA	1	0	0	Substantial
The pilot landed the amphibious aircraft on water with the wheels extended, and the aircraft flipped over to an inverted position.								
6/3/89	Stinson 108-2	NA	Wasilla, Alaska, U.S.	Personal	1	0	0	Substantial
Immediately after takeoff from the water, the pilot conducted a low-altitude steep left turn, which resulted in a stall and a spin into the lake.								
6/10/89*	Piper PA-24	NA	Naked Island, Alaska, U.S.	Personal	0	0	2	Destroyed
After an engine failure, the pilot ditched the aircraft in Prince William Sound near Naked Island. The pilot and passenger were rescued by occupants of a nearby boat and were treated for hypothermia.								
6/11/89*	Cessna 150L	NA	Alexander River, Alaska, U.S.	Personal	0	0	2	Substantial
The airplane was landed long on an unimproved landing strip. It touched down hard, and the propeller struck the ground. A go-around was attempted, but there was insufficient thrust from the damaged propeller. The pilot intentionally swerved the airplane into the adjacent river to avoid people and equipment on the far end of the landing strip.								
6/17/89	Cessna 150M	NA	Knoxville, Tennessee, U.S.	Instructional	0	0	1	Substantial
The student pilot, making a practice solo flight, discontinued the takeoff after she observed the instruments indicating that the engine was not developing full power. The airplane veered off the runway and continued over the grass surface into the river and lake surrounding the airport.								
6/19/89*	Ercoupe 415C	NA	Canaan, Connecticut, U.S.	Personal	0	0	2	Substantial
The pilot was flying the airplane back to its departure airport when the engine failed. The pilot could not land the airplane on a highway because trees were in the flight path, so he ditched in a lake.								
6/26/89*	Douglas DC-3	NA	Petersburg, Alaska, U.S.	Positioning	0	0	2	Substantial
On takeoff, the pilot experienced loss of aileron control. He could not fly the airplane back to the airport for landing and ditched the aircraft eight kilometers south of Petersburg. The aircraft had not undergone a current annual inspection and was being flown on a ferry permit.								
6/28/89	Cessna U206	NA	Eveleth, Minnesota, U.S.	Personal	1	0	0	Substantial
Witnesses observed the aircraft bounce hard on the first landing attempt on Ely Lake and then settle right-wing-low and right-float-low and strike the water again. During the subsequent water strike, the aircraft flipped inverted. The pilot had not maintained currency in the aircraft.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/4/89	Cessna 180	NA	Port Alsworth, Alaska, U.S.	Personal	0	0	3	Substantial
The engine failed on final approach. After hitting the water, the airplane flipped inverted.								
7/5/89	De Havilland DHC-2 MK 1	NA	Cape Richards, Queensland, Australia	Nonscheduled passenger	0	0	7	Destroyed
During takeoff, the overweight aircraft's right float hit a wave, causing the left wing to strike the water and the aircraft to cartwheel.								
7/9/89	Pitts S-1	NA	Butler, Tennessee, U.S.	Personal	0	0	1	Substantial
During an aerobatic maneuver, the pilot did not maintain clearance from the water surface, and the aircraft was flown into the lake.								
7/13/89	Piper PA-28	NA	Naknek, Alaska, U.S.	Personal	0	0	1	Substantial
The student pilot reported that during takeoff, the airplane was flown to 100 feet AGL, then stalled. The airplane struck a lake near the departure end of the runway.								
7/13/89	Cessna 210N	NA	Atlantic Ocean	Personal	0	1	0	Destroyed
The pilot told ATC that he was having a "little trouble breathing." Military aircraft in the area were vectored to intercept and escort the airplane. The intercepting pilots observed a person in the aircraft with his head back in a reclining position and moving very little. Aircraft speed slowed, and the aircraft began descending and then entered a descending spiral. The aircraft touched down in the ocean in a wings-level attitude. After stopping, the aircraft sank, but rescue personnel retrieved the pilot. He was in shock with a gunshot wound in his abdomen, rib cage and left arm. He was hospitalized with indications of fully developed peritonitis.								
7/16/89*	Piper PA-32-300	NA	Luquillo, Puerto Rico, U.S.	Business	0	0	2	Substantial
While flying the airplane over the ocean, the pilot smelled something burning. Shortly afterward, the engine failed. The pilot glided the aircraft to about 0.5 mile from shore, then ditched it in the ocean.								
7/24/89	Piper PA-28-161	NA	Stonington, Connecticut, U.S.	Personal	0	1	1	Destroyed
The pilot said that after takeoff, when the aircraft had reached 200 feet MSL, he suddenly realized that the fog was denser than he had expected. He said that he experienced vertigo and lost control of the aircraft, which hit the tops of trees and then struck the Pawcatuck River. As the aircraft sank, the occupants exited and swam to a dock.								
7/31/89	Allison Convair 340/580	Air Cargo NZ	Auckland, New Zealand	Scheduled cargo	3	0	0	Destroyed
After an apparently normal takeoff on a dark, drizzly night, the aircraft climbed, then descended and struck an airport boundary embankment in nearly level attitude. The aircraft broke apart after striking water in an adjacent harbor.								
8/3/89	Cessna 172	NA	Apalachicola, Florida, U.S.	Aerial observation	0	0	1	Destroyed
While returning from a fish-spotting trip, the pilot flew the airplane at an altitude of about 50 feet. The aircraft was flown into the water about 1,500 feet from the shore. During the impact, the pilot's seat belt failed, and he was ejected from the aircraft, which sank.								
8/6/89	Cessna 172H	NA	Dana Point, California, U.S.	Business	1	0	0	Destroyed
Witnesses observed the airplane being flown in slow circles when the nose dropped and the engine sound increased. The nose of the airplane then rose to a near-vertical climb, and the airplane "looped over" onto its back. It then dived nearly vertically while rotating 180 degrees and struck the Pacific Ocean nose-first.								
8/11/89	Lake LA-250	NA	Bullfrog, Utah, U.S.	Personal	0	2	1	Substantial
The pilot was practicing "splash and go" landings on Lake Powell. During a landing run, the aircraft struck an unseen submerged object. The aircraft sank in 130 feet of water. The object penetrated the hull between the rudder pedals and broke both of the pilot's legs. All three occupants were rescued by a passing ski boat. The pilot was airlifted for emergency medical treatment.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/13/89	Cessna 172P	NA	Pass-a-Grille, Florida, U.S.	Unknown	4	0	0	Destroyed
The aircraft was being used to demonstrate flight characteristics. During a flight over the Gulf of Mexico, the aircraft entered a descent and struck the water about three miles from land. A witness said that the airplane was spinning in a nose-down attitude. The aircraft sank almost immediately in 28 feet of water.								
8/15/89	AN 24	CAAC	Shanghai, China	Scheduled passenger	34	NA	NA	Destroyed
The aircraft overran the runway into a river on takeoff.								
9/3/89	150	NA	Grafton, New South Wales, Australia	Personal	1	0	0	Destroyed
The pilot was returning to the airstrip after an aerobatic flight. On crosswind, the aircraft was seen descending to 700 feet before its nose dropped and the aircraft dived into the river. The pilot had failed to report a previous heart attack.								
9/7/89	Piper PA-32-260	NA	Lake Havasu City, California, U.S.	Personal	2	0	0	Destroyed
Witnesses observed the aircraft approach at a low altitude and circle a point on the lake. They said that the airplane was in a right bank and gradually descended during the turns until it struck the water.								
9/8/89	Lake LA-4-200	NA	Klawock, Alaska, U.S.	Business	0	1	2	Destroyed
While turning from base leg to final approach for a lake landing, the pilot misjudged the aircraft height above the smooth, glassy surface of the water. The left wing struck water, and the aircraft cartwheeled. About five minutes later, the aircraft sank in 50 feet of water.								
9/16/89	Rockwell 112B	NA	La Grange, California, U.S.	Personal	2	0	0	Destroyed
The pilot filed a VFR flight plan but found himself in IMC. The aircraft was seen by a witness diving as it descended below clouds. The aircraft struck a lake.								
9/19/89	De Havilland DHC-6	NA	Sleepy Bay, Alaska, U.S.	Business	0	0	5	Substantial
The pilot said that he overflew the intended landing area and observed two-foot to three-foot swells. He decided to land parallel to the swells and into a quartering headwind. Touchdown was reported to have been smooth. The aircraft then entered a large swell, four feet to five feet high, and became airborne. The aircraft struck the water hard, and the front spreader bar and strut system on the floats failed.								
9/20/89	Boeing 737	USAir	Flushing, New York, U.S.	Scheduled passenger	2	3	58	Destroyed
As the first officer began the takeoff on Runway 31, he felt the airplane drift left. The captain observed the left drift and used the nosewheel tiller to help steer. As the takeoff run progressed, the flight crew heard a bang and a continual rumbling noise. The captain took over and rejected the takeoff but did not stop the airplane before it ran off the end of the runway into Bowery Bay.								
9/23/89	Learjet 25D	Province of Misiones	Posadas, Argentina	Public use	2	0	5	Destroyed
During a nonprecision approach, the aircraft undershot the runway, striking the river about a mile short of the runway. The accident happened in daylight with low cloud and reduced visibility in heavy rain.								
9/23/89	Dornier 228-200	Indian Airlines	Pandharpur, India	Scheduled passenger	11	0	0	Destroyed
The aircraft struck the reservoir behind the Ujani Dam on the Bhima River some 30 minutes after takeoff. Prior to impact, the aircraft was seen in a steep dive that apparently continued until it struck the water.								
9/29/89*	Bellanca 17-30A	NA	Palo Alto, California, U.S.	Instructional	2	0	1	Substantial
During the turn to final, the engine failed and the aircraft was ditched in a bay short of the runway.								
10/6/89*	Aero Commander 500-S	NA	Port Hedland, Western Australia, Australia	Unscheduled passenger	0	0	4	Substantial
Just after takeoff, the right engine surged and failed. The pilot was unable to maintain the aircraft's altitude and ditched the aircraft.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
10/14/89	Cessna 172H	NA	Bay City, Michigan, U.S.	Personal	0	0	2	Substantial
Touchdown was farther down the runway than the pilot had planned. The aircraft departed the end of the runway, went up and over a dike and landed in a river.								
10/26/89	Beech F35	NA	Lake Berryessa, California, U.S.	Personal	2	0	0	Destroyed
While the airplane was being flown over Lake Berryessa, it struck two transmission wires that spanned the lake. The airplane then struck the water.								
11/1/89*	Skyvan	RV Aviation	Aland Island, Finland	Cargo	0	0	2	Destroyed
About an hour after takeoff, the aircraft's right engine failed. The crew declared an emergency and began to divert toward Aland Island, the nearest airfield. While the crew flew the airplane at 2,000 feet and positioned for an approach, the left engine also failed. The aircraft was ditched just offshore and the crew was rescued without injury.								
11/2/89	Aerostar 600	NA	Apopka, Florida, U.S.	Unscheduled cargo	2	0	0	Destroyed
About 30 minutes from the destination airport (Orlando, Florida), the aircraft struck the water of Lake Apopka while apparently in a shallow descent with a slight left-wing-low attitude.								
11/5/89*	Gulfstream American AA-5B	NA	Windmill Point, Virginia, U.S.	Instructional	0	0	1	Substantial
The student pilot said that at an altitude of 3,500 feet, the oil pressure decreased and the engine failed. The aircraft was over the Chesapeake Bay and the student was unable to glide the aircraft to land, so he ditched it in the bay. The student reported that the aircraft stayed afloat for about 20 minutes after the ditching, then sank. He swam for about 40 minutes, then was rescued by a sailboat crew.								
11/9/89	Cessna 310I	NA	Provo, Utah, U.S.	Aerial observation	2	0	0	Destroyed
The Cessna was one of two airplanes being flown to produce a video. The aircraft were flown at a low altitude over Utah Lake, which was calm in light winds. The Cessna struck the lake and sank in 12 feet of water. The medical examiner reported that although both occupants had suffered blunt-force trauma, their deaths were caused by drowning.								
11/14/89	Beech A36	NA	Shell Lake, Wisconsin, U.S.	Business	3	0	0	Destroyed
The airplane was flown on an approach to an uncontrolled airport during moderate snow conditions. The airplane was flown into a lake during the descent.								
11/15/89*	Douglas DC-3	Victoria Air	Barualite, Philippines	NA	0	0	5	Substantial
The aircraft was ditched. No other details were available.								
11/22/89*	Cessna 210E	NA	Gulf of Mexico	Personal	3	0	1	Destroyed
During cruise flight, the propeller assembly separated from the engine. The pilot ditched the airplane next to an oil platform about 10 miles from land. The pilot, his wife and two small children exited and attempted to swim to the platform. The sea was rough, and no life raft or life vests were on the airplane. The pilot's wife and children were lost at sea.								
11/28/89	Britten-Norman BN-2	NA	Block Island, Rhode Island, U.S.	Unscheduled passenger	8	0	0	Destroyed
For an undetermined reason, the aircraft struck water in Block Island Sound, three miles to five miles from Block Island. The main wreckage was found in 130 feet of water.								
12/24/89*	Mooney M20	NA	Fort Lauderdale, Florida, U.S.	Personal	0	0	1	Destroyed
The pilot reported that during an overwater flight, he observed a partial loss of manifold pressure and engine power. He initiated emergency procedures, but was unable to restore power or maintain altitude. The airplane was ditched at sea, and the pilot was rescued by the Coast Guard.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
1/2/90*	IPTN 212-200	Pelita Air Service	In Java sea, off Pabelokan Island, Indonesia	Unscheduled passenger	9	0	7	Destroyed
During flight at 9,500 feet about 50 minutes after takeoff, the aircraft's right engine reportedly failed. The crew shut down the engine and feathered the propeller; altitude could not be maintained, despite the jettisoning of luggage, and the aircraft was ditched.								
1/16/90	Cessna 310R	NA	Burlington, Vermont, U.S.	Personal	3	0	0	Destroyed
The aircraft was being vectored to an ILS approach at night in IMC and was flown into Lake Champlain.								
2/10/90	Cessna 172C	NA	Prue, Oklahoma, U.S.	Personal	0	2	1	Substantial
The airplane struck high-voltage power lines and then struck a lake.								
3/1/90	Beech B36TC	NA	Inver Grove, Minnesota, U.S.	Ferry	1	0	0	Substantial
During a takeoff in an airplane with a heavy gross weight in unfavorable winds, the liftoff was premature, and the pilot did not attain or maintain adequate airspeed. An inadvertent stall/mush resulted, and the aircraft struck the river.								
3/4/90*	Cessna 172	NA	Portrush, U.K.	Personal	0	0	1	Destroyed
Following an engine failure, the pilot attempted an emergency landing on Portrush Beach but was not able to maintain altitude. The aircraft was ditched 0.5 mile short of the beach and sank in two minutes to three minutes. The pilot swam ashore and was hospitalized for hypothermia.								
3/8/90	Piper PA-30	NA	Dayton, Tennessee, U.S.	Personal	1	0	0	Destroyed
The pilot reported an autopilot malfunction. There were no further communications with the pilot, and the aircraft struck a river at a steep angle almost directly below the last reported position.								
3/17/90*	Cessna 177 Cardinal	NA	English Channel	Private business	0	0	1	Destroyed
In cruise flight at 4,500 feet, engine-oil temperature began to increase and oil pressure decreased. The pilot flew the aircraft to 2,500 feet and reduced power. The aircraft descended into the sea 15 nautical miles from Ramsgate, England. The pilot was rescued.								
3/18/90	Douglas DC-3	Tan-Sahsa	Roatan Island, Honduras	Scheduled passenger	0	0	32	Substantial
The aircraft overran the runway on landing and continued into the sea.								
3/30/90*	Cessna 150L	NA	Vieques, Puerto Rico, U.S.	Instructional	0	0	2	Substantial
The instructor pilot took control of the airplane over water when the student pilot said that he could not get the engine to produce more than idle power. The instructor had the same problem and ditched the airplane.								
4/4/90	DHC-6 Twin Otter 200	Islena Airlines	Utila, Honduras	Scheduled passenger	0	0	20	Destroyed
On final approach in a westerly direction, the two pilots reportedly were blinded by the sun and allowed the aircraft to undershoot the runway. The aircraft struck the sea 175 feet short of the runway threshold.								
4/5/90*	Lockheed 1049 Super Constellation	Aerolineas Mundo SA	Levittown, Puerto Rico, U.S.	Ferry	1	0	2	Destroyed
Shortly after takeoff on a cargo flight, the aircraft's no. 3 engine failed and the aircraft was returned to the departure airport for landing. After off-loading the cargo, the crew conducted a takeoff for a three-engine ferry flight back to the base. About 20 minutes after departure, the pilot said that the no. 2 engine was on fire and the crew was turning back. The crew shut down the no. 2 engine and attempted unsuccessfully to extinguish the fire. The engine eventually separated from the aircraft. The no. 1 engine reportedly also failed, and the pilot ditched the aircraft just off the shoreline.								
4/12/90	DHC-6 Twin Otter 300	Widerøe's Flyveselskap	Lofoten Islands, Norway	Scheduled passenger	5	0	0	Destroyed
Following what appeared to be a normal takeoff and initial climb, the aircraft was seen to enter clouds at an altitude estimated between 1,000 feet and 1,100 feet. Shortly afterward, the pilot apparently lost control of the aircraft, which struck the sea in a nose-down, left-bank attitude.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
4/18/90	DHC-6 Twin Otter 200	Aeroperias	Contadora Island, Panama	Scheduled passenger	20	0	2	Destroyed
On takeoff, the aircraft flew through a flock of birds and apparently sustained a number of strikes on the starboard engine. The pilot was unable to maintain altitude and the aircraft struck the sea about one mile off the coast, some two minutes after departure.								
4/19/90	Cessna 177B	NA	North Captiva, Florida, U.S.	Personal	3	0	0	Destroyed
Witnesses said that after takeoff, the aircraft was flown in a steep climb and that the engine failed as the aircraft was over water at 200 feet to 300 feet. An immediate left turn was made, followed by a nose-down descent. About 100 feet above the water, engine power was restored, but the aircraft struck the water.								
4/26/90	American Aircraft AA-5B	NA	Rottnest Island, Western Australia, Australia	Personal	0	0	2	Substantial
The pilot decided to return the airplane for landing after weather deteriorated, but he was unable to avoid entering a cloud. The pilot conducted an instrument descent and flew the aircraft out of clouds just above the sea. While the pilot was turning the aircraft sharply to miss a boat, a wing struck water. The aircraft landed safely.								
4/28/90*	Cessna 172D	NA	Isla Grande, Puerto Rico, U.S.	Personal	0	0	2	Substantial
Flying the airplane at about 4,500 feet, the pilot reduced the throttle setting to idle for an extended descent and did not apply sufficient carburetor heat. The engine failed, and the pilot ditched the airplane short of the airport.								
5/7/90	Piper PA-18-125	NA	Rogerson, Idaho, U.S.	Personal	1	0	1	Substantial
The aircraft was flown into a reservoir after striking a tent and a vehicle during the second of two low passes over a camp site. The passenger drowned after the aircraft sank and his coveralls could not be cut free.								
5/24/90	Cessna 185	Markair Express	Uganik Bay, Alaska, U.S.	Passenger/cargo	0	0	3	Substantial
The pilot said that, immediately after a water takeoff, the aircraft encountered a downdraft and gusty winds. It then entered an uncommanded roll and descent. The pilot leveled the wings, but the aircraft struck the water before he could stop the descent.								
5/25/90	Piper PA-18-150	NA	Wasilla, Alaska, U.S.	Personal	2	0	0	Substantial
Several witnesses said that they heard a power reduction from the airplane's engine about one minute after takeoff. The airplane was turned steeply, as if for a landing on the lake, and then stalled and spun into the water.								
5/29/90*	Piper PA-28-181	NA	Lake, Burragorang, New South Wales, Australia	Instructional	0	0	3	Substantial
The aircraft was being operated in high relative humidity and with a rich mixture setting. There was an engine failure, probably caused by carburetor icing. The aircraft was ditched into the lake, 10 meters from shore.								
5/31/90*	Cessna 404 Titan	Northair	Colonsay, Scotland	Aerial observation	0	1	2	Destroyed
The aircraft was ditched in the sea after the pilot reported a right-engine problem. The crew was immersed in the sea, and the life raft took on water before the crew was able to get in. All three crewmembers suffered from the onset of hypothermia before rescue by helicopter 40 minutes later.								
6/1/90	Cessna 441 Conquest	NA	In sea off Marathon Key, Florida, U.S.	NA	NA	NA	NA	Destroyed
The wreckage of the aircraft was found, but the circumstances of the accident have not been established.								
6/5/90*	Piper PA-32	NA	Libreville, France	Personal	0	0	1	Destroyed
The aircraft was ditched after a reported fuel blockage.								
6/6/90	Cessna 172N	NA	Chandeleur Island, Louisiana, U.S.	Personal	0	0	2	Substantial
When attempting to conduct a takeoff from the rough, sandy beach, the pilot lifted the nose landing gear off the ground prematurely to avoid damaging the nose-landing-gear fairing. After liftoff, he overcontrolled the airplane and allowed it to stall. The wing dragged on the ground, and the airplane cartwheeled into the water inverted.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
6/14/90*	Piper PA-34 Seneca	BAE	NA	Commercial	0	0	1	Destroyed
The airplane was ditched after a reported fuel shortage and sank.								
6/16/90	Grumman G-21A	NA	Long Beach, California, U.S.	Test flight	0	1	1	Substantial
The pilot conducted an inadvertent wheels-down landing in water, and the aircraft nosed over.								
7/1/90	Osprey	NA	Iron Mountain, Michigan, U.S.	Personal	1	0	0	Destroyed
Witnesses observed the airplane entering a shallow left bank shortly after takeoff. The bank gradually increased to about 60 degrees. The airplane's nose dropped, and the airplane entered a descending spiral until it struck a river.								
7/1/90	North American AT-6	NA	Buffalo, New York, U.S.	Aeronautic display	1	0	0	Destroyed
While performing aerobatic maneuvers in an air show, the pilot began to roll the airplane. After 270 degrees of roll, the rate decreased considerably. The aircraft nose dropped, and the airplane struck the water in a 40-degree nose-down, 45-degree right-wing-low attitude.								
7/2/90*	Cessna 337	NA	Bedford, New York, U.S.	Ferry	0	0	2	Substantial
The pilot was operating the airplane on a ferry permit when there was a double power loss caused by fuel starvation. He ditched the airplane in a reservoir.								
7/12/90	Lake LA-4-200	NA	Bellingham, Washington, U.S.	Personal	0	0	2	Substantial
The pilot and his passenger were performing a series of landings on Lake Whatcom. During the second takeoff run, the amphibious aircraft struck an unseen object, tearing a hole in the hull. The aircraft sank a few minutes after the occupants exited.								
7/14/90	Cessna U206F	NA	Augusta, Maine, U.S.	Personal	1	0	0	Substantial
Witnesses said that the pilot was landing his aircraft on a lake with variable crosswind and quartering tailwind conditions. The airplane was said to have touched down in the water, tipped slightly and righted itself. The downwind float then submerged, and the airplane nosed over.								
7/29/90	Cessna 210N	NA	Lake Eyre, South Australia, Australia	Nonscheduled passenger	0	0	6	Substantial
During a scenic flight over Lake Eyre, the water's glassy surface resulted in diminished horizon definition. The aircraft contacted the lake in a near-level attitude and in cruise configuration.								
8/6/90	Cessna 150L	NA	Holland, Michigan, U.S.	Personal	2	0	0	Destroyed
The pilot and passenger departed on a local night flight in clear weather. After about 15 minutes, the aircraft struck Lake Michigan, about one mile from shore. Two days later, wreckage of the aircraft was found in about 50 feet of water. The passenger was still strapped in the aircraft. The pilot's body was found Aug. 18, 1990, after it had washed onto shore. There was evidence that both occupants had died from drowning.								
8/12/90	Piper PA-18-150	NA	Aniak, Alaska, U.S.	Personal	2	0	0	Substantial
The float-equipped airplane was found floating upside down in a lake near the area where the pilot and passenger had been hunting. There had reportedly been strong winds, rough swells and water spouts.								
8/12/90	Cessna 185F	NA	Wrangell, Alaska, U.S.	Aerial observation	1	1	0	Destroyed
While turning the airplane, the pilot did not maintain adequate airspeed. Following a descending left turn, the airplane struck water just offshore.								
8/14/90	Cessna 172M	NA	Kewaunee, Wisconsin, U.S.	Personal	2	0	0	Destroyed
The aircraft was being flown from West Bend, Wisconsin, to Washington Island, Wisconsin. The aircraft did not arrive and was presumed to have struck the water of Lake Michigan. The bodies of the pilot and passenger later washed ashore.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/14/90	Bellanca 7GCAA	NA	Saltaire, New York, U.S.	Positioning	1	0	0	Destroyed
The airplane was seen in a right turn over the water. The airplane struck the water with the right wing, and the wing separated from the airplane. The airplane sank, and the wreckage and the pilot's body were not recovered.								
8/25/90	Champion 7GCAA	NA	Clark Lake, Michigan	Personal	1	0	0	Destroyed
The pilot was flying the aircraft in aerobatic maneuvers in low flight. Following what was described as a steep pull-up, the aircraft was observed to impact water in a steep descent. Toxicology checks showed that the pilot had a blood alcohol level of 0.26 percent.								
8/28/90	Cessna 152	NA	Provincetown, Massachusetts, U.S.	Aerial observation	2	0	0	Destroyed
Witnesses on a boat saw the airplane being maneuvered while on a fish-spotting mission and observed it entering a spin and striking the water. Bodies of the occupants were found several weeks later.								
8/30/90	Beech A23A	NA	St. Paul, Minnesota, U.S.	Personal	1	0	0	Substantial
About 1.5 hours after takeoff, the pilot reported an engine failure. When asked about her position, the pilot said that she was "over the river." A witness saw the aircraft at an estimated 500 feet to 800 feet AGL. He said that the aircraft's nose rose to a high angle, then the right wing dropped and the aircraft went into a spin and dove into the Mississippi River.								
9/5/90	Boeing B75N1	NA	Marseilles, Illinois, U.S.	Personal	0	1	1	Substantial
While the pilot was intentionally conducting a low-level flight, the aircraft struck a wire. With the wire attached, the aircraft descended into a river. The passenger reported that the pilot was reading a chart at the time of the wire strike.								
9/7/90	Piper PA-32RT-300T	NA	Glacier Island, Alaska, U.S.	Personal	2	0	0	Substantial
About 20 minutes after takeoff, the pilot reported a rough-running engine and smoke in the cabin. He then reported that he was losing visibility because of the smoke and declared an emergency. Radio contact with the pilot was lost, and it was presumed that the aircraft struck Prince William Sound. Four days later, the passenger's body was recovered. A post-mortem examination revealed that the passenger had drowned.								
9/11/90*	Boeing 727-200	Faucett	North Atlantic, SE of Newfoundland, Canada	Ferry	16	0	0	Destroyed
During a ferry flight from Malta to Miami, Florida, U.S., the aircraft disappeared and is presumed to have struck the sea. The last contact with the crew occurred when they told ATC that they had low fuel and that they were descending through 10,000 feet with the intention of ditching.								
9/22/90*	Commander 690B	Westport Air Travel	North Castle, New York, U.S.	NA	0	0	6	Destroyed
Media reports said that the pilot declared an emergency and ditched the aircraft in Byram Reservoir, seven miles northeast of White Plains, New York.								
10/4/90	Cessna 152	NA	Kearny, Arizona, U.S.	Personal	0	0	2	Substantial
The pilot said that the aircraft landed fast and did not stop before reaching the end of the 1,665-foot runway. The aircraft ran off the departure end of the runway and struck a small lake. The aircraft sank, and the two occupants extricated themselves and swam to shore.								
10/10/90*	De Havilland DH-82A Tiger Moth	NA	Takapuna Beach, New Zealand	Personal	1	1	NA	Destroyed
The pilot became incapacitated, and the aircraft was ditched.								
10/15/90	Piper PA-28-161	NA	Everglades City, Florida, U.S.	Personal	3	0	0	Destroyed
The non-instrument-rated pilot departed on a night VFR flight over water. Witnesses saw the airplane being flown to 125 feet to 300 feet AGL and being leveled. The airplane was then seen in a left turn descending in a 20-degree nose-down attitude, right-wing-low, after which it struck the water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
10/20/90	Stinson SR8C	NA	Lakeville, Massachusetts, U.S.	Personal	0	0	2	Substantial
The pilot was maneuvering his airplane at a low altitude while sightseeing and taking pictures over a lake. He turned the airplane left in order to avoid the reflection of the sun on the glassy surface of the lake. The airplane descended and struck the water.								
10/25/90*	Piper PA-28-181	NA	Orlando, Florida, U.S.	Personal	0	0	5	Substantial
When the airplane was six miles from the destination airport, the engine failed because of fuel exhaustion. Because of unsuitable terrain, the pilot ditched the aircraft in a lake short of the airport.								
11/14/90	Cessna 172A	NA	Brigham City, Utah, U.S.	Personal	0	2	0	Substantial
Shortly after takeoff from a peninsula in night VMC, the pilot reported that he turned the airplane onto downwind after he lost sight of the horizon. The next thing the pilot remembered was the airplane striking the water and nosing over.								
11/16/90*	Piper PA-32-301R	NA	Alton, New Hampshire, U.S.	Personal	1	0	1	Substantial
The passenger said that as soon as the pilot disconnected the autopilot, the engine failed. The pilot conducted a forced landing in Lake Winnipesaukee. The passenger said that she and the pilot climbed out on the wing of the airplane and attempted to swim to shore. The passenger said that when she arrived at the shore, she could not locate the pilot.								
11/17/90*	Cessna 172P	NA	Atlantic Ocean	Personal	2	0	2	Destroyed
The pilot became lost. He circled his airplane above a ship and ditched the airplane because of low fuel supply. Two passengers were rescued by ship personnel. The aircraft was equipped with a four-person life raft and four life vests, but a passenger inflated the life raft before ditching. He punctured it to regain space. The life vests were not located by the occupants.								
12/12/90*	Piper PA-28-151	NA	Jupiter, Florida, U.S.	Personal	0	0	4	Substantial
During cruise flight about 0.5 mile offshore at an altitude of 500 feet, the pilot heard a knocking sound and the engine failed. Unable to maintain the airplane's altitude, the pilot ditched the aircraft.								
12/15/90*	PBN BN-2A-7 Islander	Royal Hong Kong Auxiliary Air Force	Tolo Harbour, Hong Kong	Instructional	0	0	2	Destroyed
Media reports said that the aircraft was ditched in Tolo Harbour, apparently after an engine failure during a crew-training flight.								
12/21/90	Cessna 152	NA	Camden, New South Wales, Australia	Instructional	2	0	0	Destroyed
The aircraft failed to return from a training flight and was later located in 47 meters of water.								
1/2/91	Cessna 172P	NA	Rattlesnake Island, Ohio, U.S.	Instructional	1	0	2	Substantial
The runway was covered with one inch of snow. After touchdown, the flight instructor attempted to conduct a go-around. The airplane failed to climb and struck the water about 100 feet beyond the departure end of the runway. The occupants attempted to swim to shore, but the student pilot drowned.								
1/9/91	Cessna 182K	NA	Hobart, Tasmania, Australia	Personal	4	0	0	Destroyed
While being flown over a lake at low altitude, the aircraft struck a power line. The aircraft dragged the power line about 500 meters before diving into the water.								
1/15/91	Cessna 172RG	NA	Hayward, California, U.S.	Business	1	0	0	Destroyed
The pilot failed to maintain altitude on the approach to the Hayward airport, and the aircraft descended into San Francisco Bay.								
1/18/91	Cessna 180K	Aquatic Aviation	Patterson, Louisiana, U.S.	Unscheduled passenger	1	0	2	Minor
The pilot noticed that the left float was sinking because of several missing bilge plugs. After shutting down the engine, he attempted to pump out the float and plug the holes with wadded paper. When the airplane began to list, he told his passengers to don life vests. The passengers exited the airplane. When they looked around for the pilot, he had disappeared. He was last seen holding onto his life vest and treading water. He was presumed drowned. His inflated life vest was recovered.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
2/20/91	British Aerospace 146-200	LAN Chile	Santiago, Chile	NA	20	2	50	Destroyed
Following a VOR approach, the aircraft reportedly aquaplaned and overran the end of the runway and struck the Beagle Channel. The aircraft came to rest partly submerged some 20 meters offshore.								
3/2/91	Cessna 182P	NA	Pacoima, California, U.S.	Instructional	0	0	2	Substantial
The flight instructor and private pilot/instrument student were departing on an instrument training flight. About 250 feet AGL, the engine failed and the instructor conducted an emergency landing in a flood-control basin.								
3/5/91	Cessna 150	NA	Chesapeake, Virginia, U.S.	Instructional	0	1	0	Substantial
The pilot was performing touch-and-go landings when directional control was lost. The airplane went off the side of the runway and came to rest in water.								
3/10/91	Beech F33A	NA	Sterling, Colorado, U.S.	Personal	2	0	0	Destroyed
A young pilot and his passenger were observed "buzzing" a reservoir in an airplane. The witnesses said that the aircraft was skimming the glassy surface of the water when it struck the water, pitched up abruptly, then nosed down to strike the water again and sink.								
3/30/91*	Cessna 172N	NA	Bar Harbor, Maine, U.S.	Personal	0	1	1	Substantial
During the approach, the engine failed. The pilot advanced the throttle with no change. He added carburetor heat, and power was restored for one minute, then the engine failed again. The pilot ditched the aircraft in the harbor. The pilot and passenger exited the aircraft and clung to it until they were rescued about 45 minutes later.								
4/4/91	Douglas DC-3	Central Mountain Air Services	Lake Thutade, British Columbia, Canada	Passenger	6	1	0	Destroyed
The aircraft struck the frozen lake after appearing to have struck the ice with a wingtip during a turn at low altitude and to have cartwheeled.								
4/16/91	Waco ASO	NA	Lake Apopka, Florida, U.S.	Aerial observation	3	0	0	Destroyed
The purpose of the flight was to observe alligators in a lake. A witness observed the biplane being dived toward the lake and pulled up multiple times. On the last pull-up, the airplane slowed and entered a spin at an altitude too low to allow recovery. The airplane struck the lake.								
4/19/91*	Dornier 228	Air Tahiti	Nuku Hiva, French Polynesia	Scheduled passenger	10	8	2	Destroyed
The airplane was ditched in the sea near the airport after both engines failed on approach. The aircraft floated and was towed to shore.								
4/25/91	Cessna 150J	NA	Kure Beach, North Carolina, U.S.	Personal	2	0	0	Destroyed
The pilot flew the airplane at low altitude over the surface of the ocean. A witness said that the landing gear struck a wave, then the aircraft nosed over. The pilot was rescued, but the passenger drowned. The pilot had flown the aircraft without the owner's consent, and toxicology testing revealed that he had a blood-alcohol level of 0.165 percent.								
5/7/91	Cessna 172K	NA	Bunnell, Florida, U.S.	Instructional	0	0	2	Substantial
The accident report said that after takeoff, the flight instructor and student pilot were "unable to push the control column." The instructor reduced power; the aircraft stalled, struck a lake and came to rest inverted.								
5/9/91	Cessna TU-206G	NA	Gulf of Mexico	Positioning	1	0	0	Destroyed
The airplane did not arrive at its destination on a positioning flight. After a search, the airplane was found three weeks later on the floor of the Gulf of Mexico.								
5/24/91	Rockwell S-2R	NA	Larsen Bay, Alaska, U.S.	Personal	1	0	0	Destroyed
The airplane struck the bay one mile offshore and sank in 185 feet of water. Witnesses said that the airplane was being flown near the water in conditions of low ceiling and fog.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
5/30/91	Piper PA-24-250	NA	Long Boat Key, Florida, U.S.	Personal	1	0	0	Destroyed
While over water at night, the airplane disappeared from radar and radio contact was lost. Witnesses on the beach observed the airplane in a spin until it struck water.								
6/1/91*	A.S.T.A. (GAF) Nomad N24A	Agape Flight	Matthewtown, Great Inagua, Bahamas	Unscheduled passenger	2	0	1	Destroyed
About 30 minutes after departure while the airplane was in cruise at FL 90, one of the aircraft's engines failed. The pilot diverted to Matthewtown on Great Inagua Island. Later, he declared an emergency and said that the aircraft was losing altitude and that the second engine was "rough." The aircraft continued toward Matthewtown but eventually was ditched in the sea about 1.25 miles off Great Inagua Island.								
6/1/91	Lake LA-4-200	NA	Battle Creek, Michigan, U.S.	Instructional	0	0	2	Substantial
While the aircraft was being taxied on step, it encountered a power boat's wake and became airborne. The student pilot reduced the power, and the aircraft pitched down. The instructor took over the controls but was unable to arrest the descent. The aircraft struck the water nose-down. The aircraft nose filled with water, and the aircraft sank.								
6/5/91	Piper PA-38-112	NA	South Port, Florida, U.S.	Instructional	1	0	0	Destroyed
The airplane struck electrical transmission lines that crossed a lake.								
6/9/91	Piper PA-28-181	NA	East Haddam, Connecticut, U.S.	Personal	3	0	0	Substantial
At liftoff, the engine sputtered. Witnesses heard the engine running intermittently and roughly. The airplane was found in 10 feet of water in a pond beyond the end of the runway. The airplane door was damaged when the airplane struck the water, preventing the occupants from escaping.								
6/18/91*	Grumman HU-16E Albatross	Pacific Flying Fish	In Pacific Ocean	Ferry	0	1	2	Destroyed
During cruise flight, oil pressure failed on the no. 2 engine. Flight could not be sustained using the remaining engine. According to the pilot, the temperature of the remaining engine exceeded the normal range. The pilot elected to ditch the aircraft. During the landing, the aircraft received substantial damage and almost immediately was flooded, causing the aircraft to sink. The crew evacuated but did not have time to retrieve emergency equipment. They were rescued after about 20 hours in the water.								
6/18/91	Taylorcraft BC-65	NA	Kakhonak, Alaska, U.S.	Personal	2	1	0	Substantial
Shortly after takeoff, the airplane was banked left. It stalled and struck the lake about 200 yards offshore.								
6/28/91	Mitsubishi MU-2B-36A	NA	Goleta, California, U.S.	Personal	4	0	0	Destroyed
The pilot became spatially disoriented after continuing VFR flight into IMC, resulting in a near-collision with another aircraft. The pilot began a left turn over the shoreline, as if to circle for spacing, but his aircraft descended and struck the ocean.								
7/7/91	DHC-2 Beaver (Turbo)	NA	Sabaskong Bay, Ontario, Canada	Personal	0	0	1	Major partial
The pilot forgot to retract the wheels of the amphibious float-equipped aircraft. During the subsequent water landing, the aircraft nosed over.								
7/7/91	Piper PA-22	NA	Ventnor, Isle of Wight, England	Banner towing	0	2	0	Destroyed
The banner-towing airplane descended, following a partial power failure, into the sea. The pilot freed himself from the aircraft and was able to release his passenger as the aircraft sank. Both occupants were rescued by personnel of a trawler after about 10 minutes.								
7/13/91	De Havilland DHC-2 Beaver	Kabeelo Airways	Jubilee Lake, Ontario, Canada	Unscheduled passenger	0	0	1	Destroyed
The pilot turned the airplane onto the final-approach path to the lake and flew the airplane toward the surface of the water. As the floats contacted the water, a violent "water loop" developed, and the resultant forces tore the floats and wings from the aircraft. The aircraft sank rapidly. The pilot experienced difficulty escaping from the aircraft, which was 15 feet below the surface before he struggled free. He swam to the surface and was rescued by fishermen.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/15/91*	Piper PA-28R-200	NA	South Lake Tahoe, California, U.S.	Business	0	0	5	Substantial
The engine failed while the aircraft was above Lake Tahoe in cruise flight. The pilot ditched the airplane in the lake.								
7/20/91	Piper PA-11	NA	Eagle Lake, Maine, U.S.	Personal	0	0	2	Substantial
The pilot was conducting touch-and-go landings on a lake. The pilot said that he was making a slight bank correction when the left float dragged in the water. The airplane cartwheeled and sank in 130 feet of water. The pilot said that his depth perception was poor because of "glassy water" conditions.								
7/21/91	Piper PA-20	NA	Ione, Washington, U.S.	Personal	2	0	0	Destroyed
While being flown low over a river, the airplane struck a power line. The airplane then struck the water and sank.								
7/25/91*	Cessna 177RG	NA	Ashland, Kentucky, U.S.	Business	0	0	2	Substantial
The airplane was being flown through 300 feet AGL, soon after takeoff, when the engine failed. The pilot unsuccessfully tried to restart the engine. Because he was beyond gliding distance to land, he ditched the airplane in the Ohio River.								
8/6/91	PBN BN-2A-9 Islander	Avalki Air	Rarotonga, Cook Islands	Scheduled passenger	6	0	4	Destroyed
The aircraft struck the sea shortly before its scheduled arrival at Rarotonga.								
8/9/91	Piper PA-18	NA	Anchorage, Alaska, U.S.	Personal	0	0	1	Substantial
The airplane's left wing began to rise during the takeoff run on the lake and the pilot lost directional control of the airplane. The airplane nosed over onto its back and sank in 20 feet of water.								
8/9/91*	Cessna 210	NA	Delavan, Wisconsin, U.S.	Personal	0	0	2	Substantial
On final approach, the engine failed because of fuel exhaustion. The pilot made an emergency water landing about 1,000 feet from shore. The aircraft sank in about 10 feet of water.								
8/11/91*	Cessna 152	NA	Bear Mountain, New York, U.S.	Personal	0	0	2	Destroyed
After about three hours of flight, the engine failed because of fuel exhaustion. The pilot made a forced landing on a river.								
8/13/91	Bellanca 17-30A	NA	Boyne City, Michigan, U.S.	Business	1	0	0	Substantial
The pilot was flying over a lake to disperse ashes from cremated remains. Witnesses observed the aircraft in low-level flight before seeing it descend and strike the surface of the lake.								
8/14/91	De Havilland DHC-2 Beaver	NA	Ugashik, Alaska, U.S.	Unscheduled passenger	0	0	2	Substantial
During the takeoff on the water, the pilot lost control of the airplane and the left wing tip struck the water. The airplane nosed over onto its back and sank into the lake.								
8/16/91	Beech 58	NA	Brookhaven, New York, U.S.	Personal	1	0	0	Destroyed
The pilot had been treated for seizures. He became incapacitated in flight and his airplane descended and struck the water.								
8/20/91*	Piel CP301 Emeraude	NA	Point of Ayre, Isle of Man, U.K.	Personal	0	0	1	Substantial
Following an engine failure, the pilot declared mayday and attempted to glide the aircraft back to land. A successful ditching was subsequently carried out and the pilot was later rescued from the floating wreckage.								
8/29/91*	Cessna 150	NA	Atlantic Ocean	Instructional	0	0	1	Destroyed
The student pilot missed several key landmarks on a solo cross-country flight. Becoming disoriented, he flew east from the mouth of Chesapeake Bay out to the Atlantic Ocean. Sixty miles east of the coast, fuel was exhausted and the pilot successfully ditched the airplane in the ocean. He was rescued by personnel on a pleasure boat.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/7/91	Commander 690A	Occidental de Aviación	In sea off San Andreas Island, Colombia	NA	9	0	0	Destroyed
While inbound to San Andreas Island, the pilot advised ATC that he was encountering "very bad weather conditions." This was the last contact with the flight. An air and sea search was launched for the missing aircraft but was called off after a week with no results.								
9/21/91	Lake LA-4	NA	Wilton, Maine, U.S.	Personal	0	0	2	Substantial
The pilot said that when he landed the airplane on rough water, the airplane bounced and the right wing tip struck the water. The airplane nosed over and sank.								
9/28/91	Christen Eagle II	NA	Incline Village, Nevada, U.S.	Aeronautic display	2	0	0	Destroyed
The pilot failed to recover from an aerobatic maneuver in a timely manner and the airplane struck the water.								
9/29/91	Cessna 172N	NA	Knoxville, Tennessee, U.S.	Personal	0	0	2	Substantial
The pilot conducted a takeoff in fog. He aborted the takeoff but there was insufficient runway distance to safely stop the airplane. The airplane skidded off the departure end of the runway and sank in a river.								
10/11/91	Boeing 737-300	Cayman Airways	Georgetown, Cayman Islands	Scheduled passenger	0	0	67	Substantial
After touchdown, the aircraft could not be brought to a halt and it overran into the sea, eventually coming to rest some 100 feet beyond the runway end.								
10/15/91*	Piper PA-18	NA	Montague Island, Alaska, U.S.	Business	0	0	1	Substantial
The engine seized without warning while the airplane was in cruise flight. With no suitable landing area on the beach, the pilot ditched the airplane in the ocean and swam about 0.5 mile to shore.								
11/3/91	Piper L-3	NA	Plymouth, Massachusetts, U.S.	Personal	2	0	0	Destroyed
The non-instrument-rated pilot continued VFR flight into IMC at low altitude, resulting in collision with water.								
11/16/91	Cessna 208B Caravan I	Federal Express Corp. (Baron Aviation Services)	Destin, Florida, U.S.	Scheduled cargo	1	0	0	Destroyed
The aircraft struck the water of Choctawhatchee Bay during the final stages of the approach, some three miles short of the runway. The U.S. National Transportation Safety Board determined the probable cause to be the pilot's failure to follow IFR procedures by disregarding the minimum descent altitude and failing to maintain clearance from the terrain.								
12/8/91	Cessna 177B	NA	Dalmatia, Pennsylvania, U.S.	Personal	0	0	1	Destroyed
The pilot said that while flying above a river his attention was diverted and he did not see power lines until it was too late to avoid them. The airplane struck the river and the pilot swam to shore.								
12/17/91	NA	NA	Anglesea, Victoria, Australia	Personal	3	0	0	Destroyed
The aircraft encountered IMC in the Anglesea area and struck water off the coast.								
12/27/91	Cessna 172M	NA	Sanford, Michigan, U.S.	Personal	2	0	0	Destroyed
The aircraft was seen in low-level cruise flight over a lake. The aircraft's vertical stabilizer struck wires about 50 feet above the lake. The aircraft departed controlled flight and struck the water.								
12/28/91	Beech 1900C	Business Express	Block Island, Rhode Island, U.S.	Training	3	0	0	Destroyed
The aircraft struck the sea during a night training flight.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/8/92*	Cessna 210	NA	Hamilton Island, Queensland, Australia	Personal	0	0	6	Substantial
The pilot reported an engine failure at 1,200 feet on final approach. Restart attempts were unsuccessful. The aircraft was ditched short of Runway 32.								
1/13/92	Piper PA-28-161	NA	Homestead, Florida, U.S.	Personal	2	0	0	Destroyed
The non-instrument-rated pilot was flying his airplane over Biscayne Bay at night in IMC. Witnesses on a sailboat reported seeing the airplane descend in a 45-degree nose-down attitude into the bay.								
1/13/92	Cessna 421C Golden Eagle	Meade J. Williamson	In sea off Georgia, U.S.	Personal	5	0	0	Destroyed
ATC radar data and radar communications indicated that the aircraft entered a thunderstorm, then made a 180-degree turn to exit the storm. Aircraft debris was found in the sea off of Georgia, U.S. The U.S. National Transportation Safety Board determined that the probable cause of the accident was the pilot's inadequate weather evaluation and his continued flight into known adverse weather conditions.								
1/13/92*	Cessna 172G	NA	Atlantic Ocean	Public use	1	0	1	Substantial
During cruise flight at 1,200 feet, the engine began to miss. Attempts at correction were unsuccessful. The condition continued and the aircraft began to shake violently and oily smoke entered the cockpit. The pilot ditched the aircraft. Both occupants exited with no injuries, but the passenger reportedly lost his life vest during the evacuation. The aircraft was equipped, as required, with a four-person life raft and manually operated emergency position-indicating radio beacon, both of which were in the baggage compartment and were not recovered before the aircraft sank.								
1/14/92	Cessna 310Q	Jim Meyers Co.	Honolulu, Hawaii, U.S.	Personal	5	0	0	Destroyed
The flight departed Honolulu and, for about one hour, recorded radar data showed the aircraft northeast of Molokai, Hawaii, and Maui, Hawaii, at altitudes varying from 100 feet to 13,600 feet before it disappeared from radar. The aircraft was not recovered. Other pilots in the area reported IMC.								
1/23/92	Beech 99	Nature Island Express	Canefield, Dominica	Crew training	2	0	0	Destroyed
Following an apparently normal takeoff roll and initial climb, the aircraft began to lose altitude and struck the sea some 300 yards from the airport. According to unconfirmed reports, an engine failure had been simulated during the takeoff and initial climb with the operating engine then being shut down inadvertently.								
1/27/92	Beech 3T (C18S)	Air Rainbow	Nanaimo, British Columbia, Canada	Unscheduled passenger	7	2	0	Destroyed
The float-equipped aircraft became airborne after a takeoff run of about 2,000 feet. It climbed gradually to an altitude of about 50 feet above the water surface. After turning 30 degrees to the right, the aircraft began rolling rapidly from side to side and its altitude suddenly decreased. The left wing tip and the left float struck the water and caused the aircraft to cartwheel. The aircraft then burst into flames and erupted in a fireball. The Transportation Safety Board of Canada determined that the aircraft had encountered turbulence and downdrafts after takeoff, and had stalled at an altitude too low for the pilot to recover.								
2/8/92*	Cessna 150M	NA	Stuart, Florida, U.S.	Instructional	0	0	2	Substantial
After flying the aircraft from 1,500 feet to 2,000 feet, the flight instructor said, the engine rpm decreased and the engine began to run roughly. The flight instructor ditched the aircraft offshore.								
2/23/92	Taylorcraft BC-12D	NA	Gibson Island, Maryland, U.S.	Personal	0	0	1	Substantial
The pilot said that he had descended out of 1,200 feet to 350 feet over a river. He flew the aircraft along the river and began a turn to the right. The pilot said, "I was looking to the left in the turn when I heard the airplane strike the water."								
3/11/92	SX300	NA	Okeechobee, Florida, U.S.	Personal	2	0	0	Destroyed
A witness observed the airplane roll into a 90-degree bank to the right and then descend nose-low and left-wing-low until impact with the water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
3/14/92*	Cessna 182A	NA	Norfolk, Virginia, U.S.	Personal	2	2	0	Destroyed
The pilot was flying the airplane over Chesapeake Bay, descending to the destination, when the engine failed. The pilot could not restart the engine and ditched the airplane in the bay.								
3/22/92	Fokker F28-4000	USAir	Flushing, New York, U.S.	Scheduled Passenger	27	9	15	Destroyed
During an attempted takeoff from Runway 13 at La Guardia Airport, the aircraft landed upside down in about four feet of water at the end of Bowery Bay. Eighteen of those who died reportedly drowned while in their seats.								
3/22/92	Rans S-12	NA	Cabo Rojo, Puerto Rico, U.S.	Personal	0	1	1	Substantial
While attempting to perform a precautionary landing on a beach following a partial engine failure during cruise flight, the non-FAA-certified pilot inadvertently stalled the airplane. The airplane descended uncontrolled and collided with the water in a nose-low and right-wing-low attitude.								
4/1/92*	Cessna 303 Crusader	NA	English Channel	Personal	0	0	2	Substantial
Fumes were detected in the cockpit and a return to the airport was initiated. When the fumes and smoke increased from the instrument panel, the pilot descended the aircraft and declared mayday. A ditching, 15 miles offshore, was successfully conducted into the wind in a swell of eight feet to 10 feet. The occupants evacuated without injury, while the aircraft floated for about 1.5 minutes. The occupants had difficulty inflating the life raft, but were rescued by helicopter.								
4/3/92	Grob G115	NA	Loch Muick, U.K.	Instructional	2	0	0	Destroyed
The aircraft struck Loch Muick. Wreckage and bodies were subsequently recovered.								
4/10/92*	PBN BN-2A-26 Islander	Taiwan Airlines	Orchid Island, Taiwan, China	Unscheduled passenger	7	0	3	Destroyed
After takeoff from Orchid Island, soon after reaching its en route height of 1,500 feet, power was apparently lost on the aircraft's no. 1 engine. Attempts were made to restart the engine but without apparent success. The aircraft descended and was ditched.								
4/22/92	Navion A	NA	Monteverde, Florida, U.S.	Personal	1	0	0	Destroyed
The non-instrument-rated pilot attempted VFR flight and encountered IMC en route. He lost control of the airplane, which struck a lake.								
4/22/92	Piper PA-18-150	NA	St. Augustine, Florida, U.S.	Personal	1	0	0	Destroyed
Witnesses said that the airplane made two passes about 100 feet above a marina. On the second pass, the airplane was pulled up sharply, and the engine power was heard increasing. At 400 feet, the airplane stalled and entered a spin to the left into the water.								
5/9/92	Cessna 150G	NA	Samburg, Tennessee, U.S.	Personal	1	1	0	Substantial
The aircraft was observed in a maneuver similar to a hammerhead stall. When the maneuver was repeated, the airplane did not level off and struck the water.								
5/23/92	Cessna 150E	NA	North Myrtle Beach, South Carolina, U.S.	Banner towing	0	0	1	Destroyed
The airplane was 400 feet from the shoreline at 400 feet AGL when a Piper Cub flew within 100 feet of the Cessna's right wing. The Piper then was turned left in front of the Cessna and the Cessna pilot lost control of the airplane, which struck the water.								
5/26/92*	Bellanca 17-30A	NA	Graford, Texas, U.S.	Instructional	0	0	2	Substantial
After takeoff for an instrument-flight instruction trip, the landing gear did not retract. The pilot at the controls was attempting to land at the departure airport when the engine failed. The instructor pilot then took over control and made an emergency forced landing on the water.								
5/31/92	Cessna A150L	NA	Cocoa Beach, Florida, U.S.	Instructional	2	0	0	Destroyed
The flight was conducted for instruction in aerobatics. Witnesses reported seeing the aircraft four miles offshore, at an estimated 500 feet, in a 45-degree nose-down attitude diving toward the water. The aircraft was descending at high speed and was not spinning. The aircraft struck the water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/None	Damage to Aircraft
6/22/92*	Stinson 108-3	NA	Corbett, Oregon, U.S.	Personal	0	0	2	Substantial
After a takeoff from rough water and a climb to 200 feet, the pilot of the floatplane heard a loud "pop" in the right front of the aircraft. A severe vibration followed. The pilot decided to make a precautionary landing, but did not realize that the floats had separated from the airplane. The airplane fuselage struck the water and the airplane sank.								
6/25/92	IPTN 212-100	Dirgantara Air Service	Datu Island, Indonesia	Ferry	3	0	0	Destroyed
The pilot advised ATC that the aircraft's right engine had failed. The flight continued but apparently altitude could not be maintained on one engine. The aircraft descended at a rate of about 200 feet per minute. The last contact with the aircraft crew occurred some 30 minutes later when it was at 3,500 feet. The aircraft struck the ocean.								
6/28/92*	Rans S-12	NA	Saluda, Virginia, U.S.	Aerial observation	0	0	2	Substantial
The pilot was circling the airplane at 100 feet AGL so that the passenger could photograph a lighthouse. The engine failed and the pilot ditched the airplane in the water, from where the occupants were rescued by personnel on a nearby boat.								
6/28/92	Piper PA-28-180	NA	Mokane, Missouri, U.S.	Personal	1	0	0	Destroyed
Witnesses saw the accident airplane being flown at low altitude along a river toward suspended power-transmission lines. The witnesses saw the airplane roll just before it struck the top wire in the array. The right wing was torn away and the airplane descended into the river and sank.								
6/28/92	Piper PA-23-250	Caribbean Air Carrier	St. Thomas, U.S. Virgin Islands	Unscheduled passenger	4	0	0	Destroyed
Soon after takeoff, the pilot radioed the tower and advised of an engine fire. The flight was cleared to return but the aircraft struck water about five miles west of the airport.								
7/9/92*	Cessna U206F	NA	Portland, Maine, U.S.	Business	1	0	1	Substantial
During an ILS approach at the destination, there was a total loss of electrical power. The pilot decided to descend below the clouds into VMC, which he encountered about 400 feet over Casco Bay. The pilot said that he was reading a chart to locate the destination airport when the engine failed. The pilot ditched the airplane in the bay, escaped from the airplane and was rescued by the Coast Guard. The passenger did not escape from the airplane.								
7/30/92	Teal TSC-1A2	NA	Oshkosh, Wisconsin, U.S.	Personal	1	0	0	Substantial
Waves on the lake were two feet to three feet when the pilot of the amphibian attempted to land. The airplane "porpoised" on initial touchdown and the porpoising continued, becoming more severe with each bounce. The last entry into the water was on the nose of the airplane. The bow of the hull collapsed aft and the airplane inverted and sank.								
7/30/92*	Cessna 150F	NA	Granbury, Texas, U.S.	Personal	0	0	2	Substantial
The student pilot noted a 200-rpm drop on the engine tachometer at an estimated 120 feet AGL. Houses were below the airplane, so the pilot continued toward the lake. After clearing the residential area, the airplane was descended over the lake and the pilot ditched the airplane at 50 miles per hour. Before the airplane sank, the pilot and passenger exited. They were rescued by a nearby boater.								
7/31/92	Yakovlev Yak-42	China General Aviation	Jiangsu, China	Scheduled passenger	108	0	18	Destroyed
After takeoff, the aircraft reportedly climbed to about 60 meters before descending and touching down again. The aircraft overran the airport perimeter wall and came to rest in a water-filled ditch some 600 meters beyond the runway.								
8/6/92*	Beech C90	NA	Pontiac, Michigan, U.S.	Executive corporate	0	0	1	Substantial
The aircraft was on final approach when a fuel-crossfeed warning light illuminated. Trying to troubleshoot the fuel system, the pilot inadvertently discontinued fuel to both engines. The aircraft was ditched in the lake short of the airport.								
8/8/92	Cessna 310M	NA	Honolulu, Hawaii, U.S.	Personal	2	0	0	Destroyed
The aircraft was being flown along the Oahu coast. While in a turn, the aircraft began a descent, and a loss of radar contact occurred at about 700 feet. The aircraft struck the ocean. Thunderstorms and lightning were reported near the accident area.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/8/92*	Piper PA-28R-201	NA	Baltimore, Maryland, U.S.	Personal	0	0	2	Substantial
An engine failure caused by fuel starvation occurred after takeoff at an altitude of 300 feet. The pilot ditched the airplane in the water.								
8/9/92*	Cessna 210J	NA	Groton, Connecticut, U.S.	Personal	0	0	1	Destroyed
Engine-oil temperature began to increase while the airplane was at 6,000 feet. The pilot asked ATC for vectors to the nearest airport. About eight nautical miles from the airport, the engine-oil pressure dropped to zero and the engine failed. The pilot made a forced landing in the ocean and evacuated the airplane, after which the airplane sank.								
8/12/92	De Havilland DHC-2 Beaver	Alaska West Air Service	Crescent Lake, Alaska, U.S.	Unscheduled passenger	0	0	5	Substantial
About five seconds after the pilot leveled the wings on final approach for a glassy-water landing on a large lake, the airplane landed prematurely and hard. The floats were separated and the airplane sank immediately. The pilot said that because of the flat lighting and glassy water, he lost his depth perception and misjudged his altitude. He said that when the airplane hit the water, he thought he was still 70 feet to 80 feet above the water.								
8/13/92*	Beech 76	NA	Nantucket, Massachusetts, U.S.	Personal	0	1	0	Substantial
The airplane was in cruise flight at 2,500 feet when the left engine failed, followed shortly by the right engine. The pilot made a quick, unsuccessful attempt to restart the engines and then concentrated on executing a forced landing in the ocean.								
8/16/92	Piper PA-31-310B Navajo	Copenhagen Air Taxi	Karlstad, Sweden	Unscheduled passenger	5	0	3	Destroyed
While approaching Karlstad, the pilot reported that he was low on fuel. The pilot commenced a straight-in approach but while the aircraft was still some seven nautical miles from the airfield, both engines failed because of fuel exhaustion and the aircraft struck Lake Vanem.								
8/18/92	Convair 440	SASA	La Paz, Bolivia	Passenger	10	0	0	Destroyed
The aircraft failed to arrive at its destination after taking off in bad weather. The wreckage was subsequently found in a lake 28 miles from La Paz. No survivors were reported.								
8/22/92*	Piper PA-32-260	NA	Newburyport, Massachusetts, U.S.	Ferry	0	0	1	Substantial
The airplane was in cruise flight 200 feet offshore at about 75 feet above the ocean when the engine failed. The pilot said that he unsuccessfully tried to restart the engine several times before ditching the airplane in the ocean. The airplane sank in 45 feet of water.								
8/25/92*	Helio H-391B	NA	Edmonds, Washington, U.S.	Personal	0	0	1	Destroyed
The pilot increased power to initiate a climb and the engine power was reduced. He ditched the aircraft in Puget Sound when he was unable to reach an airport or the shore for an emergency landing.								
9/4/92*	Cessna 425 Corsair	Marina Aeroservice	Malaga, Spain	Ferry	0	0	1	Destroyed
Following fuel exhaustion during final approach, the pilot was forced to land the aircraft in the sea some 70 meters to 80 meters from the shore.								
9/9/92	Cessna 182R	NA	Westerly, Rhode Island, U.S.	Personal	2	0	0	Destroyed
Before takeoff, the non-instrument-rated 79-year-old pilot was advised that VFR flight was not recommended. During the flight, the pilot indicated in his last radio transmission that he was descending into Westerly, Rhode Island. The aircraft did not reach the destination airport. A search was initiated after debris was found by a fisherman. The aircraft was located five days later in 50 feet of water, five miles from the airport.								
9/15/92	Piper PA-28R-200	NA	Avalon, California, U.S.	Personal	0	0	2	Substantial
The pilot said that while the aircraft was en route between the mainland and Santa Catalina Island, the engine failed and the aircraft struck the water.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/18/92	Douglas DC-6A	Aeroejecutivos	Curacao, Netherlands Antilles	Unscheduled cargo	3	0	0	Destroyed
The aircraft struck the sea off Curacao while on a flight to Miami, Florida, U.S.								
10/25/92*	Piper PA-32-300	NA	Fort Pierce, Florida, U.S.	Personal	0	0	2	Substantial
The pilot reported an engine failure and conducted a forced landing in a canal.								
11/4/92	Cessna 172P	NA	Doughboy Bay, New Zealand	Personal	0	0	1	Substantial
The report said only, "Taxiing, became airborne, [struck the] sea."								
11/5/92*	Douglas DC-7CF	Aerochago	Dania Beach, Florida, U.S.	Unscheduled cargo	0	0	5	Destroyed
On takeoff, the aircraft's no. 4 engine reportedly failed just after rotation. The takeoff was continued and the aircraft climbed away safely. However, while fuel was being dumped prior to returning to the airport, the no. 2 engine began to overheat and eventually failed. The DC-7 was unable to maintain altitude on two engines and the crew was forced to ditch in shallow water off the beach.								
11/29/92	Piper PA-31 Navajo	San Rafael	Chaiten, Chile	NA	8	0	0	Destroyed
The aircraft reportedly struck the sea "immediately after takeoff."								
12/5/92	Aeronca 7AC	NA	Medford, Oregon, U.S.	Personal	2	0	0	Destroyed
The pilot flew the aircraft to a low altitude to "buzz" a private residence and the aircraft struck electrical wires above a lake. The aircraft struck water in an uncontrolled descent and sank in the lake.								
12/6/92	Helio H-700	NA	Shelton, Connecticut, U.S.	Personal	1	0	2	Substantial
The amphibious airplane was being landed on the water. The pilot said, "Landed on river … immediate pitch-forward to inverted."								
12/10/92*	Cessna 172	NA	English Channel	Personal	0	0	2	Destroyed
Following fuel exhaustion, the aircraft was turned toward land and the pilot declared mayday. The aircraft was ditched about 100 meters in front of a fishing vessel. Despite two activations of the carbon-dioxide cylinder, the passenger's life vest required inflation by mouth. The passenger door jammed in the ditching. The floor-level pilot-seat travel limiter was impossible to locate quickly, and the seat, which was fully forward, partially blocked the door. The occupants were rescued by personnel on the fishing vessel.								
12/14/92	Piper PA-31P	NA	Oceanside, California, U.S.	Personal	2	0	0	Destroyed
The pilot flew the airplane after takeoff to 5,200 feet. Recorded conversations between the pilot and control tower did not reveal anything out of the ordinary. Radar data showed that the airplane descended at an excessive rate until it struck the ocean about one mile offshore.								
12/22/92*	Velocity HXB	NA	Savannah, Georgia, U.S.	Personal	0	0	1	Substantial
The engine failed during cruise flight at 6,500 feet. The airplane was landed in the Savannah River.								
12/25/92*	CJ-1	NA	Lake Thompson, Western Australia	Personal	0	0	1	Substantial
The pilot reported that he was conducting aerobatics over Lake Thompson when, at the top of a vertical climb during the entry to a stall turn, the propeller stopped rotating and the engine failed. Although the aircraft was made to dive to its maximum speed, the propeller did not turn over and start the engine. Because there were no suitable forced-landing areas available, the pilot elected to ditch the aircraft in the lake.								
12/31/92	Piper PA-28-140	NA	Brilliant, Alabama, U.S.	Personal	2	0	0	Destroyed
The takeoff was in night IMC. The wreckage of the aircraft was located Jan. 31, 1993, in a lake.								
1/1/93*	Beech 19A	NA	Moorabbin, Victoria, Australia	Personal	0	1	0	Substantial
The engine failed when the aircraft was outbound from Moorabbin. Being unable to return safely, the pilot elected to ditch the aircraft about 200 meters from the shoreline of Port Phillip Bay.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/2/93*	Dornier 228-100	Indian Coastguard	Bay of Bengal, off Paradip, India	Demonstration	4	0	2	Destroyed
The aircraft was ditched in the sea while en route to Calcutta, coming down about 300 kilometers southwest of its destination.								
1/5/93*	Mitsubishi MU-2B-35	NA	Nome, Alaska, U.S.	Positioning	0	0	1	Substantial
While the aircraft was in night cruise flight at FL 200, the right-engine fuel-filter-bypass warning light illuminated, followed by the same warning light for the left engine. Both engines failed. The pilot made a forced landing on a moving ice pack in the Bering Sea.								
1/16/93*	Vari-eze	NA	Portland, Texas, U.S.	Personal	0	0	2	Destroyed
While the airplane was being maneuvered over water, the engine failed because of carburetor ice. The pilot attempted to correct the problem, without success. He attempted to glide the airplane to land, but was unable to do so. He elected to land the airplane in the water.								
1/28/93	Cessna 182 Skylane	NA	Belfast, Ireland	NA	1	0	0	Destroyed
The aircraft struck water during an instrument approach to Belfast following a diversion resulting from poor weather.								
2/7/93*	Piper PA-23-250	NA	Atlantic Ocean	Ferry	1	0	0	Destroyed
The pilot was ferrying the airplane from San Juan, Puerto Rico, to Fort Lauderdale, Florida, U.S. He expressed confidence that he could complete the flight without making a refueling stop. After about 6.5 hours of flight time, the pilot reported that both engines had failed and that he was going to ditch the airplane. The airplane wreckage and pilot were not recovered.								
2/7/93*	Piper PA-28-151	NA	New Cumberland, Pennsylvania, U.S.	Instructional	1	0	0	Substantial
After a touch-and-go landing, the student pilot began a climb to prepare for another approach. At 800 feet, the engine failed. The pilot made a forced landing in the river.								
2/18/93	Cessna 172C	NA	Coffs Harbour, New South Wales, Australia	Personal	1	0	0	Destroyed
The pilot reported that he had no visibility and was returning to land at Coffs Harbour. Soon after the pilot was cleared to join the circuit for landing, communication with the aircraft was lost. The aircraft had struck the sea in a heavy rainstorm.								
2/26/93	Learjet 31	Lider Taxi Aéreo	Rio de Janeiro, Brazil	Unscheduled passenger	0	0	6	Destroyed
During the final stage of the approach, the aircraft undershot the runway, touching down in the water some 300 feet short of the runway threshold. The accident happened in daylight with poor weather including reduced visibility and heavy rain.								
2/28/93	Dornier 228-200	Formosa Airlines	Lan Yu, Taiwan, China	Unscheduled passenger	6	0	0	Destroyed
The aircraft disappeared shortly before it was scheduled to land and was believed to have struck the sea.								
3/16/93	Piper PA-34-200 Seneca	Sky's the Limit	Carpenteria, California, U.S.	Personal	6	0	0	Destroyed
About 27 minutes after departure, in darkness with good visibility and no low cloud, the aircraft struck the sea about one mile offshore. Radar data showed the aircraft begin a descent of about 300 feet per minute until it disappeared from the screen.								
3/19/93*	Piper PA-12-150	NA	Anchorage, Alaska, U.S.	Business	0	0	1	Destroyed
After the engine failed and the pilot had attempted without success to restart it, he was forced to land the airplane in the waters of Knik Arm.								
4/2/93	McDonnell Douglas DC-9-15	LAV-Aeropostal	Isla de Margarita, Venezuela	Test	11	0	0	Destroyed
During a flight test following routine maintenance, the aircraft struck the sea off Isla de Margarita. Flight operations appeared to have been normal until some nine minutes after the beginning of test maneuvers when a brief "mayday" was received by ATC.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
4/2/93*	Cessna 172	NA	Mussleburgh, Scotland	Business	0	0	2	Substantial
On initial approach to Edinburgh, Scotland, engine-oil pressure decreased. The engine subsequently failed. The aircraft was ditched 50 meters from shore, and the two occupants swam ashore.								
4/4/93	Lake LA-4-200	NA	Gold Bar, Washington, U.S.	Personal	4	0	0	Substantial
The airplane was found submerged in 40 feet of water about 40 feet from the shore of Lake Isabel. Impact damage indicated a near-vertical nose-down attitude at impact.								
4/17/93	Lake LA-4	NA	Superior, Wisconsin, U.S.	Personal	2	0	0	Destroyed
The pilot and passenger departed Duluth, Minnesota, U.S., on a cross-country flight. When the pilot was reported missing, a search was initiated. Investigation determined that the airplane had not reached the destination. Six days after the flight left Duluth, the body of the passenger was found on the shore of Lake Superior. After about two months, the body of the pilot was found washed up on the lake shore. The airplane was not found and was presumed to be in Lake Superior.								
4/19/93	Van's Aircraft RV-6	NA	Kingston, Tennessee, U.S.	Personal	2	0	0	Substantial
A pilot who witnessed the accident said that the accident airplane was in a left turn from the base leg to the final approach course when it stalled and entered a spin. He then saw a splash on the lake.								
4/22/93	Piper PA-28-140	NA	Carters Beach, Westport, New Zealand	Other	1	0	0	Destroyed
An unqualified pilot stole the aircraft, which dove into the sea.								
4/25/93	Champion 7GCBA	NA	Duluth, Minnesota, U.S.	Personal	0	0	1	Substantial
Following a landing, the pilot added power for another takeoff in a light crosswind and the airplane became airborne in a slight right bank. The pilot was unable to maintain directional control and his airplane's right wing tip struck the water in a nearby lake, substantially damaging the airplane and causing it to turn 180 degrees from its intended heading as it came to rest.								
4/25/93*	Cessna TU-206D	NA	Culebra, Puerto Rico, U.S.	Personal	1	0	1	Destroyed
During flight about 2,000 feet over water, the engine failed. The pilot could not restart the engine. He ditched the airplane at the mouth of a bay in ocean waters.								
5/6/93	Shorts 330-100	Atlantic Air	Tortola, British Virgin Islands	Scheduled passenger	0	0	30	Destroyed
During the takeoff run, the aircraft reportedly "didn't feel right" to the pilot, who elected to reject the takeoff. The aircraft could not be stopped before the end of the runway, and it overran the runway and struck the sea.								
5/17/93	Commander 690A	Líneas Aéreas Covitrans	Sepahua, Peru	Unscheduled passenger	1	1	0	Destroyed
Arriving at Sepahua, the crew discovered that there was a "light fog" across the runway. The pilot elected to make a low pass along the runway to assess the situation and determine if a landing would be possible. During this pass, the aircraft suddenly banked hard to the right. The right bank increased until the aircraft became inverted. The aircraft descended and struck the river. Unconfirmed information said that during the pass, the pilot noticed at the last moment a radio antenna located 50 yards from the runway and attempted an extreme maneuver to avoid striking the antenna.								
5/17/93*	Piper PA-28-140	NA	Canton, Kentucky, U.S.	Personal	0	0	4	Substantial
Following the engine's failure because of fuel exhaustion, the pilot ditched the airplane in a shallow lake about four miles from the destination airport.								
6/13/93	Thorp T18C	NA	South Lake Tahoe, California, U.S.	Personal	2	0	0	Destroyed
The engine failed and the pilot initiated an emergency descent for a forced landing. Witnesses saw the descending airplane. One witness saw the airplane between 400 feet and 500 feet above water, approaching the shoreline and rolling into a left bank turn. The bank angle increased until the airplane was upside down. The airplane then descended in a near-vertical nose-low attitude until it struck the lake.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/13/93	Rutan Long EZ	NA	San Pedro Bay, California, U.S.	Personal	1	0	0	Destroyed
A witness reported seeing the airplane being flown between 200 feet and 300 feet above the water. The airplane was put into a steep right bank turn, descended into the water and cartwheeled.								
6/13/93	Thorp T-18	NA	Chatham, Massachusetts, U.S.	Personal	1	1	0	Destroyed
The pilot was flying passes over jet skiers on the water. About 25 feet above the water, a 360-degree aileron roll was performed. At the completion of the roll, the right wing contacted the water, followed by the fuselage. The airplane broke up and sank in 18 feet of water.								
6/23/93*	Grumman American AA5A	NA	Comet Mine, Alaska, U.S.	Personal	0	0	3	Substantial
An engine failure occurred over terrain unsuitable for an emergency landing. The pilot ditched the airplane, which then sank.								
6/25/93	Mooney M20K	NA	Hobart, Indiana, U.S.	Personal	1	0	0	Destroyed
The pilot and airplane failed to arrive at the destination. The southern part of Lake Michigan and the adjacent land were searched without result. Pieces of an airplane were later found along the Michigan, U.S., lakeshore that matched the missing airplane's interior and exterior colors. The pilot was presumed dead.								
6/26/93*	Piper PA-38	NA	St. Petersburg, Florida, U.S.	Instructional	0	2	0	Substantial
Following a power failure, the flight instructor took control of the airplane from the student pilot and initiated a turn back to the airport from which the flight had originated. The instructor leveled the wings and ditched the airplane in Tampa Bay. After 10 seconds to 15 seconds, the aircraft sank. The instructor and the student exited the aircraft and were rescued by boaters.								
7/1/93	Cessna 180K	NA	Webster, New Hampshire, U.S.	Personal	1	0	0	Destroyed
Soon after takeoff from a lake, about 40 feet above the lake's surface, the airplane stalled. It then struck the water in a nose-down attitude and nosed over.								
7/2/93	Maule M-7-235 Super Rocket	Ontario Ministry of Natural Resources	Porcupine Lake, Ontario, Canada	Instructional	0	0	2	Substantial
The pilot inadvertently landed the amphibious aircraft on the water with the landing gear extended. On touchdown, the aircraft nosed over and came to rest partially submerged and inverted. The pilot exited the aircraft by kicking out the right mid-cabin window and was rescued.								
7/2/93*	Piper PA-24-180	NA	Malibu, California, U.S.	Personal	0	0	1	Substantial
The engine failed during cruise flight. The pilot conducted the required emergency procedures, but was unable to restart the engine. The pilot elected to ditch the airplane into the Pacific Ocean about two miles offshore. The airplane sank to a 20-foot depth after the pilot was rescued.								
7/10/93*	Piper PA-31	NA	Atlantic Ocean	Personal	0	0	2	Destroyed
The left engine and, soon afterward, the right engine failed because of fuel exhaustion. The airplane was ditched and the occupants were rescued.								
7/11/93	Maxair MU532	NA	Fox Lake, Illinois, U.S.	Personal	0	1	0	Substantial
The pilot reported that while he was maneuvering his airplane over a lake about 50 feet above the water, a gust of wind forced the nose of the airplane downward and it struck the water.								
7/18/93*	Cessna 172N	NA	Atlantic Ocean	Personal	0	0	4	Destroyed
Inaccurate fuel-consumption calculations by the pilot contributed to engine failure because of fuel exhaustion. A descent was initiated and the airplane was ditched about seven nautical miles from the destination airport.								
7/23/93	British Aerospace 146-300	China Northwest Airlines	Yinchuan, China	Scheduled passenger	55	16	42	Destroyed
On takeoff at Yinchuan, the aircraft failed to become airborne, struck earth banks just beyond the end of the runway and broke up. It came to rest in shallow water. A report said that the takeoff had been conducted with flaps retracted although the correct flap setting had been selected.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
7/23/93	Cessna 175B	NA	Blythe, California, U.S.	Personal	2	0	0	Destroyed
The airplane was seen being flown along the Colorado River, "buzzing" onlookers from an altitude no more than 50 feet above the water. The airplane struck a cable that spanned the river and struck the river.								
7/24/93*	Cessna 152	NA	St. Augustine, Florida, U.S.	Personal	0	0	2	Substantial
The airplane was in cruise flight when there was an uncommanded reduction in engine power. The carburetor heat was turned on and an increase in engine rpm was noticed, followed by a decrease in engine rpm. The pilot conducted a forced landing on the ocean adjacent to the beach.								
7/25/93*	Beech D18S	NA	Kodiak, Alaska, U.S.	Business	0	0	1	Substantial
About 10 minutes after takeoff, during cruise at 800 feet AGL, the right-engine oil pressure began decreasing and temperature began increasing. About two minutes later, the right engine began running roughly and backfiring, and the pilot shut it down. Meanwhile, the pilot inadvertently turned the airplane into a small bay rather than toward the departure airport. When the airplane got into a low-speed buffet, and the pilot believed the airplane was about to go inverted, he cut power on the left engine, leveled the wings and ditched the airplane in the shallow water near the shoreline.								
7/28/93	DHC-2 Beaver	Aero Golfe	Lac Allard, Quebec, Canada	Unscheduled passenger	5	0	1	Destroyed
Shortly after takeoff from the lake, the aircraft's right engine failed. The pilot, apparently believing that there was not enough space to conduct a forced landing straight ahead, attempted a turn. While in the turn, the aircraft stalled and struck the lake.								
7/30/93	Cessna 170	NA	Dry Bay, Alaska, U.S.	Business	1	0	0	Destroyed
The pilot conducted a takeoff from a beach for a destination about 40 miles away. The weather along the route of flight was reported to have been marginal VFR, with visibility less than 0.5 mile. The next day, pieces of airplane wreckage identified as being from the accident airplane were found about four miles offshore near the point of departure.								
7/31/93	Sea Ray	NA	Oshkosh, Wisconsin, U.S.	Personal	0	0	2	Substantial
The pilot of the amateur-built amphibian said that the airplane was not going to clear trees on takeoff, so he initiated a low-level right turn. While in the descending turn, the passenger abruptly moved the control to the right, the right float dug into the water and the airplane struck the water.								
8/1/93*	Cessna 180	NA	Naubinway, Michigan, U.S.	Personal	1	0	1	Substantial
The pilot was flying his float-equipped airplane along the northern shore of Lake Michigan when he encountered deteriorating weather. He elected to make a precautionary landing in the lake because of the reduced visibility and low ceiling. The passenger said that the water was rough and that the airplane was landed hard, dug in the right float and nosed over. With the pilot's assistance, she was able to escape through the passenger window and swim to the surface. She went back to help the pilot (her husband) but he was stuck halfway out of the window and she could not free him.								
8/2/93	Cessna 208 Caravan I	MarkAir Express	Kodiak, Alaska, U.S.	NA	0	0	1	Destroyed
The aircraft inverted during an attempted water landing. The amphibious aircraft was equipped with floats and apparently touched down with the wheels extended. The pilot said that he had not used the aircraft checklist because he was distracted and preoccupied by other mission-related factors such as radio communication, crosswinds, the weather and remaining fuel.								
8/5/93*	Piper PA-18-150	NA	Cape Canaveral, Florida, U.S.	Banner towing	0	0	1	Substantial
The engine failed during a banner-towing flight while the airplane was just offshore. The aircraft was ditched in the ocean and nosed over.								
8/6/93	Lake LA-4	NA	Blair Lake, Alaska, U.S.	Personal	0	0	3	Substantial
The pilot of the amphibian encountered a "porpoising" loss of control while step taxiing in choppy lake conditions. Porpoising progressed to wing-float pitching and striking the water. The airplane sank.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/11/93	Piper J3C65	NA	Stonington, Connecticut, U.S.	Personal	0	1	0	Substantial
The pilot was maneuvering at a low altitude in conditions of high humidity when the engine failed. The pilot said that he had used carburetor heat before the maneuver. After the engine failure, the pilot said, the airplane entered a spin and he regained control, but not in time to avoid striking the water.								
8/15/93	Cessna 305A	Aerial Advertising	Beach Haven, New Jersey, U.S.	Banner towing	0	0	1	Substantial
This was the pilot's third banner-towing flight of the day. Unknown to the pilot, the third banner was 50 feet to 75 feet longer than the previous ones. The pilot was unable to release the banner, and it dragged on the ground and then in the water of a nearby bay. The pilot reported that when the banner went into the water, the resultant drag was too strong for the airplane to overcome. Flight could not be sustained, and the airplane struck the water.								
8/17/93	Swearingen SA-226-TC	Aviation Services	Hartford, Connecticut, U.S.	Positioning	2	0	0	Destroyed
The airplane touched down with the landing gear retracted, and the propeller blades contacted the runway. The second-in-command, who was the pilot flying, initiated a go-around. Witnesses saw the airplane in a steep left bank just before it struck a river next to the airport.								
8/20/93*	Bellanca 17-30A	NA	Hilton Head Island, South Carolina, U.S.	Personal	0	0	2	Substantial
The pilot reported that the engine had failed at 1,500 feet AGL, about six miles north of Hilton Head Airport. Unable to reach the airport, the pilot force-landed the airplane in the ocean, and both occupants were recovered.								
8/25/93*	Piper PA-22-108/U	NA	McCaysville, Georgia, U.S.	Personal	0	0	2	Substantial
Following a takeoff that had been aborted because of engine problems, the pilot attempted another takeoff. As the airplane was flown through 200 feet AGL, the engine developed a rough condition again. The pilot attempted to restore full power, which included the application of carburetor heat. The pilot made an emergency landing in a nearby river.								
8/27/93	Yakovlev Yak-40	Tajik Air	Khrong, Tajikstan	Scheduled passenger	82	4	0	Destroyed
The Yak-40, which is normally configured for 38 passengers, had 81 passengers on board. On takeoff, the aircraft failed to become airborne and overran the runway at high speed. After striking an earth embankment and a concrete pillbox, the aircraft fell into the Pyanj River and was destroyed.								
8/28/93*	Champion Citabria 7-GCBC	NA	Fire Island, New York, U.S.	Banner towing	0	0	1	Substantial
A partial engine failure occurred while the airplane was towing a banner at 1,300 feet above the water. To avoid hitting people on the beach with the banner, the pilot flew the airplane to 400 feet to drop the banner. Because of the beach crowd, he also elected to make a water landing.								
9/12/93	Boeing 747-400	Air France	Papeete, Tahiti, French Polynesia	Scheduled passenger	0	0	270	Major partial
Following a VOR/DME approach to Faaa Airport, Papeete, the aircraft was landed "long and fast." After touchdown, the thrust reverser for one engine failed to deploy, and the engine remained at "high forward thrust." As the aircraft slowed, it veered to the right, ran off the runway and came to rest in a shallow saltwater lagoon to the side of the runway.								
9/13/93	Taylorcraft BC12-D	NA	Puget Bay, Alaska, U.S.	Personal	0	0	1	Substantial
The pilot misjudged his altitude above the water while on short final approach for a glassy-water landing. As he made a minor correction in order to land directly into the wind, the left float hit the water. The floats were torn from the aircraft, which sank immediately. The pilot had not filed a flight plan, and was not rescued until nine days later.								
9/19/93	Socata TB 10	NA	Aguadilla, Puerto Rico, U.S.	Personal	3	0	0	Destroyed
A preflight weather briefing was not obtained before departure. Thunderstorms with heavy rain showers were forecast. The flight proceeded toward the thunderstorm, according to witnesses, but there were no witnesses to the accident. The airplane minus the right wing was recovered.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
10/1/93	Cessna 182H	NA	Clear Lake Reservoir, California, U.S.	Personal	1	0	1	Substantial
The pilot said that while making a turn over the glassy water of the reservoir, the water, sun, haze and color of the background terrain resulted in an optical illusion. He said that he lost reference to the horizon, and the airplane struck the water about halfway through the turn.								
10/3/93*	Cessna 150G	NA	Osceola, Missouri, U.S.	Personal	0	0	1	Substantial
During cruise flight, there was a complete loss of engine power. The pilot was forced to ditch the airplane in a nearby lake.								
10/11/93*	Cessna 172	NA	Blountville, Tennessee, U.S.	Personal	0	0	1	Substantial
While the pilot was receiving vectors for an IFR approach to the destination airport, the engine failed. The pilot elected to ditch the airplane in a nearby lake.								
10/12/93	Piper PA-23-250 Aztec C	Aviation Associates	Little Exuma, Bahamas	Personal	5	0	0	Destroyed
The aircraft disappeared while en route to Nassau (Bahamas) International Airport and later was found to have struck the sea off Hog Key, Little Exuma. Weather at the time of the accident is believed to have included a depression centered over the Exuma Cays, producing strong winds, low cloud and heavy rain.								
10/16/93	Cessna 172M	NA	Culebra, Puerto Rico. U.S.	Personal	0	0	1	Substantial
The pilot was practicing low flight over water and took evasive action to avoid a bird. During the evasive maneuver, the left wing struck the water.								
10/25/93	Piper PA-28-180	NA	Centerville, Maryland, U.S.	Personal	0	0	1	Destroyed
After 1.5 hours of flight, the pilot switched from the right fuel tank to the left tank. The engine began to run roughly and power decreased. The pilot was not able to correct the problem, and he could not maintain altitude. The airplane descended until it struck water and sank.								
10/29/93	Grumman American AA5A	NA	Richmond Hill, Georgia, U.S.	Personal	1	0	0	Substantial
Witnesses observed the airplane flying over the Ogeechee River. The airplane appeared to dive toward the river. It appeared that a right turn was being attempted when the airplane hit the water. The investigation determined that the pilot had been physically impaired by medications.								
10/29/93	Beech A36	NA	Ormond Beach, Florida, U.S.	Personal	3	0	0	Destroyed
The pilot was observed departing a bar about 0230 with a 12-pack of beer and two people who were later identified as passengers of the accident airplane. The pilot's body and those of the two passengers washed ashore the next day, along with a few parts of the airplane. Toxicology tests found alcohol, tranquilizers, cocaine and other drugs in the pilot's blood.								
11/1/93*	Cessna P210N	NA	Fort Lauderdale, Florida, U.S.	Ferry	0	0	1	Destroyed
The pilot reported an engine failure during descent. He conducted a forced landing on the water. The airplane sank and was not recovered.								
11/1/93	Cessna A188B/A1	NA	Ballidu, Western Australia	Aerial application	0	0	1	Substantial
The pilot was flying the aircraft at a low altitude over the lake when the wheels struck the water. The aircraft came to rest inverted in the lake.								
11/4/93	Boeing 747-400	China Airlines	Hong Kong	Scheduled passenger	0	1	295	Destroyed
The aircraft touched down normally during the landing but did not decelerate normally. It departed the runway end and fell into Hung Hom Bay. The probable cause of the accident was determined to be the captain's inadvertent advance of the thrust levers when the thrust reversers were not deployed.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
11/13/93*	Cessna 152	NA	Riverhead, New York, U.S.	Personal	0	0	2	Substantial
During a flight over the Long Island Sound, the engine failed. The pilot said that the engine could not be restarted and that the airplane did not have enough airspeed or altitude to reach land. The pilot ditched the airplane.								
11/19/93*	Cessna U206F	Red Baron Aviation	Tampa, Florida, U.S.	Unscheduled cargo	0	0	2	Substantial
After departure, while on initial climb, the engine failed. The pilot conducted a forced landing on water.								
11/28/93	Cessna 150H	NA	Dardanelle, California, U.S.	Personal	0	0	2	Substantial
During initial climb, the pilot said, a previously hidden "cell of virga" was encountered. The pilot said that he turned the airplane away from the cell, but encountered strong turbulence and wind shear, accompanied by a downburst. Unable to arrest the sink rate, the airplane contacted the water in a "high rate of descent."								
11/29/93*	Cessna 152	NA	Port Stephens, New South Wales, Australia	Personal	0	0	2	Substantial
The pilot declared mayday when the engine failed over Port Stephens. The aircraft had insufficient altitude to reach the shore and the pilot ditched it in the water. Both occupants escaped from the aircraft before it sank.								
12/4/93	Piper PA-28R-200	NA	New Haven, Connecticut, U.S.	Personal	4	0	0	Destroyed
During a night approach in adverse weather, the aircraft struck the water 4.5 miles from the airport. Another pilot who had just landed said that conditions were "rough and turbulent, especially at traffic-pattern altitude."								
12/4/93	Mooney M20J	NA	Jones Beach, New York, U.S.	Personal	3	0	0	Destroyed
After departure, the pilot attempted to gain clearance from ATC for a transition flight through Class B airspace at 1,000 feet. The pilot declined the clearance ATC gave him, canceled his request and planned to return to the airport. It was a dark night, with weather marginal for VFR at times, and a pilot reported fog in the area. Radar data showed an airplane maneuvering over the Atlantic Ocean, then radar contact ended. The search of the waters off of the south shore of Long Island and alert notice were canceled on December 22. For several weeks after the accident, pieces of aircraft debris — one of which had the accident aircraft's registration number — washed up on the beach.								
12/9/93	DHC-6 Twin Otter 300	Air Senegal	Dakar, Senegal	Scheduled passenger	3	0	0	Destroyed
The Twin Otter collided with a Gambia Airways YS-11 (C5-GAA) an altitude between 2,700 feet and 2,900 feet. The crew of the Twin Otter lost control and the aircraft struck the sea. Although the YS-11's left wing was damaged, the pilot was able to maintain control and to safely conduct a landing.								
1/13/94*	Beech 90 King Air	Charles Kuykendall	Marseille, France	Ferry	0	0	1	Destroyed
As the aircraft was flown to the south of Martigues, France, smoke began emerging from the control pedestal. Because of the large quantity of fuel on board, the pilot elected to ditch the aircraft immediately. The aircraft later sank in deep water. The pilot was rescued by helicopter.								
1/14/94	Aero Commander 690	Newcastle Aviation	Sydney, New South Wales, Australia	Unscheduled cargo	1	0	0	Destroyed
The aircraft disappeared from radar during final approach and later was found to have struck the sea about 10 nautical miles south of the airfield and about 500 meters to the right of the extended centerline of the runway.								
1/15/94*	Consolidated PBY-5A Catalina	B. Emeny	Pacific Ocean	Ferry	0	0	8	Destroyed
While the aircraft was in flight at 5,000 feet, its port engine began to "backfire." The pilot altered course toward Christmas Island and reduced power on the port engine. Eventually, the engine had to be shut down. Attempts were made to feather the propeller, but it continued to "windmill." The aircraft weight was reduced but, with the propeller windmilling, altitude could not be maintained and the pilot prepared for a forced landing in darkness and at maximum landing weight. Without a local altimeter setting, the pilot could not ascertain the actual altitude, and the aircraft forcefully struck the water at an indicated altitude of 200 feet. After being landed on the water, the aircraft began to develop leaks. The occupants bailed water for some time but became exhausted; they then decided to abandon the aircraft, which sank several hours later. The occupants were rescued by the crew of a container ship.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/17/94*	Piper PA-28-180	NA	Boynton Beach, Florida, U.S.	Personal	0	0	1	Destroyed
After departure, the airplane was flown to 1,000 feet. There was an uncommanded reduction in engine power and the engine began to backfire. The pilot repositioned the fuel selector and turned on the auxiliary fuel pump, but the airplane was unable to maintain altitude and the pilot ditched the airplane in the Atlantic Ocean.								
1/18/94*	Cessna 140	NA	Lopez, Washington, U.S.	Personal	1	0	0	Substantial
On the first flight after an oil change, an engine failure occurred when the oil-temperature-sensing bulb nut backed out of its attach point, and all of the engine oil was lost from the engine. The aircraft was ditched in the waters off Lopez Island.								
1/20/94*	Cessna 152	NA	Osprey, Florida, U.S.	Instructional	0	0	2	Substantial
During cruise flight, the engine failed. The instructor took control of the airplane and performed a forced landing just offshore because of obstructions on the intended touchdown location.								
1/24/94	Cessna 425 Corsair	Aero West	Rorschach, Switzerland	Unscheduled passenger	5	0	0	Destroyed
The aircraft struck Lake Constance during the final stage of an approach and sank in 160 meters of water.								
1/29/94	Beech 35	NA	Leesburg, Florida, U.S.	Instructional	0	0	2	Substantial
While in the traffic pattern, on base leg to final leg, the pilot lost visual contact with the runway when he encountered low-level fog. The airplane continued to descend and struck a lake.								
2/7/94	Cessna 310R	Pacific Air Charter	La Jolla, California, U.S.	Unscheduled cargo	1	0	0	Destroyed
In conditions of dark night, moderate to severe turbulence and heavy rain, control was lost and the aircraft entered a dive from 4,400 feet to the ocean. The wreckage was located 1,000 feet below sea level.								
2/25/94*	Piper PA-28-140	NA	Miami, Florida, U.S.	Personal	0	1	2	Substantial
The pilot said that while he was flying the airplane through 600 feet to 800 feet after takeoff, the engine failed. Attempts to restart the engine were unsuccessful and the aircraft was ditched in a lake.								
2/27/94*	De Havilland DH-82	NA	Surfers Gardens, Queensland, Australia	Unscheduled passenger	0	0	2	Substantial
The pilot reported that the engine power decreased to idle. He made a forced landing in the ocean, about 15 meters from the shore.								
3/8/94*	Cessna TU-206F	NA	Crystal River, Florida, U.S.	Business	0	0	1	Substantial
While in cruise flight, the pilot noted a loss of oil pressure followed by a reduction of power. He turned to the nearest land and initiated a forced landing. When he realized that he would not reach land, he ditched the airplane in the sea.								
3/18/94	Grumman G73 Turbo Mallard	Chalk's International Airlines	Key West, Florida, U.S.	Ferry	2	0	0	Destroyed
On takeoff, the aircraft was seen to climb apparently normally to an altitude of about 100 feet. Then, "the engines made an unusual sound." The aircraft yawed to the right, rolled left and struck the sea.								
3/20/94	Piper PA-28R-200	Sunshine Flying Club	Sarasota, Florida, U.S.	Personal	4	0	0	Destroyed
On final approach, the airplane deviated laterally through the final approach course, as if the pilot was overcorrecting. About 400 feet altitude and one mile from the runway, the flight deviated to the left and a nonstandard missed approach began. An alternate IFR missed-approach procedure was issued, but the instruction was not followed. Radar data showed that the airplane flew south about 2.5 miles, then began turning and radar contact ended. Witnesses saw the airplane descending through fog in a steep, nose-down, right-bank attitude. The plane struck water in a boat-docking area.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
3/26/94	Cessna U206G	Key West Seaplane Service	Key West, Florida, U.S.	Personal	0	0	4	Substantial
The pilot said that the aircraft performance was sluggish for the weight conditions during the takeoff run and initial climb from a channel. After takeoff, the aircraft had a shallow rate of climb, and as the aircraft approached land, glassy water and a downdraft were encountered. As the pilot initiated a right turn to remain over water, the right float struck the water and the aircraft cartwheeled and came to rest inverted in the water.								
3/27/94*	Piper PA-28	NA	Bognor Regis, England	Personal	0	0	2	Destroyed
The engine ran rough and oil pressure was low. The aircraft was ditched in the sea 100 yards offshore.								
4/4/94*	Piper PA-28R-200	NA	White Plains, New York, U.S.	Personal	0	0	1	Substantial
During a forced landing, the pilot attempted to stop the airplane with heavy braking, but there was insufficient runway available and there were trees off the end of the runway. The pilot lifted the airplane off the runway, retracted the gear and tried to increase engine power, but there was no response. He elected to ditch the airplane in a lake.								
4/17/94	Pitts S-2A	Tsunami Aviation Hawaii	Kahuku, Hawaii, U.S.	Personal	1	0	0	Destroyed
The pilot was performing a weekly air show for guests of a waterfront hotel. After completing two rolls at an altitude of 200 feet to 300 feet, the airplane slowly rolled inverted and descended in an arc into the water.								
4/24/94*	Douglas C-47A (DC-3)	South Pacific Airmotive	Sydney, New South Wales, Australia	Unscheduled passenger	0	1	24	Substantial
Following takeoff, during climb through 200 feet AGL, the left engine reportedly failed. The engine was shut down and the propeller was feathered. The pilot apparently then was unable to climb or maintain altitude on one engine. The aircraft began to descend, and the pilot elected to ditch the aircraft in Botany Bay, just beyond the end of the runway. The aircraft came to rest some 100 meters from the shore. All occupants successfully evacuated the aircraft before it sank and were rescued by the crews of fishing boats.								
4/28/94	Piper PA-28	NA	English Channel	NA	1	0	0	Destroyed
The aircraft disappeared from radar while crossing the English Channel. No trace of the aircraft or pilot was found by the rescue services.								
5/1/94*	Beech 35	NA	Gustavus, Alaska, U.S.	Personal	0	0	2	Substantial
The pilot switched from his auxiliary fuel tank to his left-main fuel tank when the engine stopped producing power. He had to ditch the airplane in the bay.								
5/7/94*	Piper PA-46-310P	NA	Gulf of Mexico	Personal	0	0	4	Destroyed
During cruise flight, engine-oil pressure declined to zero. The pilot shut down the engine and made a forced landing in the Gulf of Mexico near a ship. The airplane remained afloat for five minutes to seven minutes. During this time, the emergency exit was opened. All occupants donned life vests, exited and boarded the life raft, which the pilot had deployed. All were rescued by personnel from the ship.								
5/21/94	Mid State Ultra Light Challenger II	NA	Islamorada, Florida, U.S.	Personal	1	0	2	Substantial
While the airplane was on final approach for landing at 75 feet to 150 feet AGL, the airplane rolled to the left and the nose pitched down. The pilot attempted a recovery procedure without success. The airplane struck water in a nose-down attitude.								
5/22/94*	Ercoupe 415D	NA	Boynton Beach, Florida, U.S.	Personal	0	0	2	Substantial
While on the approach, the pilot said, he inadvertently pulled the mixture control instead of the carburetor heat control. After realizing his mistake, he pushed in the mixture control but the engine did not respond. Unable to land at the airstrip, he ditched the aircraft into a canal short of the airstrip.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
5/24/94*	**Cessna 152**	NA	Kenai, Alaska, U.S.	Instructional	0	0	1	Destroyed
The student pilot was completing an extended cross-country flight. Fuel exhaustion occurred two minutes before landing, and the pilot ditched the airplane.								
5/26/94	Mitsubishi Mu-2B-60	Air Oceana Tahiti	Papeete, Tahiti, French Polynesia	Medical evacuation	5	0	0	Destroyed
During the final stage of an ILS approach, the aircraft struck the sea. Just before the accident, the pilot had reported the airfield in sight. There was no indication of a problem and no distress call was received.								
5/28/94*	Cessna A150L	Airplane Sales and Service	Leonardtown, Maryland, U.S.	Personal	0	0	1	Destroyed
The pilot was making low-level circular passes over a residence when the engine failed. The pilot adjusted the throttle and mixture but could not restart the engine. He ditched the aircraft in a pond behind the residence. The pilot exited the airplane as the airplane sank.								
5/28/94*	Cessna P210N	D.C. Leasing	Milwaukee, Wisconsin, U.S.	Personal	0	0	4	Substantial
The pilot told ATC that the airplane's fuel gauges were "dipping" while he was flying the airplane to his home airport. He asked ATC for a diversion to a closer airport. While the pilot was talking to ATC, the airplane's engine stopped functioning and the airplane was ditched in a lake.								
5/31/94	Cessna 172N	Venture Aviation	Roosevelt, Arizona, U.S.	Personal	0	1	0	Destroyed
Witnesses in boats said that the aircraft was flown in a low pass over an airstrip, then was flown out over the lake surface at an estimated 50 feet AGL. The aircraft was flown for about a mile over the water, then was seen to begin a turn. The left wing tip struck the water and the aircraft cartwheeled into the lake. The witnesses said that the lake surface was glassy smooth.								
5/31/94*	Cessna 210L	Mercy Flight	Pahokee, Florida, U.S.	Personal	0	0	2	Substantial
The pilot was practicing an instrument approach. His improper positioning of the fuel selector valve caused an engine failure because of fuel starvation at an altitude that was too low for restart procedures. The pilot made a forced landing on a lake.								
6/6/94*	Beech 24R	Vest Air Leasing	Nantucket, Massachusetts, U.S.	Personal	2	0	0	Destroyed
The pilot advised ATC that the airplane engine had failed, he was unable to maintain altitude and was ditching the airplane. Initial attempts to locate the wreckage and rescue the pilot and passenger were unsuccessful. There was no survival equipment aboard the airplane.								
6/12/94*	Dale Tiny Two	Pilot	Hesperia, California, U.S.	Personal	0	0	1	Substantial
The engine failed and the pilot, after unsuccessfully attempting to restart the engine, ditched the aircraft in a lake. The aircraft sank in 30 feet of water.								
6/19/94*	Waco YMF5	NA	Put-in-Bay, Ohio, U.S.	Business	0	0	3	Substantial
While the airplane was in cruise flight at 1,700 feet over a lake, the engine failed. The pilot was unable to restart the engine and was forced to ditch the airplane. The pilot said that the shore of the lake was heavily covered with trees and he had not thought it would be safe to attempt a landing there.								
6/19/94	Cessna 152	West Valley Flying Club	Half Moon Bay, California, U.S.	Personal	2	0	0	Destroyed
The pilot and passenger departed a coastal airport as the return portion of a night cross-country flight. The departure route placed the airplane over an ocean bay. Weather was reported as an 800-foot to 1,000-foot overcast. Witnesses heard the aircraft engine and then observed the airplane descending from the bottom of the overcast in a spin. The airplane struck the water in a near-vertical, nose-down attitude.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/22/94	De Havilland DHC-3	Wings of Alaska	Juneau, Alaska, U.S.	Unscheduled passenger	7	4	0	Substantial
The accident aircraft, a floatplane, was one of five to depart a lodge. The pilot of the first aircraft radioed to the pilots of the other aircraft to cross the river to the east shoreline. A passenger in the accident aircraft said that when the aircraft was over the middle of the river, she could not see either shore through the fog. The pilot of the accident aircraft said that he encountered deteriorating weather and began a descent, intending to make a precautionary landing. He began to level the aircraft, expecting conditions to improve. The floatplane struck the surface of "glassy water."								
6/25/94	Skybolt	NA	Penzance, England	Commercial aircraft test	2	0	0	Destroyed
The pilot failed to recover from an aerobatic maneuver and the aircraft struck the sea.								
6/30/94*	Piper PA-30	NA	Sandy Hook, New Jersey, U.S.	Personal	0	0	1	Destroyed
During cruise flight, the no. 1 engine failed. The pilot's attempts to restart the engine were unsuccessful. The pilot was unable to feather the propeller, and ditched the airplane in the Atlantic Ocean. The airplane came to rest in about 200 feet of water, and was not recovered.								
6/30/94	Lake LA-250	NA	Jefferson City, Missouri, U.S.	Maintenance test	0	0	2	Destroyed
During the takeoff run on the Missouri River, the airplane "porpoised" on the choppy water, became airborne, then descended nose-first into the water. The pilot and passenger escaped through the popped-out windshield and were later rescued. The airplane was not recovered from the river.								
7/3/94	Kitfox	NA	Cranfield, England	Aerial observation	0	0	2	Substantial
The aircraft struck the surface of a lake during air-to-air photography of another aircraft.								
7/6/94	Consolidated PBY-5A Catalina	Erickson Group	Lincoln City, Oregon, U.S.	Crew training	0	0	2	Major partial
During the takeoff run on Devil's Lake in strong crosswinds, gusting up to 30 knots, the pilot was unable to maintain directional control and elected to abort the takeoff. He then found that there was only limited steering because the aircraft was not equipped with a water rudder. The aircraft struck a boat house.								
7/6/94*	Cessna U206G	NA	Whyalla, South Australia, Australia	Aerial observation	1	0	1	Destroyed
The aircraft was flown in a survey flight between 110 feet and 600 feet AGL. At 83 kilometers south of Whyalla, the pilot declared mayday, advising of an engine failure, but did not have time to give the exact location. After an extensive search, the passenger was found alive in Spencers Gulf by fishermen, and a short time later the body of the pilot was found in the same area.								
7/8/94	Cessna T210M	NA	Beaver Island, Michigan, U.S.	Business	2	0	0	Destroyed
The private pilot and pilot-rated passenger, neither of whom had an instrument rating, attempted to take off the aircraft from an island in Lake Michigan. Weather was reported as dense fog and low ceilings. The airplane struck the lake less than one mile from the departure end of the runway.								
7/8/94*	Piper PA-32-260	NA	Gulf of Mexico	Personal	1	3	0	Destroyed
While the airplane was over water, an engine failure occurred. Before ditching, the pilot advised ATC of his position. The airplane was ditched at sea, and the four occupants egressed from the sinking plane. The pilot reported that three life vests were aboard the airplane, but they were not recovered before the airplane sank. (The pilot had not briefed the passengers about the life vests before the flight.) About three minutes after ditching, a Coast Guard airplane flew overhead and found the four survivors. A rescue boat and a helicopter were dispatched to the area, but one of the survivors drowned before help arrived.								
7/15/94	Cessna 172XP	NA	Indian Shores, Florida, U.S.	Ferry	1	0	0	Destroyed
The airplane was seen flying about 200 feet above the water along the beach. A large bird collided with the airplane in the windshield area. The airplane rolled inverted and struck the water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
7/24/94*	Ted Smith Aerostar 601	Island Air Export	Atlantic Ocean	Personal	0	1	0	Destroyed
Smoke and heat began coming from under the instrument panel, and the communication radios failed. The pilot turned off the master battery switch, and smoke "poured" out from under the instrument panel. He elected to ditch the airplane near a boat.								
7/29/94	Bellanca 17-30	Wooden Airplane Co.	Waterford, Michigan, U.S.	Personal	0	3	0	Substantial
During the climbout, the engine ran roughly, then failed. The pilot reported that during the descent he attempted to switch fuel tanks. The airplane struck a lake.								
8/12/94	Piper PA-18-150	NA	Grand Lake Stream, Maine, U.S.	Personal	1	0	0	Destroyed
While the airplane was flying just above the surface of Lake Pocumcus, the pilot initiated a vertical climb. A witness said that the airplane gained about 300 feet altitude and airspeed declined severely. The airplane descended straight down and struck the water.								
8/14/94	Piper PA-601P	NA	Atlantic Ocean	Personal	4	0	0	Destroyed
The airplane struck the Atlantic Ocean. Thunderstorms and IMC prevailed. A portion of the airplane and its occupants were located on, and recovered from, the ocean floor on Oct. 1, 1994.								
8/18/94	Piper PA-23	NA	San Juan, Puerto Rico, U.S.	Personal	0	0	2	Substantial
The pilot said that during the takeoff the left engine failed. The aircraft drifted to the left and did not climb high enough to clear a construction crane to the left of the runway. The left wing of the aircraft struck the crane and the aircraft descended and struck the water in an upright attitude.								
8/26/94	Dassault DA 200	Aerocorp	Lake Pontchartrain, Louisiana, U.S.	Corporate/ executive	0	0	7	Substantial
The captain initiated an abort late in the takeoff roll, but the aircraft accelerated 12 knots past V_R (rotation speed) before deceleration began. During the abort, the airplane ran off the end of the runway and into the lake.								
8/28/94*	Grumman S2F FireCat	Conair Aviation	Quesnel, British Columbia, Canada	NA	0	0	1	Destroyed
While the aircraft was in cruise flight at 6,500 feet, the pilot noted that the power from the no. 1 engine was considerably reduced from normal. The aircraft then began to vibrate and oil was seen to be streaming from the no. 1 engine breather pipe. The pilot elected to shut down the no. 1 engine and feather the propeller. During the shutdown procedure, the pilot inadvertently activated the firewall shutoff switches to the no. 2 engine. With no power being produced by either engine, the pilot decided to conduct a forced landing in the Fraser River.								
9/16/94	Piper PA-28-236	Pilot	Vernon, New Jersey, U.S.	Business	2	0	0	Destroyed
The instrument-current pilot was cleared to fly the airplane to 6,000 feet. Radar data showed that the airplane began a right turn and climbed to 3,300 feet, then descended to 3,200 feet and continued the right turn. The turn and descent continued until radar contact with the airplane ended. One witness saw the airplane descend into the water.								
9/17/94	DHC-6 Twin Otter 100	Pacific Coastal Airlines	Port Hardy, north of British Columbia, Canada	Unscheduled passenger	3	1	0	Destroyed
On takeoff, as the flaps were being retracted after the aircraft became airborne, the aircraft suddenly pitched up "violently." Control was not regained by the pilot and the aircraft struck the water and sank. The loss of control apparently followed the failure of the down-elevator-control cable, resulting from salt-water–induced corrosion.								
9/21/94*	Cessna 177RG	NA	Massacre Point, Queensland, Australia	Personal	0	0	2	Destroyed
The pilot reported that the engine failed during cruise at 8,500 feet. The aircraft was over water and the pilot initiated a glide toward the coast. The airplane was ditched in the Gulf of Carpentaria. Both occupants were rescued by SAR helicopter.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/23/94	Lockheed 100-30 Hercules	Pelita Air Service	Hong Kong, China	Ferry	6	4	2	Destroyed
Following a normal takeoff, the pilot heard a "high-pitched noise" from the right and the aircraft began to yaw and bank toward the right. The pilot attempted to control this movement by applying left aileron, then left rudder, but was unsuccessful. Control was not regained; the aircraft lost altitude and struck the waters of Kowloon Bay.								
9/26/94*	Yakovlev Yak-40	Cheremshanka Airlines	Vanavara, Russia	Scheduled passenger	28	0	0	Destroyed
After three missed approaches were conducted at the scheduled destination because of weather, the flight was diverted to the alternate airport, Vanavara. As the pilot neared Vanavara, some 3.5 hours after departure, the fuel exhaustion occurred and all three engines failed. The pilot attempted to conduct a forced landing on the Chamba River but apparently the aircraft struck the river bank and was destroyed.								
10/5/94*	Rutan VariViggen	NA	Lake Rotorua, New Zealand	Personal	0	0	NA	Substantial
The report said only, "Canopy detached, hit propeller, aircraft ditched."								
10/18/94*	Piper PA-28	NA	English Channel	Personal	0	0	1	Substantial
The engine failed twice, recovered each time, then failed and could not be restarted. The pilot declared mayday and ditched the aircraft in the sea. The aircraft sank three minutes later. The life raft could not be inflated. The pilot was rescued by the coast guard and was treated for mild hypothermia.								
10/20/94*	Piper PA-28-140	NA	Mana Island, New Zealand	Personal	0	0	2	Destroyed
The report said only, "Engine failure, aircraft ditched."								
10/27/94	United Consultant Corp. UC-1	NA	Fremont Lake, Wyoming, U.S.	Instructional	2	0	0	Substantial
The private pilot was receiving instruction to obtain a multiengine sea rating. Witnesses reported hearing what sounded like an explosion. The airplane was later found submerged in the lake. A pilot who flew over the lake shortly after the accident reported rough and turbulent conditions with severe downdrafts. He also reported that the lake was choppy, with whitecaps.								
10/30/94	Cessna 175 Skylark	NA	Irish Sea	Personal	2	0	0	Destroyed
Radio contact with the aircraft was lost as it was flown over the Irish Sea. SAR was deployed but was unable to locate the wreckage. Eight days later small pieces of the aircraft and the passenger's body were found. No life vest was worn.								
11/5/94	Boeing A-75N1	Pilot	Sayville, New York, U.S.	Personal	2	0	0	Destroyed
Several witnesses, both on the ground and in flight, saw the airplane being maneuvered. The ground witnesses reported that the airplane completed a loop and then struck the water in a nose-low attitude. The in-flight witness reported that the airplane was in a steep left turn, entered a left spin, recovered and struck the water in a nose-low, wings-level attitude.								
11/9/94	Learjet 55	Líder Taxi Aéreo	Rio de Janeiro, Brazil	Unscheduled passenger	0	0	5	Destroyed
The aircraft overran the runway on landing and fell into the waters of Guanabara Bay.								
11/12/94*	Pezetel 106A	NA	Gulf of Mexico	Ferry	1	0	0	Destroyed
The agricultural airplane was equipped with a kit that extended its fuel range to 10 hours. It was being transported to Caracas, Venezuela, from Americus, Georgia, U.S. According to the Coast Guard, the airplane circled a Liberian-registered ship for about 10 minutes with an intermittent rough-running engine, until the airplane was ditched in the sea with eight-foot to 10-foot waves. The vessel was not able to rescue the pilot or to recover the wreckage.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
12/2/94*	Britten-Norman Islander BN2B-20	Southern Cross Aviation	Pacific Ocean	Ferry	0	1	0	Destroyed
The airplane was being operated as part of a flight of two on a ferry flight from the Marshall Islands to Honolulu, Hawaii, U.S. About two hours after departure, while at an altitude of 7,000 feet, the accompanying airplane's pilot noticed smoke emerging from the accident airplane's left engine. The accident airplane's pilot declared an emergency. The left engine failed and the pilot feathered the propeller. The pilot was unable to maintain level flight and the aircraft was ditched in rough water and sank. The pilot launched and boarded a raft and was rescued 20 hours later.								
12/10/94*	Piper PA-28-235	NA	Seattle, Washington, U.S.	Personal	2	0	0	Destroyed
The aircraft was ditched in Puget Sound following an engine failure caused by fuel exhaustion.								
12/30/94*	Piper PA-32R-300	NA	Bermagui, New South Wales, Australia	Personal	0	0	1	Destroyed
The pilot reported that he was flying at 500 feet, taking photographs of a boat, when there was a sudden and severe engine vibration. Concerned that the engine might break its mounts, the pilot shut down the engine and ditched the aircraft in the sea.								
1/2/95	Cessna 208 Caravan I	Taquan Air Service	Craig, Alaska, U.S.	Scheduled passenger	0	0	8	Major partial
After landing, just after the float-equipped aircraft came off the step and the pilot began to taxi, its right float struck a partially submerged log. The aircraft sustained substantial damage to its floats and left wing.								
1/10/95	DHC-6 Twin Otter 300	Merpati Nusantara Airlines	Flores Island, Indonesia	Scheduled passenger	14	0	0	Destroyed
The aircraft disappeared while en route and was believed to have struck the Malo Strait between Flores and Rinja Island. The accident happened in daylight but in "bad weather."								
1/11/95	Learjet 35	Canada Jet Charters	Dixon Entrance, Queen Charlotte Island, Canada	NA	5	0	0	Destroyed
The aircraft apparently was flown into the waters of Dixon Entrance while the pilot conducted an NDB approach to Masset, Queen Charlotte Island.								
1/11/95	McDonnell Douglas DC-9-14	Intercontinental Colombia	Maria la Baja, Colombia	Scheduled passenger	51	1	0	Destroyed
The aircraft struck the water of Maria la Baja while positioning for a VOR/DME approach to a runway at Cartagena. No problems had been reported by radio.								
2/9/95	Cessna 172G	NA	Pope Valley, California, U.S.	Personal	1	0	0	Destroyed
The airplane was seen flying in a nose-level attitude over a lake. The airplane struck high-tension wires that spanned the lake, plunged into the water and sank.								
2/12/95	Cessna 182Q	San Carlos Flight Center	San Francisco, California, U.S.	Personal	3	0	0	Destroyed
The aircraft struck the ocean about five miles west of San Francisco under undetermined circumstances.								
2/20/95*	Piper PA-32-260	NA	Caribbean Ocean	Personal	2	0	0	Destroyed
While the aircraft was being climbed through 1,700 feet, the pilot said, there was a total engine failure. The pilot notified the tower of the emergency, attempted to restart the engine unsuccessfully, and made a forced landing in the Caribbean Sea.								
3/3/95*	Cessna 175	NA	Quantico, Virginia, U.S.	Personal	0	0	1	Substantial
The failure of a connecting rod resulted in engine failure and a zero oil-pressure indication. The pilot ditched the airplane in the Potomac River.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
3/12/95	Piper PA-32R-300 Lance	Excelair Services	Mediterranean Sea	Unscheduled passenger	6	0	0	Destroyed
The aircraft disappeared while en route and was believed to have struck the sea. The accident happened in darkness and in "bad weather."								
3/12/95	Boeing 737-200	Cameroon Airlines	Douala, Cameroon	Scheduled passenger	72	6	0	Destroyed
The aircraft was destroyed when it struck a mangrove swamp while on approach to Douala. According to unconfirmed reports, the accident occurred during a go-around.								
3/16/95*	DHC-6 Twin Otter 200	Great Barrier Airlines	Pacific Ocean	Ferry	0	0	3	Destroyed
While the aircraft was in normal cruise flight at 12,000 feet, some 400 miles from Hawaii, U.S., the pilot declared an emergency and reported "fuel transfer problems." The flight was continued toward Hawaii but, when still some 175 miles from the islands, the pilot was forced to ditch. The aircraft later sank; the three occupants were rescued.								
3/24/95	Aeronca 7AC	NA	Dauphin Island, Alabama, U.S.	Personal	0	2	2	Substantial
According to witnesses, the airplane was flying about 10 feet above the water, and about 150 yards from the shore. The airplane then climbed abruptly and the engine noise stopped. The airplane nosed over and struck the water, nearly straight down.								
3/28/95	Cessna 172N	NA	Venice, Florida, U.S.	Personal	2	1	1	Substantial
After takeoff, the aircraft was observed to be flown into the fog several times and the aircraft was flown over the airport three times. After the third pass, the pilot told the passengers that he was going to land on the next attempt. The aircraft was again seen entering the fog and the survivors later said that they heard the stall-warning horn. The pilot applied power but the aircraft descended nose-low and right-wing-low, then struck the water.								
4/8/95	Cessna 172F	NA	Seneca, South Carolina, U.S.	Personal	1	1	0	Substantial
After takeoff, the pilot turned south toward Lake Keowee. As the flight approached the lake, the pilot decided to circle his brother's lakeside home. As the pilot maneuvered the airplane, it struck a set of utility lines that crossed the lake. The airplane fell 140 feet into the lake.								
4/22/95	Bombardier Searey	Pelican Corp.	Orlando, Florida, U.S.	Personal	0	0	1	Substantial
The pilot was taxiing the airplane after landing and observed an alligator to his left. He said that he abruptly applied aileron flight-control input and the right wing struck the water. The airplane sank.								
4/23/95*	Mooney M20J	NA	Cleveland, Ohio, U.S.	Personal	0	0	2	Substantial
During the approach, the engine began to run roughly. As the airplane neared the airport, the roughness ended. The pilot elected to overfly the airport and land on a different runway. As the airplane turned to final approach, the engine failed and there was insufficient altitude to reach the runway. The pilot ditched the airplane in Lake Erie.								
4/24/95	Cessna 185E	Harbour Air	Surf Inlet, British Columbia, Canada	Unscheduled passenger	1	0	2	Destroyed
The float-equipped aircraft had been chartered to meet with a tug boat. The aircraft capsized, probably when the pilot attempted to turn it while operating in extremely rough water and in a strong wind. Water had also leaked into the floats. After the aircraft capsized, the pilot gave both passengers a life vest, took one himself, and all three men jumped into the water. The two passengers reached the shore, but they said that the pilot was swept away by the current and that he slipped from his life vest. He was presumed to have drowned.								
4/29/95*	Piper PA-28	NA	North Sea	Personal	1	0	0	Destroyed
The aircraft was ditched in the sea after engine failure. The pilot evacuated the aircraft uninjured, but in the 19 hours before SAR services located him, he died of drowning or hypothermia because of inadequate survival protection.								
5/5/95	Piper PA-32-260	R&D Aero Service	North Miami Beach, Florida, U.S.	Personal	0	0	1	Substantial
Soon after takeoff, the pilot observed that the oil pressure began decreasing. He turned the airplane to return to the departure airport, but the engine failed and the airplane struck a lake near the airport.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
5/12/95*	Cessna 310K	NA	Sequim, Washington, U.S.	Personal	0	0	4	Substantial
After about 50 minutes of flight, while over the water at an altitude of less than 1,000 feet, the right engine developed a strong vibration. In response, the pilot shut down the right engine. According to the pilot, he was then unable to obtain sufficient power to maintain level flight in single-engine operation. He could not reach a suitable landing area. The airplane was ditched at sea on "glassy" water and sank in about 150 feet of water.								
5/16/95*	BAe Nimrod R.1P	Royal Air Force	Moray Firth, Scotland	Test	0	0	7	Destroyed
About 30 minutes after takeoff on a test flight, while the aircraft was flying at 15,000 feet, a fire broke out on the no. 4 engine. Attempts to extinguish the fire proved unsuccessful and it apparently quickly spread to the no. 3 engine. The pilot declared an emergency and diverted to RAF Lossiemouth, but the situation rapidly worsened with the fire spreading to the wing. The pilot subsequently decided to carry out an immediate ditching in the Moray Firth some four miles off Lossiemouth. The aircraft touched down at relatively low speed in a nose-up attitude. Despite the sea being described as "calm," the aircraft bounced twice and its fuselage aft of the wing trailing edge failed and broke away shortly after it came to rest. Nevertheless, the main part of the aircraft remained afloat for some 20 minutes, allowing the crew to escape.								
5/21/95	Cessna 310Q	Air Southwest Florida Corp.	Atlantic Ocean	Ferry	1	0	0	Destroyed
The aircraft was over the ocean at night when the pilot reported a lack of fuel, and both engines failed. The airplane struck the ocean about 37 miles west of the Portuguese coastline.								
5/29/95*	Piper PA-31 Navajo	Senegalair	Dakar, Senegal	Unscheduled passenger	6	3	1	Destroyed
About 40 minutes after takeoff, the pilot asked Dakar ATC for clearance to descend to FL 040 because of a technical problem and said that the aircraft was being flown on one engine. This was the last contact with the flight. The pilot subsequently attempted to ditch just off the shore close to Mbour. The aircraft came down about 500 meters from the beach and sank in shallow water.								
5/30/95	Piper PA-28-151	NA	Honolulu, Hawaii, U.S.	Personal	3	0	0	Destroyed
The pilot reported an engine failure to ATC. The pilot reported that he had less than 10 U.S. gallons of fuel and that there were three people on board. ATC radio and radar contact with the aircraft ended. A pilot flying in the vicinity reported seeing the aircraft inverted in the water. The bodies of two victims were recovered from the water and the third was missing.								
6/1/95	Aero Commander 680	Pilot (co-owner)	North Bend, Oregon, U.S.	Personal	3	0	0	Destroyed
About two minutes after takeoff, witnesses saw the airplane being pulled up sharply into a steep climb from underneath an 800-foot ceiling. The airplane then went into an uncontrolled, nearly vertical dive and struck a river.								
6/2/95*	Cessna 402B-II	Líneas Aéreas Entre Rios	River Plate, Buenos Aires, Argentina	Personal	6	0	1	Destroyed
Shortly after takeoff, power reportedly failed on one engine. The pilot apparently elected to return to the departure airport and initiated a 180-degree left turn. The aircraft began to lose altitude and was ditched in the river some 2,700 meters from the shore, about three minutes after takeoff. The aircraft subsequently sank.								
6/2/95	Piper PA-32-260	Corporate Charter Services	Vieques, Puerto Rico, U.S.	Unscheduled cargo	1	0	0	Substantial
The airplane was observed to depart and fly at a low altitude until it disappeared. The airplane was located on the sea bottom about one month later. The pilot was not located.								
6/14/95*	Vans RV6	NA	Sligo Bay, Ireland	NA	0	0	1	Destroyed
The engine failed because of fuel starvation, subsequently found to be the result of an unapproved modification to the fuel system. The aircraft was ditched in the sea.								
6/20/95	De Havilland DHC-2/Piper PA-12	NA	Nondalton, Alaska, U.S.	Business/ Personal	5	0	0	Destroyed
The float-equipped De Havilland, on a local-business flight transporting fishing-lodge clients, collided with the Piper PA-12, on a personal flight. Both aircraft descended into a river in the remote area.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/24/95*	Piper PA-36-300	Cooperativa de Elet LTDA	Atlantic Ocean	Ferry	0	0	1	Destroyed
The pilot said that he had just changed the fuel selector to the hopper tank when the engine failed. He switched the fuel selector back to the main tank but was unable to restart the engine. He ditched the airplane and was picked up by a passing boat.								
7/5/95	Piper PA-18	NA	Nulato, Alaska, U.S.	Personal	1	2	0	Substantial
The pilot was flying the airplane low along the Yukon River when he elected to maneuver at low altitude. The airplane struck the water when the airplane was at low airspeed during a turn. An investigation revealed that the passenger who was killed had been sitting in the extended baggage compartment, which was not equipped with a seat or a seat-restraint system.								
7/5/95	Mooney M20F	NA	Cedar Key, Florida, U.S.	Personal	1	0	0	Destroyed
Radar data indicated that the airplane was on a heading of 123 degrees. The controller suggested that the airplane be flown south for about 25 miles to avoid thunderstorms. Radar data for the next seven minutes indicated that the airplane's heading was changed only to 148 degrees. The pilot advised the controller that the flight was experiencing turbulence. The airplane then entered a rapid descent from 9,200 feet to 1,100 feet, after which radio and radar contact ended. Wreckage from the airplane was located in the Gulf of Mexico.								
7/10/95	Cessna A185F Skywagon	Mount Lake Air Service	Elliot Lake, Ontario, Canada	Unscheduled passenger	3	1	0	Destroyed
The pilot performed an aerobatic maneuver at low altitude in a heavily loaded floatplane with insufficient altitude to complete the maneuver. One passenger was thrown from the airplane at impact, after which a helicopter operating in the area evacuated him to a hospital.								
7/11/95*	Piper PA-18-150	NA	McCall, Idaho, U.S.	Personal	0	0	2	Substantial
During the climb phase of a go-around, the airplane encountered downdrafts. The airplane could not be flown so as to clear the terrain and the pilot maneuvered the airplane for a forced landing in a river.								
7/12/95	DHC-6 Twin Otter 300	Milne Bay Air	Alotau, Papua New Guinea	Scheduled passenger	15	0	0	Destroyed
About half an hour after takeoff, the aircraft was seen in a steep dive after an apparent loss of control. Control was not recovered and the aircraft struck shallow water just offshore. The investigation found indications of an in-flight fire in the rear of the fuselage.								
7/14/95	Cessna 172A/ Piper PA-18	Pilot/owner	Naknek, Alaska, U.S.	Aerial observation	2	0	0	Destroyed
Two float-equipped airplanes, both on fish-spotting missions, collided while maneuvering about 400 feet above the water. After the collision, both airplanes broke apart and fell into the water.								
7/29/95	Cessna 421C	Business Flying Enterprises	Cordova, Alaska, U.S.	Personal	4	0	0	Destroyed
The pilot radioed ATC and said that his airplane's right engine had come apart. The pilot attempted to fly to and land at Middleton Island, Alaska. During the flight, the airplane consistently descended. He flew past the island and was southeast of the island when radar contact ended. Flight crewmembers of rescue aircraft said that they saw bubbles, an oil slick and airplane debris in the ocean about three miles south of the Middleton Island airport.								
8/2/95*	Cessna 206G	Rust's Flying Service	Skwentna, Alaska, U.S.	Unscheduled passenger	0	0	4	Substantial
About 45 seconds after takeoff from a remote lake, the engine of the float-equipped airplane failed. The pilot performed an emergency landing in an adjacent creek.								
8/12/95*	Cessna 177B	NA	Seattle, Washington, U.S.	Personal	0	0	4	Substantial
While the airplane was in cruise flight approaching the final destination in a three-segment recreational flight, the engine failed. The pilot ditched the airplane offshore.								
8/18/95*	Beech P-35	NA	Bend, Oregon, U.S.	Business	0	0	1	Substantial
During cruise flight, the pilot observed a reduction in oil pressure, which was followed by a total engine failure. The pilot elected to ditch the airplane in Lava Lake, because no other suitable forced-landing site was available.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/26/95*	Cessna 172	NA	Atlantic Ocean	Personal	0	0	1	Destroyed
The engine power began to decrease while the airplane was over the ocean, about 35 miles east of the destination of West Palm Beach, Florida. The pilot initiated a glide and prepared for ditching. Just before impact, he observed oil on the windshield and cowling. After the ditching, the pilot exited the airplane, inflated his life vest, and was soon rescued.								
8/28/95	Beech E-18S	Caribbean Leasing Co.	Atlantic Ocean	Unscheduled cargo	1	0	0	Destroyed
While en route at 6,000 feet, 46 miles from Freeport, Bahamas, his destination, the pilot radioed the Miami (Florida, U.S.) Flight Service Station and requested a weather briefing for Freeport. The pilot then reported an emergency. When asked its nature, he replied, "Fire onboard." No further transmissions from the flight were received and efforts to contact the flight were unsuccessful. SAR efforts were initiated. Two and one-half hours later, an oil slick, the accident aircraft's left-main landing gear and debris were found floating on the ocean surface 40 miles from Freeport. The main wreckage was not recovered.								
9/3/95	Cessna 172M	NA	Orr, Minnesota, U.S.	Personal	1	0	1	Destroyed
A witness said that the airplane appeared "fast" on final approach and was not flared before striking the water. On impact the airplane "nosed over to the right." The witness noted that the water was "glassy smooth" at the time of the accident. The pilot-rated passenger reported that the pilot flew a "steep" final approach.								
9/3/95	Druine D31 Turbulent	NA	Rye, England	Personal	0	0	1	Substantial
The aircraft was seen by witnesses to fly overhead and then enter a spin to the right, going through 270 degrees before striking a river at a steep angle of descent. The pilot, who had no recollection of the accident, was rescued from the river bank.								
9/4/95	Gillet C.P. 328	Pilot	Fire Island, New York, U.S.	Personal	1	1	0	Destroyed
The pilot/owner departed with another pilot for a local flight in the kit airplane designed for aerobatics. About 25 minutes later, witnesses 0.75 mile offshore saw the airplane strike the water in a spin. The second pilot had been seen two hours earlier that day in another airplane performing aerobatics over the water near the area of the accident.								
9/10/95*	Cessna 180A	Alaska Air Ventures	Glennallen, Alaska, U.S.	Public use	0	0	1	Destroyed
The pilot of the float-equipped airplane was departing from a remote lake after deplaning two hunters. Winds from a nearby glacier produced choppy waves, three feet to four feet high. The wind was estimated at 30 knots. During the takeoff run, the floats received several hard impacts from the waves that were washing over the tops of the floats. The pilot aborted the takeoff. The left float began to fill with water and the airplane rolled over. The pilot exited the airplane and climbed onto the inverted airplane floats. The floating airplane was spotted by a passing float-equipped airplane that landed to lend assistance. The pilot had developed symptoms of hypothermia. The pilot was unable to retrieve a rope from the other airplane but did manage to grab a sleeping bag. The second airplane departed to radio for more assistance. The pilot received serious injuries during a rescue attempt and subsequent accident to a helicopter that came to the pilot's aid. The airplane sank after the rescue.								
9/20/95	DHC-3 Otter	Walston Air Services	Kenora, Ontario, Canada	Unscheduled passenger	6	0	0	Destroyed
The aircraft appeared to have been making a normal approach until its right wing suddenly dropped. Control was not recovered and the aircraft struck the water in a nose-down, right-wing-low attitude, about 0.25 mile short of the expected touchdown point.								
9/24/95	Snyded Pitts S1E	NA	Somers, New York, U.S.	Personal	0	0	1	Substantial
The pilot said that he "saw the water and went down to get a closer look." The airplane struck power lines during the descent. The pilot said that he "put the plane down on the water." Although the pilot received only minor injuries, a 46,000-volt power line fell into the water, resulting in three persons being ejected from their boat. The three boat occupants attempted to swim to shore, but two were killed, apparently by electrical shock.								
10/1/95*	Mooney M20E	Pilot	Long Beach, California, U.S.	Personal	1	0	2	Destroyed
While flying the airplane over the ocean, the pilot reported to the radar sector controller that the engine failed. The engine restarted, but did not sound like it was in good condition. Then the pilot reported that the engine had failed again and that he was going to ditch the airplane in the ocean. The sector controller immediately initiated SAR procedures. The two passengers were rescued; neither the pilot nor the airplane was recovered.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
10/2/95	Cessna 172M	NA	Fillmore, California, U.S.	Instructional	0	0	1	Substantial
The engine failed in flight because of fuel exhaustion. During the landing roll, the airplane nosed over when it struck a river.								
10/17/95*	SIAI Marchetti SF.260	NA	Atlantic Ocean	Ferry	0	0	1	Destroyed
The pilot reported that the engine had failed for unknown reasons. The pilot ditched the airplane in the Atlantic Ocean about 129 miles southeast of Great Exuma, Bahamas. He was rescued by the Coast Guard, but the aircraft was not recovered.								
10/18/95	Dornier 228-200	Air Maldives	Male, Maldives	Scheduled passenger	0	1	7	Destroyed
At touchdown or shortly after touchdown, the aircraft yawed toward the left. The co-pilot, who was the pilot flying, reportedly overcorrected for the yaw and the aircraft turned "abruptly" to the right. The captain then attempted to regain control but the aircraft ran off the side of the runway. It continued across the grass and fell into the sea.								
10/18/95*	Piper PA-31-350	East Coast Aviation Services	Atlantic Ocean	Unscheduled passenger	0	0	5	Substantial
While the airplane was being flown from 5,000 feet to 3,000 feet, the pilot informed ATC that the left engine had failed and the engine cowling was open. The flight crew was unable to arrest a descent of 300 feet per minute to 500 feet per minute. The crew informed ATC that they would be landing in the water. All the occupants exited from the left-front pilot's emergency door. The survivors were in the water for about 30 minutes before being rescued.								
10/26/95	Beech 65-B80	Dana Lisa Nyerges	Paint Rock, Texas, U.S.	Unscheduled cargo	2	0	0	Destroyed
Witnesses observed the airplane strike the water while "buzzing" a lake, "emerge from a cloud of water" and enter a climb trailing white vapor." As the airplane approached the lake shore, the right propeller stopped turning and the airplane entered a steep right bank and struck the ground.								
11/10/95	Piper PA-23-250	Fairbank Farms	Ashville, New York, U.S.	Executive-Corporate	1	0	0	Destroyed
The aircraft was being flown on final approach to a private airport at night, with crosswinds present. The runway had no electronic or visual glideslope. The aircraft struck trees and came to rest, inverted, in a reservoir abeam of the approach end of the runway.								
11/19/95	Beech 58	NA	Cleveland, Ohio, U.S.	Personal	3	2	0	Destroyed
After the airplane was airborne following takeoff, the tower controller instructed the pilot to contact departure control. The pilot acknowledged, and there was no further communication from the pilot. The airplane struck a lake north of the airport. The pilot of another airplane, who departed soon after the accident flight, reported being disoriented after departure because there was no visible horizon, overcast clouds blocked light from above and there were no lights from below.								
11/23/95	Cessna 150	Jersey Club	Sea, northwest of France	Personal	1	0	0	Destroyed
The aircraft was being flown under VFR when radar and radio contact ended. The wreckage and the pilot's body were found at sea.								
11/25/95	Bellanca BL-17-30A	NA	Kings Bay, Georgia, U.S.	Personal	2	0	0	Destroyed
On the approach to Jacksonville, Florida, in dark-night conditions, the pilot became disoriented and said to the approach controller, "10 miles east-northeast inbound landing, circle around out here and get a heading or give me vector." The airplane was assigned a discrete transponder code and the pilot was given the altimeter setting, wind information and the active-runway information. There was no further radio contact with the pilot. Radar data indicated that the airplane began a left descending turn. The engine was heard to be operating normally before the airplane struck the water.								
11/27/95*	Cessna 182P	NA	Dent Island, Queensland, Australia	Personal	0	0	1	Substantial
The pilot reported a total power failure when the aircraft was flying a circuit at Hamilton Island airport. The aircraft was outside gliding range to the runway and the pilot was forced to ditch the aircraft in shallow water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
11/29/95*	De Havilland DH-82A	NA	Perth, Western Australia, Australia	Unscheduled passenger	0	2	0	Substantial
The pilot declared mayday to the Perth approach controller, advising of an engine failure. The pilot also reported that he was attempting a forced landing. Soon afterward, the aircraft was seen by several witnesses to be apparently out of control and descending rapidly. The aircraft struck the Swan River.								
12/16/95	Cessna 150M	Private owner	South Padre Island, Texas, U.S.	Personal	2	0	0	Destroyed
Witnesses observed the airplane, whose pilot was non-instrument-rated, descend out of the "broken fog" 500 feet to 550 feet above the water. They said that the airplane circled 360 degrees as though trying to "avoid flying into the fog." The airplane was destroyed by impact with the water.								
12/26/95*	Cessna 152	Jack's Aircraft	Long Beach, California, U.S.	Personal	0	0	2	Substantial
While the airplane was being descended on an overwater flight, engine rpm decreased to idle. After checking the mixture and fuel selector with no improvement, the pilot ditched the airplane.								
12/27/95*	Stinson ST-108-2	Student pilot under instruction	Lake Dallas, Texas, U.S.	Instructional	0	0	2	Destroyed
The student pilot was at the controls after takeoff when, at about 500 feet AGL, the engine failed. The instructor pilot took over control of the airplane for an emergency descent and landing at the airport. The instructor pilot decided to ditch in a lake to avoid descent in a residential area. Both pilots exited the aircraft and swam to shore. The aircraft sank.								
1/5/96	Cessna 172N	NA	Bribie Island, Queensland, Australia	Business	2	0	0	Destroyed
Several pieces of aircraft wreckage were found on a beach on Bribie Island, and a woman's body was washed up about 35 kilometers farther north. The pilot's body was recovered from the ocean the next day. The main aircraft wreckage was not located.								
1/6/96	Mooney M20F	NA	Cape Charles, Virginia, U.S.	Personal	1	0	0	Destroyed
The pilot was advised that VFR flight was not recommended. He radioed approach control in Norfolk, Virginia, and requested permission to transition through their airspace. The pilot indicated that he intended to fly along the coast in an attempt to avoid the approaching winter storm. Radio contact with the airplane ended while it was being flown over Chesapeake Bay.								
1/7/96	Cessna 172P	Gulf Aircraft Leasing	Nassau, Bahamas	Personal	5	1	0	Destroyed
The pilot advised ATC that he was losing control of the aircraft. The aircraft failed to arrive at its destination and was later found to have struck the sea.								
1/7/96*	Piper PA-34-300T	NA	Gulfport, Mississippi, U.S.	Personal	0	0	4	Substantial
Inadequate preflight planning and preparation by the pilot resulted in fuel exhaustion and failure of both engines while the airplane was over water. The airplane was ditched about 1.25 miles from shore.								
1/8/96*	PBN BN-2A-27 Islander	Mustique Airways	Bridgetown, Barbados	Unscheduled passenger	1	0	9	Destroyed
About 40 minutes after takeoff, while in normal cruise flight at 7,000 feet, the aircraft had a sudden power failure on the right engine. Following the failure of the right engine, the pilot was apparently unable to maintain height on the remaining engine and the aircraft entered a gradual descent. At the time of the engine failure the aircraft was about 90 kilometers from Barbados, but was unable to reach land and eventually was ditched about 30 kilometers from the coast.								
1/8/96*	Cessna 172N	NA	Lantana, Florida, U.S.	Personal	0	0	2	Substantial
During an overwater flight, the engine failed, and the pilot was unable to glide the airplane to land. He ditched the airplane in the ocean about one mile from land. He and the passenger were rescued by the Coast Guard.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
1/9/96	Partenavia AP68TP-300S Spartacus	Aspen Helicopter	Pacific Ocean	Ferry	1	0	0	Destroyed
The aircraft entered an uncontrolled descent and struck the sea while en route from Oxnard, California, U.S., to San Diego, California. There was no distress call and the last contact with the pilot had been routine.								
1/13/96	Anderson EA-1 Kingfisher	NA	Lake Te Anau, New Zealand	Instructional	0	0	2	NA
The amphibious airplane was being flown in circuits at a land airport when the pilot was requested to vacate the airspace for a glider launch. The airplane was landed on the lake with the wheels still down.								
1/17/96	Piper PA-32	NA	Milwaukee, Wisconsin, U.S.	Business	1	0	0	Destroyed
The pilot was flying the airplane at night over Lake Michigan when he informed Milwaukee approach control that the engine had failed. From about 20 miles northeast of Milwaukee, the pilot was able to glide about 12 miles before the airplane struck the water. The body of the pilot and the wreckage of the airplane were recovered about two months after the accident.								
1/18/96	Piper PA-28-140	NA	Harwich, Massachusetts, U.S.	Personal	1	0	0	Destroyed
The non-instrument-rated pilot encountered IMC and the airplane struck water. The airplane was found submerged one mile from the shoreline.								
1/19/96*	Piper PA-28-236	NA	Seal Beach, California, U.S.	Personal	0	0	3	Substantial
An improperly installed magneto resulted in an engine failure during overwater flight. The pilot, unable to reach land, ditched the airplane in the ocean.								
1/28/96*	Beech 77	NA	Grand Prairie, Texas, U.S.	Personal	0	0	1	Substantial
When nearing the destination airport, the engine began producing reduced power. Because he detected a strong odor of fuel, the pilot was concerned about a possible in-flight fire and he elected to execute a forced landing in Joe Pool Lake.								
2/1/96	Lake LA-4-200	NA	Motuihe Island, New Zealand	Passenger	0	0	3	Substantial
While the amphibian was being taxied, it hit two small waves, bounced about 12 feet into the air, descended steeply and came to a sudden stop on the water. The airplane took on water and was taxied to shore in time to prevent its sinking.								
2/3/96*	Cessna 182 Skylane	NA	Mediterranean Sea	Personal	0	0	2	Destroyed
The airplane was ditched at sea off Rome, Italy, following engine failure.								
2/6/96	Boeing 757-200	Birgenair	Puerto Plata, Dominican Republic	Unscheduled passenger	189	0	0	Destroyed
The aircraft was destroyed when it apparently stalled, lost altitude and struck the sea five miles off the coast some five minutes after takeoff. Investigation indicated that the airplane had a blocked pitot tube, and that the flight crew became confused by false airspeed indications and did not respond to a stall warning.								
2/21/96	Piper PA-30-160	NA	St. Petersburg, Florida, U.S.	Personal	0	0	2	Substantial
The pilot said that, while on final approach, he became distracted by the passenger, and the airplane struck water.								
2/23/96	North American SNJ-5	North American Top Gun	West Palm Beach, Florida, U.S.	Personal	1	0	0	Destroyed
During a low-level overwater aerobatic maneuver, the tail section of the airplane struck water.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants			Damage to Aircraft
					Fatal	Serious	Minor/ None	
3/4/96*	Cessna 172	NA	Ketchikan, Alaska, U.S.	Instructional	0	0	2	Substantial
During a demonstration, the engine became unresponsive and then produced only partial power. The airplane descended and the pilot declared an emergency by radio. He selected an emergency-landing area near the shore of an island, but noticed that the beach area contained large rocks. The pilot then ditched the airplane about 30 yards from shore. Both pilots swam to shore, and the airplane sank.								
3/4/96	Piper PA-23-250	NA	Sulphur Springs, Texas, U.S.	Personal	0	0	1	Substantial
Following a partial engine failure in cruise flight, the pilot decided to make a precautionary landing. While maneuvering to the airport, he noted that the "GEAR DOWN" indicator lights did not illuminate when he placed the gear handle down. After manually extending the landing gear, the pilot realized that he did not have enough altitude to reach the airport. A witness saw the airplane strike the surface of a lake and, subsequently, sink.								
3/7/96	Piper PA-28-180/ Piper PA-44-180	Private/Phoenix East Aviation	Flagler Beach, Florida, U.S.	Instructional/ Sightseeing	6	0	0	Destroyed
The airplanes collided at about 600 feet in visual meteorological conditions. The airplanes and airplane parts plunged into the ocean.								
3/12/96*	Cessna 182P	CAVU Flying Club	Darrington, Washington, U.S.	Personal	0	0	1	Substantial
The pilot reported to ATC that the airplane's engine had failed. He said that he initiated an emergency descent through clouds, broke out of the clouds at an altitude about 400 feet AGL and ditched the airplane in a shallow river because of unsuitable surrounding terrain. The airplane flipped over during the ditching.								
3/17/96	Cessna U206G	Key West Seaplane Service	Key West, Florida, U.S.	Unscheduled passenger	5	1	0	Destroyed
After takeoff, according to radar data, the airplane was flown to 200 feet, then was descended to 100 feet. The pilot was advised to turn right to pass behind the approach corridor for a departing airplane. Witnesses saw the airplane flying toward buildings and said that the airplane, which was 50 feet to 100 feet above the water, started banking to the right, and that the bank angle increased to nearly 90 degrees. The airplane then pitched nose-down and struck the water nose-low and right-wing-low, rolled inverted and sank in about six feet of water about 20 yards from a seawall.								
3/29/96	Helio H295	L.A.B. Flying Service	Angoon, Alaska, U.S.	Unscheduled passenger	0	0	2	Minor
The airplane had taken off from water in gusty winds. At an estimated altitude of 15 feet, a gust caused the pilot to lose control of the aircraft, which then struck the water. The right float was damaged and began to sink. The pilot and passenger remained on top of the left float until they were rescued. The airplane rolled to an inverted position, was towed to shallower water and was recovered.								
4/1/96	Cessna P210N	NA	Marathon, Florida, U.S.	Business	2	0	0	Substantial
During an overwater approach at night, the airplane descended into the water about seven nautical miles northeast of the airport.								
4/5/96	Dornier 228-200	Formosa Airlines	Matsu Island, Taiwan, China	Scheduled passenger	6	0	11	Destroyed
The aircraft apparently undershot the runway during the final stage of a visual approach to Matsu Island and struck the sea just offshore. According to press reports, the aircraft descended below the correct altitude because of inadequate crew coordination.								
4/7/96*	PBN BN-2A-21 Islander	Island Air Gold Coast	Currumbin, Queensland, Australia	Unscheduled passenger	0	2	8	Destroyed
Flying at 3,000 feet and about 10 nautical miles from the coast, the pilot reported that the aircraft's right engine had failed. The pilot altered course toward land, intending to fly toward Coolangatta, Australia. Shortly afterward, he conducted a forced landing in the surf on Curumbin Beach.								
4/14/96	Cessna U206G	Signal Air	Venice, Louisiana, U.S.	Personal	1	2	1	Destroyed
According to one passenger in the accident aircraft, the airplane was about 300 feet above the ground when fog was encountered. The pilot made a right turn and began to descend the airplane, which struck water and came to rest inverted.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
4/19/96	Cessna 150F	NA	Mackinac Island, Michigan, U.S.	Personal	1	0	0	Destroyed
The student pilot departed on a four-mile flight in marginal VMC with fog moving into the area. Two days later, the airplane was found in 20 feet of water near the intended island destination.								
5/3/96	Cessna 310D	NA	Los Angeles, California, U.S.	Personal	4	0	0	Destroyed
The pilot elected to go around because of an unsafe-gear indication during a night landing. The airplane was flown into a cloud layer and was later seen descending out of the clouds in a nose-down attitude. The airplane struck the ocean about three miles west of the airport.								
5/5/96*	Cessna P206D	NA	Harrison, New York, U.S.	Personal	0	0	2	Substantial
Separation of a connecting-rod bolt resulted in engine failure. The pilot said, "I realized that we could not make it to the runway and we then quickly decided to head for the water." The airplane was ditched in a reservoir.								
5/9/96	Lake LA-4-200	New Hampshire Civil Air Patrol	Sunapee, New Hampshire, U.S.	NA	1	0	0	Destroyed
During an attempt to land on water, the airplane flipped over and sank in the lake. The pilot lacked currency in type and did not follow the requirement to have a flight instructor aboard during water landings.								
5/11/96	McDonnell Douglas DC-9-32	ValuJet	Miami, Florida, U.S.	Scheduled passenger	110	0	0	Destroyed
The aircraft had just departed Miami International Airport when an intense fire erupted in the forward cargo compartment. As soon as the crew detected the fire, they immediately turned back toward Miami, but the fire burned through the aircraft's control cables and the crew could not maintain control. The aircraft struck water in the Florida Everglades, a swamp.								
5/15/96	Cessna 320A	Pilot/owner	Utah Lake, Provo, Utah, U.S.	Instructional	2	0	0	Destroyed
The owner and flight instructor were advised of a fuel leak from the underside of the right engine. One of the pilots examined the left engine and re-entered the aircraft, and the aircraft was taxied for takeoff. The first takeoff was aborted for undetermined reasons. The aircraft then departed. About 40 minutes later, a radio transmission from the aircraft indicated an engine fire. The aircraft was seen diving toward the surface of Utah Lake, and struck water that was about 12 feet deep.								
5/24/96*	Piper PA-18	NA	Kivalina, Alaska, U.S.	Personal	0	0	1	Substantial
The pilot said that he was taking off when the right wheel struck a hole in the ground. He heard the propeller strike a rock. He completed the takeoff and, after liftoff, the airplane began to vibrate. The pilot was forced to land the airplane in a river. The airplane became submerged in the water and nosed over.								
5/31/96*	Piper PA-28-161	CAVU Flying Club	Seattle, Washington, U.S.	Personal	0	0	1	Destroyed
The pilot told the controller that his airplane's engine power had failed over Elliott Bay and he was attempting to restart the engine. Radar and radio contact ended. An oil slick was found on the water by Coast Guard searchers near the last reported radar position. The pilot later pleaded guilty to charges of fraudulent insurance claims and making a false distress signal.								
6/3/96	Cessna 310C	NA	Winslow, Maine, U.S.	Personal	1	0	0	Destroyed
The airplane was in cruise flight at 18,000 feet when radar and radio communication ended. Radar data indicated that the airplane made a 180-degree turn before descending into a river.								
6/5/96	Aeronca O-58B	NA	Greenville, South Carolina, U.S.	Personal	1	1	0	Destroyed
The pilot had flown the airplane into the area, picked up a passenger and departed the airport. The airplane struck a power line that crossed a lake. The airplane struck the lake and sank.								
6/7/96	Piper PA-32R-300	Condor Air	Goleta, California, U.S.	Personal	2	0	0	Destroyed
The pilot flying became spatially disoriented, which resulted in an uncontrolled descent, leading to the airplane striking the water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
6/10/96	Aeronca 65-CA	Private owner	Lonoke, Arkansas, U.S.	Personal	1	0	0	Substantial
The airplane struck the water following a loss of control. A witness reported seeing the airplane "shoot straight up into the sky, up to about 150 feet," after which it turned nose-down and struck the water.								
6/13/96	Piper PA-24-250	NA	Big Bear City, California, U.S.	Personal	2	1	0	Destroyed
During the initial climb after takeoff, the aircraft's engine abruptly failed when the aircraft was about 200 feet AGL. Witnesses reported that the aircraft continued forward until its nose pitched up, the left wing dropped and the aircraft fell into the shallow water of a lake.								
6/24/96	Beech P-35	NA	St. Petersburg, Florida, U.S.	Personal	1	1	1	Destroyed
About five miles north of the airport, the pilot radioed the tower controller and reported that the engine had failed and that he did not think he could reach the runway. The controller observed the airplane turn left, enter a nose-high attitude and strike the water nose-low and left-wing-low.								
7/2/96	Lake LA-4-200	NA	Wolfeboro, New Hampshire, U.S.	Personal	0	0	1	Substantial
The aircraft nosed over and submerged in water during a landing on Lake Wentworth.								
7/5/96*	Cessna 210	NA	Boston, Massachusetts, U.S.	Personal	0	0	2	Substantial
A fracture failure of the crankcase resulted in separation of a cylinder, loss of engine power and a ditching.								
7/7/96*	Piper PA-23-250	NA	Harrisburg, Pennsylvania, U.S.	Personal	0	0	3	Destroyed
The aircraft's right engine failed shortly after takeoff. The pilot made an emergency landing in the Susquehanna River.								
7/12/96	Piper PA-46-310P	NA	Hartford, Connecticut, U.S.	Personal	0	2	4	Destroyed
The airplane stalled after takeoff because of incorrect airspeed and descended into the Connecticut River.								
7/14/96	Smith RV4	Private owner	Mandeville, Arkansas, U.S.	Personal	0	0	2	Substantial
While on short final, the pilot advanced the engine throttle to maintain glide path, but the engine did not respond. The airplane came to rest in water about 200 yards from the approach end of the runway.								
7/15/96	Aeronca 7CGB	Private owner	Fairhope, Alabama, U.S.	Personal	1	1	0	Substantial
Witnesses observed the aircraft being descended toward the water, then being pulled up into a steep climb. After reaching 200 feet, the right wing and nose dropped, and the aircraft descended nose-first until impact with the water of Weeks Bay.								
7/17/96	Boeing 747-100	Trans World Airlines	Moriches Inlet, New York, U.S.	Scheduled passenger	230	0	0	Destroyed
After takeoff from John F. Kennedy International Airport, New York, New York, the aircraft appeared to be climbing normally. As the aircraft passed through 13,800 feet, an explosion occurred, resulting in a catastrophic breakup of the aircraft. The pieces of the aircraft struck the sea off Moriches Inlet. The U.S. National Transportation Safety Board determined that the probable cause of the accident was an explosion in the center wing fuel tank, resulting from the ignition of the flammable air-fuel mixture in the tank.								
7/17/96	Piper PA-23-250	LCE	St. Petersburg, Florida, U.S.	Personal	0	0	1	Substantial
After departure, the pilot reported that the right engine was "running rough." The control tower cleared him for an emergency landing at the departure airport. While returning, the pilot was unable to maintain altitude, and the airplane struck water about one mile south of the airport.								
7/22/96*	Cessna 210L	Gallops	Fort Myers, Florida, U.S.	Positioning	0	0	2	Substantial
On final approach, the airplane's engine failed, and a forced landing was made in a river about 2.5 miles from the runway.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
7/24/96	Piper PA-28-181	NA	Sea Bright, New Jersey, U.S.	Personal	1	0	0	Destroyed
The non-instrument-rated pilot departed on a local flight in VMC. A witness heard the airplane's engine overhead in "very foggy" conditions. Reportedly, the airplane re-entered the fog, made an abrupt 180-degree turn and struck the water.								
7/29/96	Kis	NA	Calais, France	Personal	2	0	0	Destroyed
The aircraft struck the sea one nautical mile off Calais.								
7/30/96	Canadair CL-215	SISAM	Lercara Friddi, Italy	Fire suppression	1	0	1	Destroyed
While landing on a lake to pick up water for fighting a forest fire, the aircraft appeared to touch down hard. The impact ruptured the aircraft's hull, which rapidly filled with water, and the aircraft sank.								
8/4/96	Pitts Special S-1S	NA	Pittsburgh, Pennsylvania, U.S.	Aerobatic	1	0	0	Destroyed
At an air-show aerobatic exhibition, the pilot initiated his first maneuver, a double snap roll. Airspeeds greater than the manufacturer-recommended maneuvering airspeeds exceeded the airplane's design limits, resulting in the failure of a wing spar. The airplane descended until it struck the water in an inverted attitude.								
8/9/96	Beech A36	Fly Inc.	Atlantic Ocean	Personal	1	0	0	Destroyed
The aircraft was destroyed and its pilot killed in an in-flight collision with water. The pilot had not obtained a preflight weather briefing or in-flight weather-avoidance assistance, and inadvertently encountered a level-three thunderstorm.								
8/12/96	DHC-6 Twin Otter 300	Bradley Air Services	Baffin Island, Northwest Territories, Canada	Unscheduled cargo	2	0	0	Destroyed
The aircraft touched down several times, with full braking that continued to the end of the landing strip. A go-around apparently then was attempted. Power was applied and the aircraft became airborne, continuing in flight without gaining altitude before striking a rock. It continued in flight for another 500 feet before apparently stalling and striking the sea in a right-wing-low attitude.								
8/13/96	Cessna TR182	Private owner	Port Isabel, Texas, U.S.	Personal	2	0	0	Destroyed
During an intentional low-altitude flight maneuver, the aircraft struck a concrete bridge pylon and column, then descended uncontrolled into the water.								
8/14/96*	Douglas DC-4	Basco Flying Service	Bronson Creek, British Columbia, Canada	Unscheduled cargo	1	0	2	Destroyed
Following a fire near engine no. 2, the engine separated from the aircraft and was believed to have struck the propeller of the no. 1 engine. The aircraft became very difficult to control, and the crew decided to conduct a forced landing in the Iskuit River. After the landing, all three occupants evacuated from the aircraft. The first officer and the flight engineer reached the river bank. The captain was missing, and was believed to have drowned in the fast-flowing river.								
8/17/96	Cessna 172H	Pilot/owner	St. Petersburg, Florida, U.S.	Personal	1	0	0	Substantial
Witnesses to the accident said that the engine was not operating at the time of the accident, and that it appeared that the pilot was attempting to land the airplane on a fishing pier. The airplane hit a light pole and the fishing-pier guardrail and tumbled into the bay.								
8/19/96	Cessna 180	NA	Duxbury, Minnesota, U.S.	Personal	0	0	2	Substantial
The airplane struck the water while maneuvering to avoid trees along the water's edge.								
8/23/96*	American AA-5	NA	Annapolis, Maryland, U.S.	Personal	0	0	1	Substantial
The pilot reported that during takeoff climb, he started a left turn at 700 feet. The engine then failed. The pilot tried unsuccessfully to restart the engine, then ditched the aircraft in a creek.								
8/28/96*	Cessna 150M	MRM International Co.	Oklahoma City, Oklahoma, U.S.	Instructional	0	0	1	Substantial
While the student pilot was returning to the airport after a solo training flight at night, the engine failed. The student saw trees and maneuvered to avoid a collision, then landed the airplane in a small lake.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
8/31/96	Cessna 206	Totem Air	Yakutat, Alaska, U.S.	Positioning	1	0	0	Substantial
The operator reported that the pilot was planning to land in an area known as Halibut Cove to pick up several passengers. The flight did not return and was reported overdue. The airplane was located floating upside down by search aircraft. After arrival at the scene, search personnel reported that the airplane's windshield was broken out of the airframe and the pilot's seat belt was unbuckled. The pilot was not located.								
9/1/96	Karr Titan Tornado	NA	Union Pier, Michigan, U.S.	Personal	1	0	1	Destroyed
The aircraft was being flown in aerobatics over Lake Michigan. During the fifth successive "hammerhead turn," the airplane departed controlled flight and struck the surface of the lake.								
9/7/96	Cessna 180J	Wayco Aviation	Knot Lake, British Columbia, Canada	Positioning	1	0	0	Destroyed
The airplane did not complete a 35-mile flight to Knot Lake. A search flight sent to look for the missing airplane received an ELT signal but could not find the source. The rescue coordination center was notified and the missing airplane was found later, sinking in Knot Lake. The pilot's body was recovered from the water the next day. The pathological examination determined that the pilot had received a head laceration and had drowned.								
9/20/96	Piper PA-18	NA	Minto, Alaska, U.S.	Personal	1	0	0	Substantial
The pilot intended to land the float-equipped airplane in the area to pick up fellow hunters. Witnesses saw the airplane fly low over trees and make a turn to align with the landing area on the water. They heard the engine power increase, saw the nose of the airplane rise, watched as the airplane banked 60 degrees to the right and then saw the airplane descend nose-low into the water.								
9/24/96	De Havilland U-6A	Branch River Air Service	King Salmon, Alaska, U.S.	Unscheduled passenger	0	2	2	Substantial
The pilot failed to maintain sufficient airspeed during the initial climb after takeoff, which resulted in an inadvertent stall that ended with the airplane striking water.								
9/25/96	Piper PA-28	Woodvale Aviation	Southport, England	Instructional	2	0	0	Destroyed
The aircraft was deliberately spun as part of a flying instructor candidate's training. The entry altitude, location and weather were all suitable for the exercise but the aircraft failed to recover and struck the sea. The aircraft floated for a short time but sank inverted. Both occupants were incapacitated and subsequently drowned.								
9/30/96	De Havilland DHC-2 Beaver	Castle Rock Exploration Co.	Portage Lake, Labrador, Canada	Unscheduled passenger	2	0	0	Destroyed
The pilot apparently encountered deteriorating weather en route to Goose Bay. He landed on a pond to await improved conditions. In his last radio transmission, the pilot indicated that he would be departing the pond soon. When the aircraft did not arrive at the destination, a search was commenced. Seven days later, an oil slick and paddle with the company name on it were found on the pond. Divers located the aircraft wreckage in 120 feet of water. The bodies of the pilot and passenger were found inside the wreckage.								
10/2/96	Boeing 757-200	Aero Peru	Ancon, Peru	Scheduled passenger	70	0	0	Destroyed
Following an apparently normal takeoff from Lima, Peru, and initial climb, the first officer advised ATC of problems and requested clearance to return to the airport. The first officer told ATC that the airspeed was "too low," the aircraft altitude was increasing "too slowly" and the wind shear warning had sounded for no apparent reason. ATC began to provide radar vectors to position the aircraft for landing. When the aircraft was approximately on the base leg for the landing, the crew apparently experienced loss of control and the aircraft struck the sea.								
10/3/96*	Grumman American AA-1B	Private owner	Kona, Hawaii, U.S.	Personal	0	0	1	Destroyed
The pilot reported that the engine failed and that he was forced to ditch the aircraft. After exiting the aircraft, he remained in the water until he was located by the Coast Guard.								
10/7/96*	Cessna 152	NA	Gulf of Mexico	Personal	0	0	1	Substantial
The airplane exhausted its fuel while flying over the Gulf of Mexico. The pilot declared mayday to the Galveston Airport tower, informing controllers that he would ditch near an oil platform. After the ditching, both airplane occupants swam to the platform and were rescued.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
10/25/96	Bellanca 8KCAB	NA	Sheffield, Massachusetts, U.S.	Personal	0	1	0	Destroyed
The pilot's abrupt control of the airplane resulted in an inadvertent stall, uncontrolled descent and subsequent in-flight collision with water.								
11/3/96*	Piper PA-23-250	NA	Cairns, Queensland, Australia	Unscheduled passenger	0	0	5	Destroyed
The pilot declared mayday about 15 miles from Cairns. He advised, "I think I've run out of fuel, going in." The aircraft was ditched a short time later, two nautical miles off the coast of Wangetti Beach. All five persons on board were rescued.								
11/23/96*	Boeing 767-200ERM	Ethiopian Airlines	Grande Comore Island, Comoros	Scheduled passenger	127	5	43	Destroyed
The aircraft was destroyed when it broke up and sank during an attempted ditching following fuel exhaustion. The aircraft had been hijacked, and the pilot apparently attempted a ditching in the shallow, sheltered waters of a small bay about 500 meters off Le Galawa beach, on the northern tip of Grande Comore Island. During the ditching, the aircraft broke up and sank.								
12/11/96	Beech 18G	Tol-Air	Caribbean Ocean, off Puerto Rico, U.S.	Unscheduled cargo	1	0	0	Destroyed
The pilot feathered the left engine because of the loss of the engine cowling but did not declare an emergency. Shortly thereafter, the pilot declared that he was losing altitude at a rate of 300 feet per minute. He said that he was going to attempt to restart the engine, and that he was nearing the water. The pilot informed ATC that the airplane would not be able to reach land. The pilot was told that SAR personnel were responding, which he acknowledged. There was no further radio contact with the pilot. The wreckage was located in the ocean, but the pilot was not found.								
12/12/96	De Havilland DHC-2 Beaver	Taquan Air Service	Ketchikan, Alaska, U.S.	Unscheduled passenger	1	0	0	Destroyed
The pilot's inadequate compensation for gusty-wind conditions and failure to maintain adequate airspeed resulted in an inadvertent stall and collision with water.								
12/20/96*	Stinson ST-108-2	Yelm Aviation	Friday Harbor, Washington, U.S.	Business	0	0	1	Destroyed
After takeoff, the airplane was being flown through 2,500 feet when the engine began to vibrate severely. It then failed and the pilot was unable to restart it. Because he was too far from shore to glide to land, he chose to ditch the airplane next to a fishing trawler. The airplane sank to a depth of about 300 feet after the pilot had safely egressed.								
12/26/96	Champion 7GCB	Benson & Kobe Aviation	Fort Lauderdale, Florida, U.S.	Aerobatic	2	0	0	Substantial
The pilot performed an aerobatic maneuver at an altitude that did not allow for recovery from the maneuver, and the airplane struck the water.								
1/10/97*	Beech C24R	NA	Santa Cruz Island, California, U.S.	Personal	0	0	2	Destroyed
Following a total engine failure, the pilot ditched the airplane in the ocean and swam about 0.5 mile to shore.								
1/19/97	Cessna 180J	NA	Lopez, Washington, U.S.	Personal	0	0	2	Substantial
Immediately after takeoff, the aircraft unexpectedly entered IMC in the form of clouds and fog. The pilot lost sight of the terrain and became disoriented. The airplane struck trees and then descended into the water.								
1/20/97	Harbin Y-12-II	Helitours	Palalay, Sri Lanka	Personal	4	0	0	Destroyed
The aircraft was believed to have struck the sea while investigating a ship off the northeast coast of Sri Lanka. The last contact with the aircraft occurred when the pilot reported that he had found the ship and was descending to identify it.								
1/27/97*	Piper PA-28R-180	NA	Wynyard, Tasmania, Australia	Personal	0	0	3	Substantial
The engine was reported to have failed during initial climb. The aircraft was ditched near the airport.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
2/8/97	Cessna 402C	Tropical Transport Service	St. Thomas, U.S. Virgin Islands	Scheduled passenger	2	0	3	Destroyed
While making a visual approach at night over water in "black-hole" conditions, the pilot allowed the aircraft to descend until it struck the sea.								
2/9/97*	Cessna 150F	NA	Winter Haven, Florida, U.S.	Instructional	0	0	1	Substantial
While downwind on a second approach for landing, the student pilot observed that the airplane seemed to be performing differently than it had previously. After turning on final, the pilot observed that he was below the normal glide path. Advancing the throttle lever and getting no response, he realized that he would not reach the runway, and decided to land in a nearby lake.								
2/13/97*	Cessna 172F	NA	San Pablo Bay, California, U.S.	Personal	0	0	1	Substantial
A few minutes after takeoff, the engine began to run roughly and failed, forcing the pilot to ditch the airplane. The airplane partially sank in the shallow bay. The pilot had sprained his ankle during the water landing and decided to stay with the aircraft. He was located the following morning after manually activating the ELT.								
3/2/97	Cessna 402A	Chapi Air Travel	Maiquetia, Venezuela	Unscheduled passenger	6	0	0	Destroyed
The aircraft disappeared from radar shortly after takeoff and debris believed to have come from the aircraft later was found in the sea about 90 kilometers north of the airport.								
3/7/97*	Buesing SX-300	Pilot/owner	Sitka, Alaska, U.S.	Personal	2	0	0	Destroyed
During cruise flight at 14,000 feet and 19 miles from the nearest airport, the homebuilt airplane's pilot encountered a low-engine-power condition. He declared an emergency and was given vectors to the airport. The airplane was capable of gliding about 24 miles from 14,000 feet, but was ditched in the ocean about five miles from the airport.								
3/11/97*	American AA-5A	NA	North Bend, Oregon, U.S.	Personal	0	0	1	Substantial
The pilot flew the airplane into forecast icing conditions, where structural ice accumulated on the induction air filter and partially blocked the flow of induction air. The engine failed, and the pilot had to ditch the airplane in Coos Bay.								
3/19/97	Cessna 421	MTK Jet	League City, Texas, U.S.	Personal	1	0	0	Substantial
The right engine failed because of fuel exhaustion, and the pilot did not maintain adequate airspeed during the single-engine landing approach, which resulted in a stall and spin. The airplane struck the center of a lake.								
3/24/97	Beech V35	NA	Marco Island, Florida, U.S.	Personal	1	0	0	Destroyed
Inadvertent flight into severe thunderstorms led to the exceedance of the design stress limits of the airplane. Subsequently, the airplane broke up in flight, and descended uncontrolled into water.								
3/27/97*	Piper PA-23-250 Aztec	NA	Rio Negro, Guatemala	Unscheduled passenger	5	0	5	Destroyed
While the aircraft was en route and being flown at 1,300 feet AGL, one of the engines failed. The aircraft subsequently descended on one engine and, because of the rough, wooded terrain, the pilot elected to conduct a forced landing in the Rio Negro.								
3/30/97*	Piper PA-32-260	NA	Atlantic Ocean	Positioning	0	0	1	Substantial
While the airplane was being descended for an approach to land, the engine failed. After failing to restart the engine, the pilot ditched the airplane about five nautical miles from the shore.								
3/31/97	H-295	NA	Moruya, New South Wales, Australia	Personal	0	0	2	Substantial
The pilot reported that, soon after departure in strong gusty-wind conditions, the aircraft encountered turbulence and descended into the ocean. Both occupants evacuated the aircraft without injury.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
4/1/97	Cessna 182F	Skydive Academy of Hawaii	Mokuleia, Hawaii, U.S.	Parachutist transportation	0	0	5	Destroyed
An in-flight loss of control occurred during takeoff. Witnesses reported seeing the airplane lift off and climb steeply. One wing suddenly lowered and the airplane rapidly descended. The airplane struck trees and was destroyed when it sank in 15-foot-deep water near the shoreline.								
4/3/97	Beech 58 Baron	Avair	St. Vincent, St. Vincent and the Grenadines	Personal	6	0	0	Destroyed
Becoming airborne following takeoff, the aircraft was seen to climb to about 100 feet but it then entered a left roll and dived into the sea. The aircraft struck the water some 300 meters beyond the end of the runway, slightly to the left of the extended centerline.								
4/4/97*	Chance Vought F4U	Collings Children's Trust	New Smyrna Beach, Florida, U.S.	Personal	0	0	1	Substantial
A total engine failure occurred in flight, and the pilot ditched the airplane in the water adjacent to New Smyrna Beach.								
4/10/97	Cessna 208B	Hageland Aviation Services	Wainwright, Alaska, U.S.	Scheduled passenger	5	0	0	Destroyed
Although operating under visual flight rules, the pilot flew into IMC and failed to maintain altitude/clearance from terrain. The airplane struck the frozen Arctic Ocean while maneuvering near its destination, Wainwright.								
4/13/97*	De Havilland DHC-6 Twin Otter 300	Corporate Air	Hilo, Hawaii, U.S.	Ferry	0	0	1	Destroyed
As the aircraft neared its destination, Honolulu, Hawaii, the pilot became concerned about his fuel state. He subsequently declared an emergency and diverted towards Hilo, Hawaii. About one hour later the aircraft's fuel was exhausted and the pilot was forced to ditch some 63 nautical miles northeast of Hilo. The Coast Guard later rescued the pilot.								
4/27/97	Piper Aerostar 601P	NA	Klamath Falls, Oregon, U.S.	Personal	1	0	0	Substantial
The pilot reported a "fuel problem" to ATC and was later heard by the pilot of another aircraft to say that both engines had failed. The airplane struck the water of Lake of the Woods.								
4/29/97	Christen Eagle II	Pilot/owner	Half Moon Bay, California, U.S.	Personal	2	0	0	Destroyed
The pilot and pilot-rated passenger did not return from a scenic flight. Witnesses saw an aircraft strike the Pacific Ocean while maneuvering in a known practice area of the pilot/owner. The aircraft was not found.								
5/20/97	Capstaff Challenger II	NA	Southern Pines, North Carolina, U.S.	Personal	1	0	1	Substantial
The airplane struck power lines after takeoff and descended into a pond. The passenger escaped from the aircraft, but he reported that he was unable to release the pilot's lap belt. The pilot received multiple internal injuries and drowned.								
5/22/97*	Convair 240	Tolair Services	San Juan, Puerto Rico, U.S.	Ferry	0	0	3	Destroyed
While in normal cruise flight at 3,000 feet, the aircraft's left engine began to overheat and its oil pressure began to fluctuate. The crew shut down the engine as a precautionary measure but shortly after this action, the right engine started "banging" and power declined. The crew restarted the left engine but by this time the aircraft was descending through 500 feet. The crew declared mayday and conducted a forced landing in shallow water next to a beach.								
5/25/97*	Cessna 177	NA	Rota, Northern Mariana Islands	Personal	0	0	2	Destroyed
The aircraft was in cruise flight at 4,500 feet when fuel pressure and engine power failed. The pilot ditched the aircraft in the ocean.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/None	Damage to Aircraft
6/7/97*	Gardan 80	NA	Alderney, Channel Islands, U.K.	Personal	0	0	1	Destroyed
The aircraft fuel supply was exhausted and the aircraft was ditched in the sea about two nautical miles off Alderney. The pilot escaped from the aircraft, which sank fairly rapidly, and was rescued by the crew of a nearby fishing boat within eight minutes.								
6/30/97*	Convair 240	Silver Express Co.	San Juan, Puerto Rico, U.S.	Unscheduled cargo	0	0	3	Destroyed
During the climb through about 400 feet AGL after takeoff, as the first power reduction was being conducted, the left engine began to "backfire" and its power decreased. The engine was shut down and maximum power was selected on the right engine. The pilot apparently decided to return to San Juan for an emergency landing at the airport but the aircraft could not maintain altitude. The pilot then decided to conduct a forced landing in shallow water close to the beach. The aircraft touched down next to a reef parallel to the beach. On impact with the water, both of the aircraft's wings separated. The fuselage remained substantially intact and the occupants were able to escape without serious injury.								
7/2/97	Piper PA-32R-301	Corporate Aviation	St. Paul, Minnesota, U.S.	Business	3	1	1	Substantial
After takeoff in gusty winds, the forward baggage door opened. The pilot attempted to return to the airport, but the airplane struck trees and descended into the river.								
7/2/97	Piper PA-28R-180	NA	Penobscot, Maine, U.S.	Personal	4	0	0	Destroyed
The pilot and passengers were returning from a sightseeing flight when a witness observed the airplane in a steep right turn before it descended, struck water and sank to a depth of about 70 feet.								
7/3/97	Cessna 500 Citation I	Riana Taxi Aéreo	Rio de Janeiro, Brazil	Unscheduled passenger	0	0	5	Destroyed
Following a rejected takeoff, the aircraft overran the runway and fell into the bay.								
7/3/97	Fokker F.27-600	Elbee Airlines	Mumbai, India	Unscheduled cargo	2	0	0	Destroyed
After takeoff from Mumbai, during climb through about 1,200 feet, the pilot reported that he was altering course to the left to avoid "bad weather." Shortly afterward, the flight crew contacted ATC and was instructed to climb to FL 170 and report passing FL 080. This instruction was acknowledged but there was then no further contact with the aircraft crew. Loss of control apparently occurred and the aircraft struck the sea in a dive.								
7/3/97*	Piper PA-32	Haines Airways	Skagway, Alaska, U.S.	Unscheduled passenger	4	0	2	Destroyed
When the airplane was about 1,200 feet above water and 1.5 miles from the airport to which it was returning from a sightseeing flight, the engine failed. The aircraft was ditched about 100 feet from shore. Passengers exited first into 39-degree Fahrenheit (4-degree Celsius) water, but none exited with life vests. The pilot threw one life vest out and exited as the aircraft sank. With help from her husband, a passenger donned the life vest that was thrown out; she partially inflated it using the oral inflation tube, although it had a carbon-dioxide cylinder for rapid inflation. A rescue helicopter arrived in about 10 minutes. The passenger with the life vest and the pilot were rescued, two passengers drowned and the other two passengers were not found. The surviving passenger did not recall being briefed about the location or use of life vests. Life vests were stored in seat-back pouches, but the pouch openings were covered by slip-cover type seat covers.								
7/6/97*	Cessna P210N	NA	Destin, Florida, U.S.	Personal	0	0	2	Substantial
The airplane struck water during an emergency landing following what the pilot reported as a loss of engine power after takeoff.								
7/6/97*	Piper PA-34-200	NA	Fajardo, Puerto Rico, U.S.	Personal	0	0	1	Substantial
The pilot reported that he had been doing touch-and-go landings when he experienced a loss of elevator control during climbout. He said that the airplane had been flown to 400 feet when the control yoke stuck. Efforts to regain control of the airplane failed. The airplane was ditched in 130 feet of water, 200 meters east of the shoreline.								
7/6/97	Mooney M20A	NA	White Bear, Minnesota, U.S.	Personal	2	0	0	Destroyed
During flight, the pilot was incapacitated by an intracerebral hemorrhage (stroke). Witnesses said that the airplane descended into the water from an altitude of about 50 feet.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
7/8/97	Grumman American AA-5B	Pilot/owner	Jones Beach, New York, U.S.	Personal	3	0	0	Destroyed
The non-instrument-rated pilot departed from an airport that was in VMC. Witnesses observed the airplane fly into a fog bank. The airplane then struck the water.								
7/9/97	Grumman American AA-5B	NA	Susanville, California, U.S.	Personal	0	0	1	Substantial
During the landing, the pilot encountered unexpectedly strong crosswind gusts and the aircraft was not properly aligned with the runway. The airplane ultimately went through a barbed-wire perimeter fence before coming to rest in a lake.								
7/11/97	Antonov An-24RV	Cubana	Santiago de Cuba, Cuba	Scheduled passenger	44	0	0	Destroyed
The aircraft was destroyed when it struck the sea shortly after takeoff. The accident happened in darkness and "normal" weather.								
7/13/97	Cessna TR182	NA	Seaside Heights, New Jersey, U.S.	Personal	2	0	0	Destroyed
While maneuvering over the ocean on a dark, moonless night, the pilot began a left turn. During the turn, the airplane descended, struck the water and sank 0.5 mile offshore in the Atlantic Ocean.								
7/13/97*	Piper PA-28-181	NA	Jersey City, New Jersey, U.S.	Personal	0	0	1	Substantial
After the airplane had been flown for 2.2 hours, the engine failed from fuel starvation and the pilot ditched the airplane in the Hudson River. Investigation determined that the pilot had failed to switch fuel tanks when one tank became exhausted.								
7/20/97	Piper J3C-65	NA	Leesburg, Florida, U.S.	Personal	0	0	2	Substantial
The pilot was demonstrating stalls to his son. He initiated the second stall over a lake. While attempting to recover, he advanced the throttle lever but the engine failed to return to full power, and the airplane entered a spin. The right wing tip struck the water, and the airplane cartwheeled and sank.								
7/24/97*	Beech 65	M R Aircraft Sales and Rental	Atlantic Ocean	Personal	0	0	5	Destroyed
At a cruising altitude of 9,000 feet, the left engine failed. The flight crew feathered the left propeller and turned toward the nearest airport, which was 80 miles away. The altitude could not be maintained and the aircraft entered a 500-feet-per-minute descent. The airplane was ditched in the ocean about 50 miles from the nearest airport.								
7/25/97	Cessna 208	NA	Nadi, Fiji	Unscheduled passenger	0	0	2	Substantial
The aircraft was fitted with floats for charter operations around the Fijian islands. On takeoff, just before liftoff, the right float struck a swell. The pilot, believing that the impact was not severe, continued with the takeoff. Later examination showed that the firewall had been damaged in the water strike.								
8/1/97	Consolidated PBY-5A Catalina	Airborne Fire Attack	Moreno, California, U.S.	Fire suppression	0	0	2	Destroyed
During a water pickup, the aircraft's nose dipped and struck the water. The aircraft cartwheeled and came to rest inverted.								
8/9/97	Grumman American AA-5	NA	Lower Brule, South Dakota, U.S.	Personal	1	0	0	Destroyed
A witness said that the airplane passed overhead at a low altitude and that there was no noise from the engine. He reported that the airplane then struck water, nosed over and sank a short time later.								
8/9/97*	Cessna 150G	NA	Palos Verdes, California, U.S.	NA	0	0	1	Substantial
The engine failed and the pilot subsequently ditched the aircraft in the Pacific Ocean. In a statement to FAA inspectors, the pilot reported that he had forgotten to switch the fuel selector, resulting in fuel starvation.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
8/11/97	Cessna U206G	NA	Halibut Cove, Alaska, U.S.	Personal	3	0	0	Destroyed
The float-equipped airplane departed from water into gusting winds downwind of high, steep terrain. Witnesses said that the airplane did not climb above 200 feet AGL, which was insufficient to clear terrain at the upwind end of the lake. The airplane entered a steep left bank and turned within the confines of the upwind end of the lake. The turn was in a downwind direction, directly downwind of a 2,600-foot-high peak. The airplane abruptly pitched nose-down, struck the water in a vertical attitude and immediately sank.								
8/17/97*	Piper PA-34-200T	Aero Club, Van Nuys, California, U.S.	Kernville, California, U.S.	Unscheduled passenger	0	1	4	Destroyed
Seconds after takeoff, the engines lost partial power. Witnesses saw black smoke trailing from the airplane. The pilot ditched the airplane, which sank in 20-foot-deep water.								
8/17/97	Cessna 180H	Pilot/owner	Arctic Village, Alaska, U.S.	Personal	0	0	2	Destroyed
The airplane was at maximum gross weight and was departing a lake at 3,000 feet. After takeoff, in winds of 15 knots gusting to 25 knots, the pilot began to retract flaps when the airplane had accelerated to 75 mph. The pilot said that the airspeed dropped to 40 mph, and the airplane stalled at 50 feet to 60 feet AGL, then descended into the water.								
8/24/97	Classic Aircraft Corp. YMF-5 (Waco Classic)	Ocean Aerial Ads	Ocean City, Maryland, U.S.	Sightseeing	3	0	0	Destroyed
The pilot performed an aerobatic maneuver at a low altitude, which resulted in an inadvertent stall and spin. The aircraft struck the water in a 45-degree nose-down attitude.								
8/24/97*	Beech H35	NA	Goleta, California, U.S.	Personal	0	0	2	Destroyed
The engine failed when the airplane was about 150 feet AGL. The pilot reported that he switched fuel tanks and attempted a restart, which was not accomplished. He maneuvered to avoid a boat, then ditched the airplane in the ocean. The pilot and passenger exited the airplane before it sank.								
9/1/97	Agusta SF600 Canguro	Philippine National Police	Between Fortune and Lubang Islands, Philippines	Demonstration	5	0	0	Destroyed
Contact with the aircraft ceased during its flight and the aircraft later was found to have struck the sea.								
9/5/97*	Mooney M20E	NA	Gulf of California	Personal	0	0	4	Destroyed
The pilot topped off the aircraft with fuel before departing from Tucson, Arizona, U.S., for Mexico and had four hours' worth of fuel aboard after refueling. The pilot estimated that the aircraft had been airborne for 2.5 hours when the engine failed over the Gulf of California. The pilot declared mayday and ditched the aircraft. All four occupants exited the aircraft wearing life vests. One passenger swam 10 miles to shore and alerted authorities. The remaining three occupants of the aircraft spent about 20 hours in the water before Mexican authorities rescued them.								
9/11/97	Mooney M20F	B J Aviation	Coral Springs, Florida, U.S.	Business	1	1	0	Substantial
While the airplane was being flown through 1,000 feet to 1,500 feet, oil pressure decreased to zero momentarily, then returned to normal. There was a loud sound from the engine and the pilot initiated a descent for a forced landing on an open field. While the airplane was in a nose-low and right-wing-low attitude, the right wing collided with water in a pond and the airplane cartwheeled to the right and began sinking. The commercial pilot and an unrestrained dog were killed. The passenger exited the airplane by the cabin-entry door.								
9/19/97	Cessna 177RG	NA	Sebring, Florida, U.S.	Business	2	0	0	Destroyed
The flight was being operated in an area of thunderstorms. While en route at 6,000 feet, the pilot was cleared to descend to 5,000 feet. He acknowledged the clearance; there was no further radio communication with the pilot. Radar contact soon ceased. Witnesses heard the aircraft descending rapidly, and it struck a lake.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
10/9/97*	Piper PA-18A-150	Seashore Advertising Corp.	Gulf of Mexico	Positioning	0	0	1	Substantial
The engine failed during overwater flight, 120 nautical miles from the destination. The pilot conducted a forced landing at sea when he saw a military airplane flying in circles and a freighter ship on the surface. After the ditching, the freighter passed him by, and the military airplane kept circling. The pilot entered his life raft and the airplane sank. After about 20 minutes, the pilot was rescued by a Coast Guard aircraft.								
10/11/97	Piper PA-28-180	NA	Knoxville, Tennessee, U.S.	Personal	3	0	0	Destroyed
The airplane was seen by several witnesses after takeoff from an airport at which the tower had closed for the day. The witnesses said that the airplane was about 200 feet AGL in a nose-high attitude. There were indications that the airplane had stalled. Witnesses said that the wings were rocking, and then the airplane was turned left, went into a nose-low descent and struck the Tennessee River.								
10/12/97	Long-EZ	NA	Pacific Grove, California, U.S.	Personal	1	0	0	Destroyed
The experimental airplane struck the Pacific Ocean.								
10/29/97*	Robin 200	NA	Cromarty, Scotland	Instructional	1	0	1	Destroyed
The aircraft had a roughly running engine because of a blockage in the carburetor. The aircraft was ditched in sheltered waters about 200 meters from shore. The instructor pilot and student pilot escaped from the inverted floating aircraft but were not wearing the life vests provided. The instructor and the student swam for the shore. The instructor reached land and raised the alarm. The student's body was recovered several weeks later.								
11/6/97	Piper PA-28	NA	Bournemouth, England	Instructional	1	0	0	Destroyed
The student pilot on his first solo flight completed one circuit, made a touch-and-go landing and then flew the airplane out to sea, where it struck water. The inquest found that the pilot had committed suicide.								
11/8/97	Cessna 208B Caravan	Hageland Aviation Services	Barrow, Alaska, U.S.	Scheduled passenger	8	0	0	Destroyed
The aircraft struck the sea while in a left turn shortly after takeoff from Barrow. Another aircraft crew reported hearing a brief "mayday" call but the message contained no information about the nature of the problem.								
11/17/97	Canadair CL-415	Securite Civile	La Ciotat, France	Crew training	1	1	0	Destroyed
The pilot reported "heavy vibration." This was the last contact with the aircraft, which later was found floating inverted.								
11/18/97*	Cessna 402B-II	S.K. Griessels & R. D. Makin Partnership	Off Vilanculos, Mozambique	Personal	6	0	1	Destroyed
The aircraft was destroyed when it was ditched while attempting to land.								
11/26/97*	Piper PA-32-300	Pacific Island Aviation	Saipan, Marianas Protectorate	NA	0	0	1	Destroyed
The engine failed for undetermined reasons, which resulted in the pilot ditching the aircraft into the ocean.								
11/27/97	Maule M-7-235	NA	Rose Bay, New South Wales, Australia	Unscheduled passenger	0	0	1	Substantial
The pilot of the floatplane began the approach directly into the wind. A witness reported that just as the aircraft was flared, it yawed sharply to the right, and the right wing lifted until the left wing tip hit the water. The aircraft cartwheeled, coming to rest inverted. The pilot climbed out of the cockpit unaided and was rescued by the police.								
12/9/97	Cessna 172M	NA	New Salem, Massachusetts, U.S.	Personal	1	1	0	Substantial
While the airplane was being flown over a reservoir, the passenger believed that the airplane was low and asked the pilot, "Why don't you pull up a little bit?" The pilot said that the view was better down low and asked the passenger, "What, are you scared?" The airplane's wheels then struck the water and the airplane flipped over.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

<table>
<tr><th rowspan="2">Date: Month/Day/ Year</th><th rowspan="2">Aircraft</th><th rowspan="2">Operator</th><th rowspan="2">Location</th><th rowspan="2">Nature of Flight</th><th colspan="3">Injury to Occupants</th><th rowspan="2">Damage to Aircraft</th></tr>
<tr><th>Fatal</th><th>Serious</th><th>Minor/ None</th></tr>
<tr><td>12/19/97</td><td>Boeing 727-300</td><td>Silk Air</td><td>Musi River, Indonesia</td><td>Scheduled passenger</td><td>104</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">While en route between Jakarta, Indonesia, and Singapore, in apparently normal cruise flight at FL 350, the aircraft appeared to have suddenly departed from level flight. The aircraft entered a steep dive, descending from cruising altitude to 19,500 feet in 32 seconds. This "extreme descent" continued until impact. Following the accident, there was speculation that the captain had disabled the flight recorders and had initiated the dive. The Indonesian authorities' final report did not reach any conclusion about the cause.</td></tr>
<tr><td>1/5/98</td><td>Maule M-7-235</td><td>NA</td><td>Lady Musgrave Island, Queensland, Australia</td><td>Unscheduled passenger</td><td>0</td><td>0</td><td>5</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot reported that the aircraft flipped over and sank during an attempted takeoff.</td></tr>
<tr><td>1/9/98</td><td>Lake LA-4-200</td><td>NA</td><td>King Fisher Bay, Queensland, Australia</td><td>Unscheduled passenger</td><td>0</td><td>0</td><td>3</td><td>Substantial</td></tr>
<tr><td colspan="9">During the takeoff run, the aircraft struck an unseen submerged object. The impact launched the aircraft out of the water prematurely. The pilot placed the aircraft back into the water and continued the takeoff run. The pilot then noticed that water was entering the cabin behind the front seats and that the aircraft began to vibrate. He rejected the takeoff and stopped the engine before evacuating his passengers and himself. The aircraft sank about 15 minutes later.</td></tr>
<tr><td>2/6/98</td><td>GA 1159A Gulfstream III</td><td>Jet Aviation International</td><td>Chambery, France</td><td>Personal</td><td>0</td><td>0</td><td>5</td><td>Destroyed</td></tr>
<tr><td colspan="9">The aircraft undershot during the final stage of an ILS approach to Chambery, striking Lac le Bourget about 1.5 miles from the shore. After impact, the aircraft floated long enough to allow the occupants to escape before sinking in 90 feet of water.</td></tr>
<tr><td>2/6/98</td><td>Pitts S-2A</td><td>NA</td><td>Floraville Station, Queensland, Australia</td><td>Personal</td><td>2</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">A helicopter conducting an aerial patrol along a power line that had failed found a break in the line where it crossed a river. Debris, later identified as parts of a Pitts Special aircraft, was found downstream from the break. Several days later, the wreckage of the aircraft was located by police divers. It had come to rest upside down in about six meters of water, about 160 meters downstream from the wire strike.</td></tr>
<tr><td>2/9/98</td><td>McDonnell Douglas MD-11</td><td>Swissair</td><td>Peggy's Cove, Nova Scotia, Canada</td><td>Scheduled passenger</td><td>229</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">While in cruise flight about 56 minutes after takeoff, at FL 330, the flight crew reported smoke in the cockpit and requested a clearance to divert for an emergency landing. While being vectored to the airport at Halifax, Nova Scotia, the aircraft struck the water some five nautical miles off Peggy's Cove. The investigation found that the fire was associated with arcing from wiring for the in-flight entertainment system, which ignited a nearby thermal acoustic insulation blanket, above the rear cockpit ceiling.</td></tr>
<tr><td>2/14/98</td><td>Aviat A-1</td><td>Aerial Billboard Corp.</td><td>Clearwater, Florida, U.S.</td><td>Banner towing</td><td>0</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">While maneuvering to pick up a banner, the pilot failed to maintain adequate airspeed. A stall, loss of altitude and water strike followed.</td></tr>
<tr><td>2/22/98*</td><td>Cessna 150A</td><td>Island City Flying Service</td><td>Gulf of Mexico</td><td>Aerial observation</td><td>0</td><td>0</td><td>1</td><td>Destroyed</td></tr>
<tr><td colspan="9">While the airplane was on a fish-spotting flight, the engine failed. The pilot made a forced landing in the Gulf of Mexico, about 10 miles from Key West, Florida, U.S.</td></tr>
<tr><td>2/25/98</td><td>Lake LA-4-200</td><td>Sea Flight</td><td>Lake Murray, South Carolina, U.S.</td><td>Personal</td><td>0</td><td>3</td><td>0</td><td>Substantial</td></tr>
<tr><td colspan="9">The amphibious airplane struck a partially submerged object during a water landing that ripped and crushed the hull below the water line. The airplane subsequently nosed over and submerged in the water.</td></tr>
<tr><td>3/2/98</td><td>Cessna 401</td><td>Aerochaiten</td><td>La Puntilla, Chile</td><td>Unscheduled passenger</td><td>5</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">The aircraft struck the sea "a few minutes" after takeoff from Chaiten. Witnesses reported seeing the aircraft "flying low and on fire" just before it entered the water.</td></tr>
</table>

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
3/18/98	Saab 340B	Formosa Airlines	Hsinchu, Taiwan, China	Scheduled passenger	13	0	0	Destroyed
One minute and 45 seconds after takeoff, when power was reduced while the aircraft was climbing over the sea, the aircraft began to veer toward the right. The pilot attempted a correction but shortly afterward, loss of control apparently occurred. The aircraft entered a steep dive that continued until impact with the water.								
3/23/98	Cessna 152	MC Airlease	Dauphin Island, Alabama, U.S.	Instructional	0	0	2	Substantial
While flying the airplane at 3,500 feet, the instructor simulated an engine failure. The student initiated a descent for a forced landing at a nearby airport, and once a safe landing was ensured, at 600 feet AGL, the instructor advised the student to go around. The student was slow to apply power. The instructor applied full power and, as the instructor was completing communications with ATC, the student applied full left rudder and full aft elevator input. The airplane then began a turn to the left, from which the instructor was unable to recover before impact with the water.								
4/2/98	Piper PA-28-235	North American Flight Academy	New Orleans, Louisiana, U.S.	Personal	4	0	0	Destroyed
The airplane struck a lake following an uncontrolled descent after the pilot experienced spatial disorientation at night.								
4/19/98	De Havilland Tiger Moth	NA	English Channel	Personal	1	0	0	Destroyed
The aircraft was reported missing on a flight over the English Channel.								
4/26/98	Piper PA-18	Advertising Air Force	St. Petersburg, Florida, U.S.	NA	0	0	1	Substantial
During the initial climb, the engine partially failed and black smoke was noted coming from the exhaust. While the pilot maneuvered to return, the airplane stalled and struck the water.								
5/17/98*	Great Lakes 2T-1A-2	NA	Tower, Minnesota, U.S.	Business	0	0	2	Substantial
The pilot said that after takeoff, the airplane was in a turn when the engine rpm became intermittent. The pilot began a turn back toward the airport when the engine finally failed. The airplane was over a lake at the time. The pilot said that he turned to fly parallel to the shoreline, and the airplane touched down in the water about 100 feet from shore.								
5/20/98*	Cessna T210M	NA	Santa Barbara, California, U.S.	Personal	0	0	1	Destroyed
The pilot selected the left fuel tank. He was flying the airplane on final approach when the engine failed and he believed he was out of fuel. Unable to restart the engine, he turned away from the beach and ditched the airplane. Aircraft recovery personnel found the fuel tanks and discovered 15 gallons of fuel in the right tank.								
5/22/98	Piper PA-28-161	Inbound Aviation	Half Moon Bay, California, U.S.	Personal	4	0	0	Destroyed
The non-instrument-rated pilot lost control of the aircraft because of spatial disorientation in dark night conditions. No one saw the accident, but the following day, wreckage from the airplane and human remains washed up on shore.								
6/2/98	GA 1159A Gulfstream III	Jet Aviation International	Chambery, France	Personal	0	0	5	Destroyed
Following an ILS approach to the airport at Chambery, the aircraft undershot the runway, striking Lac le Bourget about 0.6 miles from the runway threshold. After impact, the aircraft floated for a few minutes, enabling the occupants to evacuate before it sank in 90 feet of water.								
6/4/98	Cessna 182R	Transit Aviation of Lake Charles	Bradenton, Florida, U.S.	Aerial observation	3	0	0	Destroyed
Postaccident examination showed that the aircraft had collided with trees and then struck a river while descending in a nose-down attitude at a slow speed.								
6/6/98	Maule M-5-220C	NA	Kettle Falls, Washington, U.S.	Personal	2	0	0	Destroyed
The airplane was destroyed when it struck Lake Roosevelt. Witnesses described the airplane performing maneuvers that were described as aerobatic prior to impact. This airplane was not approved for aerobatic maneuvers.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
6/7/98	Cessna U206G	NA	Berowra Waters, New South Wales, Australia	Unscheduled passenger	0	0	3	Substantial
After making a normal approach to the landing area, the pilot of the amphibious airplane closed the throttle and flared the aircraft. As the floats touched the water, the aircraft tipped forward and the nose of the aircraft dived under water, which caused the windshield to shatter. Water flooded the cabin and the aircraft came to rest inverted. The pilot and the two passengers evacuated the submerged cabin through the left cabin door. The pilot observed that the float-mounted landing gear was extended, not the correct position for a water landing.								
6/9/98*	Cessna 207A	Wings of Alaska	Juneau, Alaska, U.S.	Scheduled passenger	0	0	5	Substantial
Following an in-flight fire, the pilot ditched the airplane along the shoreline of a small island.								
7/13/98	Ilyushin IL-76M	ATI Aircompany	Khaimah, United Arab Emirates	Unscheduled cargo	8	0	0	Destroyed
A longer-than-normal takeoff roll occurred, and after becoming airborne, the aircraft never climbed above 200 meters. The aircraft then gradually descended until it struck the water.								
7/15/98	De Havilland DHC-2 Beaver	Air Rainbow Midcoast	Saturna Island, British Columbia, Canada	Unscheduled passenger	0	0	5	Substantial
The float-equipped airplane was en route on a VFR flight plan from Campbell River, British Columbia, to Renton, Washington, U.S. The pilot was following another Air Rainbow Beaver that was also proceeding to Renton. When the two airplanes approached Samuel Island, the weather deteriorated to such an extent that the pilots decided to land on the water and wait for conditions to improve. The lead airplane was landed first and, almost immediately, the pilot reported that he could see that the weather was clear ahead and that they should continue. The pilot of the accident airplane lost control of the aircraft during the rejected landing. The airplane stalled and struck the water in a steep, nose-down, left-wing-low attitude. The pilot of the other airplane returned when radio contact with the accident airplane was lost and rescued the occupants of the accident airplane.								
7/18/98	Piper PA-14	NA	Big Lake, Alaska, U.S.	Personal	0	0	2	Substantial
During takeoff from a lake, the pilot's seat slipped aft, and he lost his grip on the flight controls. The airplane struck the water and sank.								
7/18/98	Cessna A185F	NA	Moneta, Virginia, U.S.	Personal	0	0	3	Substantial
The amphibious airplane lifted off from a lake after a normal takeoff run. During a turn to avoid terrain, the airplane descended and the right float struck the water. The airplane then cartwheeled, flipped over and sank.								
7/23/98	Cessna 175	NA	Sheboygan, Wisconsin, U.S.	Personal	0	2	1	Substantial
After takeoff, the engine sputtered. Witnesses reported hearing engine rpm increase and decrease before the airplane descended, stuck the water in a left-wing-low attitude and overturned.								
7/27/98	Consolidated PBY-5A Catalina	Plane Sailing Air Displays	Southampton, England	Personal	2	0	16	Destroyed
During a touch-and-go landing, the initial touchdown was believed to have been smooth and straight. But as power was applied to complete the maneuver, the aircraft began to veer to the left. The veering motion developed rapidly and the aircraft came to a sudden stop in the water. It then began taking on water and started to sink. The aircraft floated submerged to the wings.								
7/29/98*	Embraer EMB-110 Bandeirante	Selva Taxi Aéreo	Manacapuru River, Brazil	Unscheduled passenger	5	0	18	Destroyed
The aircraft was destroyed after it apparently was ditched in the Manacapuru River while the pilot attempted to return to Manaus, Brazil. The aircraft had departed Manaus but the pilot reported that there was an engine problem and that he was returning.								
7/30/98	Beech Commuter 1900D	Proteus Air System	Vannes, France	Scheduled passenger	15	0	0	Destroyed
Loss of control occurred and the aircraft struck the Baie de Quiberon after colliding with a Cessna 177.								
8/1/98	Cessna 340A	NA	Chicago, Illinois, U.S.	Personal	1	0	3	Substantial
The pilot said that the airplane decelerated during the takeoff roll. The airplane cleared the end of the runway and then stalled into Lake Michigan. One passenger drowned.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
8/4/98*	De Havilland DHC-2 Beaver	Harbour Air	Kincolith, British Columbia, Canada	Unscheduled cargo	5	0	0	Substantial
On arrival at Kincolith, the aircraft touched down first on its right float and overturned. The occupants did not evacuate from the submerged aircraft. The water was described as "choppy."								
8/7/98*	Mooney M20A	Pilot/owner	Marathon, Florida, U.S.	Personal	0	2	0	Substantial
The airplane was on short final approach when the engine failed. The runway was beyond glide range, and the pilot conducted a forced landing in a bay.								
8/10/98*	Cessna 188	Airplane Parts and Avionics	Atlantic Ocean	Ferry	0	0	1	Destroyed
After 30 minutes in flight, the pilot observed that the oil pressure was zero. The pilot reported the problem to ATC and said that he was returning to the airport. About five minutes later, the engine failed. The pilot said that he would conduct an emergency landing on the Atlantic Ocean close to a large ship. After landing, the airplane floated for about 30 minutes and then sank. The pilot reported being in the water for 15 minutes before being rescued by the Coast Guard.								
8/15/98	Cessna 172N	Searcy Air Taxi	Cord, Arkansas, U.S.	Personal	1	0	1	Substantial
The airplane was being maneuvered at low altitude when it struck a power line, descended into a river and sank.								
8/19/98*	Cessna 402C	NA	Invercargill, New Zealand	Passenger	5	5	0	Destroyed
The airplane had a double engine failure. It was successfully ditched, and all 10 occupants evacuated; however, five people — four of whom did not have life vests — died before rescuers reached the scene about an hour later.								
8/19/98*	Cessna 402C	Southern Air	Foveaux Strait, Stewart Island, New Zealand	Scheduled passenger	5	5	0	Destroyed
About four minutes after takeoff, the pilot declared mayday and reported that both engines had failed. The pilot subsequently conducted a successful ditching, and the airplane floated for about four minutes to five minutes. The cabin apparently was not damaged and none of the occupants was seriously injured, but not all the passengers apparently found or had time to don their life vests and exited the airplane without them. The pilot reportedly attempted to re-enter the airplane to find additional life vests, but by this time the airplane was sinking and he was not successful. At the time of the ditching, there was an estimated three-meter swell and the sea temperature was 11 degrees Celsius.								
8/29/98	Beech T-34B	NA	Quantico, Virginia, U.S.	Instructional	2	0	0	Destroyed
The airplane departed on a local training flight. Witnesses reported that after the airplane became airborne, it did not climb as expected. While over the water and beyond the departure end of the runway, at an estimated height of 150 feet to 200 feet above the water, the airplane was observed to enter a shallow left turn. The bank angle increased, the nose dropped and the airplane struck the water.								
9/7/98*	Piper PA-31-350	NA	Homer, Alaska, U.S.	Business	0	0	1	Substantial
Immediately after takeoff, the right engine failed. The pilot said that he feathered the right propeller and began a wide right turn away from terrain in an attempt to return to the airport. Airspeed and altitude decreased, and the airplane was ditched on smooth water.								
9/11/98	Taylorcraft BC-12D	NA	Big Lake, Alaska, U.S.	Personal	0	0	2	Substantial
The pilot was conducting touch-and-go landings in the float-equipped airplane. The pilot said that during an approach, the airplane developed a sink rate that "felt mushy." The pilot increased engine power and aligned the airplane with the water. The right wing dropped, and the tip of the right float dug into the water. The airplane sank.								
9/18/98*	GAF Nomad N22S	U.S. Customs Service	Borinquen, Puerto Rico, U.S.	Scheduled passenger	1	0	1	Destroyed
The airplane was being flown in formation with another U.S. Customs Service Nomad from Borinquen to Curacao, Netherlands Antilles. About 70 minutes after takeoff, about 162 miles southwest of Puerto Rico, the accident airplane's rudder was damaged when it was struck by the other airplane's nose. Control was maintained, and the crew decided to return to Borinquen. During the return flight, the airplane became increasingly difficult to control and eventually was ditched near Mona Island, about 60 miles from Borinquen.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
9/24/98*	Convair 240	Trans Florida Airlines	Loiza, Puerto Rico, U.S.	Unscheduled cargo	0	0	3	Substantial
Shortly after takeoff from San Juan, Puerto Rico, the pilot advised ATC that he was returning. The aircraft was directed toward Runway 28 but, on the base leg, the aircraft began descending. The aircraft struck a mangrove swamp some three miles from the threshold of Runway 28 and came to rest in 15 feet of water.								
9/24/98*	Piper PA-22-150	NA	Lancaster, South Carolina, U.S.	Personal	0	0	1	Substantial
The pilot said that at 200 feet AGL during takeoff, "the engine went to idle as if the throttle had been pulled full out." He switched from the right fuel tank to the left fuel tank and applied carburetor heat. The pilot said that the engine regained power and the airplane was flown to 200 feet. When the pilot turned back toward the runway, the engine failed. The pilot ditched the airplane in a lake.								
9/25/98*	HEDARO Commonwealth CA25N	NA	Mitilini, Greece	Personal	0	0	1	Substantial
The engine failed during initial climb, and the airplane was ditched at sea, close to the runway.								
9/26/98	Boeing 737-200	Aerolíneas Argentinas	Ushuaia, Argentina	Scheduled passenger	0	0	62	Destroyed
During the landing roll, when about 200 feet from the runway end, the aircraft veered to the left and ran off the side of the runway. The aircraft fell down a deep slope into the waters of the Beagle Channel.								
10/2/98	Douglas DC-3C	Servivensa	Canaima, Venezuela	Unscheduled passenger	1	1	25	Destroyed
While in cruise flight at 3,000 feet MSL, the pilot reported that the no. 2 engine had failed. The aircraft continued toward Canaima, but during the approach, the no. 1 engine failed. The aircraft lost altitude, struck trees and struck a flooded area next to the Carrao River 1.6 statute miles from the airfield.								
10/9/98	Grumman American AA-5	NA	Provincetown, Massachusetts, U.S.	Personal	1	0	0	Destroyed
The pilot began an ILS approach in IMC, at night, from over water. After tracking the localizer and glideslope for part of the approach, the airplane descended and flew at 100 feet for about 12 seconds before a loss of ATC radar contact occurred. The airplane struck water.								
10/10/98*	Cessna 210A	NA	Provo, Utah, U.S.	Personal	0	0	2	Substantial
The airplane was low on approach to the runway, and the pilot abruptly moved the throttle lever, which caused the engine to flood and to fail. The pilot attempted to restart the engine but failed to follow emergency procedures in the airplane flight manual. The airplane was ditched in Utah Lake.								
10/21/98*	Aero Commander 500S	NA	Horn Island, Queensland, Australia	Unscheduled passenger	0	0	5	Substantial
The airplane was ditched about 400 meters from Runway 14 at Horn Island after both engines failed. The airplane came to rest in about two meters of water, about 200 meters from shore.								
11/15/98*	Cessna 172	NA	Essex, Maryland, U.S.	Personal	0	0	2	Substantial
Nearing the destination on a dark night, the pilot conducted a descent from 3,500 feet to 1,000 feet, entered the downwind leg, applied carburetor heat and began a left base turn at 700 feet. The pilot reported that rpm decreased and that he was unable to reach the airport. He ditched the airplane in a river.								
11/16/98	Mooney M20J	NA	San Angelo, Texas, U.S.	Personal	0	0	1	Substantial
The airplane was in cruise flight at 9,500 feet, about 12 miles east of the destination, when the pilot reported an engine failure. The airplane was at 2,200 feet when the pilot reported that he would not be able to land on the runway. During the off-airport landing, the airplane struck a tree and descended into the water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
11/16/98	Cessna 182P	NA	Santee, South Carolina, U.S.	Personal	1	0	0	Destroyed
The pilot continued VFR flight into IMC, became spatially disoriented and did not maintain control of the airplane. Witnesses said that there was fog near the destination and the airplane appeared to be circling around the lake at a "very low" altitude. Soon thereafter, a witness was moving his boat to a different fishing spot when he encountered debris floating in the lake and saw the tail of the airplane protruding from the water.								
11/20/98	Cessna 414A	NA	Mattapoisett, Massachusetts, U.S.	Personal	1	0	0	Destroyed
The airplane was level at 2,000 feet in IMC, when the pilot reported, "We've just lost our artificial horizon." About five minutes later, ATC radar contact and radio contact ceased. The wreckage of the airplane was found in 25 feet of water.								
11/29/98*	Beech A90 King Air	BPI Aerospace	Port de Paix, Haiti	Personal	0	0	1	Destroyed
While en route from North Perry, Florida, U.S., to Port-au-Prince, Haiti, the pilot declared an emergency, reported that he had a "dual engine failure" and that he was ditching. The pilot was rescued from a life raft about 10 hours later.								
12/7/98	PBN BN-2A-26 Islander	Air Satellite	Baie Comeau, Quebec, Canada	Scheduled passenger	7	3	0	Destroyed
The aircraft was destroyed after striking the St. Lawrence River about two miles from the takeoff runway. The accident occurred in driving snow and strong winds.								
12/8/98	Cessna 402B	Southern Pride Aviation	Pahokee, Florida, U.S.	Instructional	3	0	0	Substantial
The flight reportedly was a training session for the two front-seat occupants. ATC radar contact was lost when the airplane was descending through 1,300 feet AGL. Eight days later, the wreckage of the airplane and the bodies of the three occupants were recovered from the bottom of a lake.								
12/24/98	Jet Provost	NA	Bradwell, England	Aerobatic display	1	0	0	Destroyed
The airplane entered a spin during an aerobatic maneuver. The pilot ejected successfully from the airplane but died from drowning or thermal shock before he could be rescued from the sea. He was not wearing a life vest.								
1/6/99	SeaRey	NA	Brisbane Water, New South Wales, Australia	Personal	0	0	2	Substantial
The pilot reported that after touching down normally on calm water, the cockpit suddenly began to fill with water and the airplane overturned. Police rescued the pilot and passenger.								
1/13/99*	Cessna 210N	K.P. Cleary and Associates	Hallandale Beach, Florida, U.S.	Personal	0	0	1	Substantial
While the airplane was being flown through 1,500 feet during climb, engine rpm began to fluctuate as the throttle lever was moved. After advising ATC of the problem, the pilot was cleared to return to the departure airport. The engine then failed, and the pilot switched tanks several times. The pilot extended the flaps and ditched the airplane in the Atlantic Ocean. The airplane sank in 30 feet of water.								
2/5/99	Cessna 210J	Aero Jet Service Center	Naples, Florida, U.S.	Personal	1	0	0	Destroyed
The airplane struck the Gulf of Mexico while on approach to land at Naples Municipal Airport.								
2/6/99	Falco F8l Series 1	NA	Hauraki Gulf, New Zealand	Aerial observation	2	0	0	Destroyed
The pilot conducted several low passes over a yacht. On the last pass, the airplane was observed entering a turn, then suddenly rolling and descending in a steep nose-down attitude into the sea.								
2/25/99	Dornier 328-100	Minerva Italy	Genoa, Italy	Scheduled passenger	4	2	25	Destroyed
Landing at Genoa, the pilot reportedly touched down "long and fast" with a tail-wind component. Near the end of the runway, the pilot apparently attempted to turn the aircraft off one side of the runway. The aircraft overran the runway and fell into the Golfo de Genoa.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
2/28/99*	Cessna P210N	Pilot Services International	Near Maui, Hawaii, U.S.	Ferry	1	0	0	Destroyed
The pilot was ferrying the airplane from Thailand to the United States mainland. After departing Honolulu, Hawaii, U.S., the airplane was 810 nautical miles northeast of Hawaii when the pilot observed that engine-oil pressure was decreasing. He reversed course to fly the airplane back to Hawaii. During the next three hours, the pilot reported decreasing oil pressure, increasing engine temperatures and decreasing manifold pressure. The pilot told the flight crew of an escorting Coast Guard HC-130 that an engine failure was imminent and that he would need to ditch the airplane. The pilot made an emergency descent and ditched the airplane. The airplane bounced off a swell, then hit another and nosed down. The airplane remained upright about 45 minutes before sinking. The airplane doors were not opened and the pilot was not observed in the water after ditching. The HC-130 loitered over the ditched airplane until it disappeared.								
3/3/99*	Piper PA-32-260	J. Franklin Corp.	Near Cat Island, Bahamas	Business	0	0	1	Destroyed
The airplane was in cruise flight at 4,500 feet when the pilot reported that the engine-oil temperature increased rapidly to the redline. About 14 minutes later, oil pressure decreased, the engine ran roughly and the pilot could not maintain altitude. He elected to ditch near a boat. About 50 feet above the water, the propeller stopped. The airplane sank after it was ditched, and the pilot was picked up from the water by the occupants of the boat.								
3/18/99*	Cessna 206	Air Chathams	Pitt Island, New Zealand	Unscheduled passenger	0	0	5	Destroyed
The passengers were surveying and photographing Pitt Island. The pilot flew around the island and was just about to ask whether they wanted to make another orbit when the engine failed. The pilot turned toward shore for an emergency landing. He told the passengers to prepare for a ditching, to tighten their seat belts and to crack open the doors. The airplane struck the relatively calm sea about 800 meters from shore. The occupants reported that the aircraft nosed down during the ditching, became inverted and sank quickly. Although life vests and a life raft were aboard the airplane, no one was able to locate and don a life vest during the approximately 30 seconds between the engine failure and the ditching, and the life raft was not deployed. The occupants swam to shore in about one hour. Island occupants, including a doctor and a nurse, tended to the survivors, who recovered from varying degrees of hypothermia and shock.								
3/27/99*	De Havilland DHC-1A-1	NA	Picton, New Zealand	Personal	0	0	1	Substantial
The engine failed in cruise flight, and the pilot ditched the airplane in Whatamango Bay. The airplane nosed over on landing, but the pilot escaped uninjured.								
4/14/99*	Piper PA-31	Tokyo International Trading America	Monterey, California, U.S.	Ferry	0	0	1	Destroyed
An undetermined system malfunction in the right engine led to an increase in fuel usage beyond the pilot's planned fuel-consumption rate and to eventual fuel exhaustion. The pilot ditched the aircraft in the ocean. He exited the aircraft, deployed a life raft and was rescued by the Coast Guard after about 30 minutes.								
4/22/99	SeaRey	NA	Selby Beach, Maryland, U.S.	Personal	1	1	0	Substantial
The homebuilt airplane was damaged substantially during a water landing. A boater arrived at the accident site and saw the pilot and passenger in the water. The passenger was unconscious and face-down. The pilot was conscious and requesting help. The boater threw a life ring to the pilot, but the pilot was unable to hold on to it. The boater repositioned his boat, then threw a rope to the pilot and asked him to hold the passenger's head out of the water. The pilot was unable to do so. The boater then went below deck to get three life vests, one of which he put on. When he returned, the pilot was below the surface of the water. The boater dived into the water, released the extra life vest and swam about 15 feet to the two men. He lifted their heads out of the water and waited for another boat to arrive. The two injured men were pulled aboard and taken to shore. The passenger did not survive.								
5/5/99*	Piper PA-28-181	NA	Cleveland, Ohio, U.S.	Positioning	0	0	1	Substantial
As the airplane neared the destination, the engine began to run roughly. The pilot turned on the boost pump, and there was a momentary power surge. The engine then failed, and the pilot declared an emergency. The airplane was ditched in a lake.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
5/7/99*	Aeronca 15AC	NA	Pedro Bay, Alaska, U.S.	Personal	0	1	0	Substantial
The pilot reported that while the airplane was being flown through 7,000 feet during climb, he smelled smoke, and the engine began to run roughly. During an emergency descent, smoke and flames entered the cockpit from under the floor adjacent to the rudder pedals. The pilot said, "My legs were on fire, and I just wanted to put the fire out and get the airplane on the ground." He ditched the airplane in shallow ocean water near a beach.								
5/7/99	Cessna T303	NA	San Diego, California, U.S.	Personal	0	0	2	Substantial
The airplane struck San Diego Bay and sank following a loss of power in both engines during a missed approach to Runway 27 at Lindbergh Field.								
5/8/99	DHC-6 Twin Otter 300	Vanair	Port Vila, Vanuatu	Scheduled passenger	7	0	5	Destroyed
The aircraft was destroyed when it flew into the sea while descending inbound to Port Vila. According to surviving passengers, the flight had appeared to be proceeding normally until impact with the water. The accident happened in darkness and heavy rain.								
5/22/99	Beech B90 King Air	Pacific International Skydiving Center	Mokuleia, Hawaii, U.S.	Parachuting	1	0	0	Destroyed
The aircraft had transported parachutists to the jump site, and the pilot had begun to return to base. The aircraft was seen in a descending turn toward the shore. The descent continued, apparently without a level-off, until it struck the sea.								
5/29/99*	Beech D-45	Travis Air Force Base Aero Club	Lake Berryessa, California, U.S.	Personal	0	0	2	Substantial
The engine failed during cruise flight, and the airplane was ditched in Lake Berryessa.								
6/13/99	Buccaneer II	NA	Panacea, Florida, U.S.	Personal	0	1	1	Substantial
The pilot continued operation of the homebuilt airplane with known deficiencies in the pitot system and erroneous airspeed indications. An inadvertent stall occurred on takeoff, and the airplane descended out of control into the water.								
6/20/99*	Cessna 182Q	NA	Rising Sun, Maryland, U.S.	Personal	0	1	3	Destroyed
The airplane was in level flight at 4,000 feet on a dark night in IMC when the engine failed. The pilot conducted a forced landing on a river.								
6/23/99*	Cessna 185E	NA	East Haddam, Connecticut, U.S.	Personal	0	1	1	Substantial
During initial climb, the engine began to fail and the pilot attempted a forced landing in a river. The airplane stalled, struck the water nose-down and sank.								
6/26/99	SeaRey	NA	Hastings, Victoria, Australia	Personal	0	0	1	Substantial
The pilot reported that he was attempting to take off in near-perfect sea conditions. Airspeed was 40 knots to 45 knots when the amphibious aircraft settled and became partially submerged. As the pilot was exiting the aircraft, he observed that the flaps were retracted, although the flap-selector handle was in the position for 20 degrees (full) flaps, which is the normal setting for takeoff.								
7/9/99*	Grumman AA-5	NA	Iceland	Personal	0	0	2	Destroyed
The engine failed because of fuel starvation. The pilot ditched the airplane and swam to shore. The passenger's body was found after a two-hour search.								
7/16/99	Piper PA-32R-301	NA	Vineyard Haven, Massachusetts, U.S.	Personal	3	0	0	Destroyed
The airplane struck the Atlantic Ocean about 7.5 miles southwest of Martha's Vineyard during a descent at night and in haze.								
7/17/99	Piper J-3C	NA	Maple Lake, Minnesota, U.S.	Personal	0	2	0	Substantial
The float-equipped airplane was flown from one lake to another, where the pilot picked up a passenger. The pilot reported that during takeoff, he encountered pitch problems during climb. At 50 feet to 100 feet, the airplane began turning left, the nose pitched down, and the airplane descended into the lake.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/21/99	Hodre-Buull-Kolb Mark III	NA	Plymouth, Minnesota, U.S.	Personal	0	1	0	Destroyed
The pilot reported that the experimental amphibious airplane was at 200 feet during initial climb when a loss of rudder control occurred The pilot said that he tried to turn the airplane away from a beach populated with swimmers and sunbathers. The airplane struck the water nose-first.								
7/28/99*	Fairchild SA-227AC Metro III	KAL Aviation – Calavia	Near Rhodes, Greece	Unscheduled cargo	0	0	2	Destroyed
Both engines reportedly failed during the final stage of the approach to Diagoras Airport, and the aircraft subsequently was ditched in the sea just off the coast.								
9/20/99*	Cessna 177A	NA	Big Bear City, California, U.S.	Maintenance test	0	0	1	Substantial
The engine failed because of fuel-system contamination, which resulted from a maintenance technician's failure to fully inspect and verify the serviceability of the fuel system before returning the aircraft to service for a maintenance test flight. The pilot attempted to return to the departure airport but was not able to glide to the runway and ditched the airplane.								
9/22/99	Beech 200 King Air	Cia Aerospace de Venezuela	Bimini, Bahamas	Personal	2	0	0	Destroyed
While en route and flying at FL 210, the pilot advised Miami (Florida, U.S.) ATC that he had an emergency. Shortly afterward, the flight disappeared from radar. A small amount of floating debris later was recovered from the sea in the general area of the flight's last reported position.								
9/23/99	Cessna 208 Caravan I	Air Tindi	Hoar Frost River, Canada	Personnel positioning	0	0	3	Major partial
Shortly after touchdown, the front strut of the aircraft's left float failed and the float rotated and struck the propeller. The pilot shut down the engine, and he and his passengers were rescued by boat. The aircraft did not sink but was further damaged by being blown against rocks on the shoreline before it could be salvaged. The water was "rough" with an estimated three-foot swell.								
9/27/99	Piper PA-28-140	NA	Clinton, Iowa, U.S.	Personal	1	0	0	Destroyed
The airplane struck the Mississippi River. The non-instrument-rated pilot had chosen to conduct the flight although the automated weather briefing advised that VFR flight in the area was not recommended because of the low clouds, rain and a dark night.								
10/4/99	SOCATA TB-10 Tobago	Servicios Turísticos Levol	Pisco, Peru	Personal	5	0	0	Destroyed
The aircraft was destroyed when it struck the sea shortly after takeoff. The accident happened in daylight with strong winds, rain and fog.								
10/9/99	Cessna 172I	NA	North East Carry, Maine, U.S.	Personal	0	0	2	Substantial
During takeoff in gusty winds and on rough water, the airplane became airborne, the right wing dipped and the right float hit a wave. The airplane became airborne again, then rolled right and overturned.								
10/13/99*	Cessna 208B Caravan I	Skylink Express	Pointe aux Pins, Ontario, Canada	Unscheduled cargo	0	0	2	Destroyed
While the aircraft was flying over Lake Erie, there was a loud "bang" and the aircraft's propeller stopped "abruptly." The pilot shut down the engine and conducted a forced landing in the lake.								
10/15/99	Cessna 208B Caravan I	Wasaya Airways	Red Lake, Ontario, Canada	Unscheduled cargo	0	1	0	Destroyed
While the aircraft was overflying Ranger Lake, a large flock of birds flew into the flight path of the aircraft and the pilot commenced a descending turn to avoid the birds. During the turn, the right wing of the aircraft struck the surface of the lake, and the aircraft struck the water. The surface of the lake was flat and "glassy," and the pilot's depth perception was affected.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
10/17/99	McDonnell Douglas MD-11F	FedEx	Olongapo, Philippines	Scheduled cargo	0	0	2	Destroyed
Following a manually flown VOR/DME approach, the aircraft reportedly "landed long." The aircraft was not stopped before the end of the runway. After the overrun, the aircraft fell into the waters of the bay, broke up and sank.								
10/24/99	Learjet 35A	Avioriprese Jet Executive	Carnigoli, Italy	Unscheduled passenger	3	0	0	Destroyed
The aircraft was destroyed when it apparently struck the sea while on approach to Genoa, Italy. The accident happened in daylight but in poor weather with low cloud and heavy rain.								
10/30/99	Cessna T310R	Southern Aerial Photography	Key West, Florida, U.S.	Personal	4	0	0	Destroyed
The airplane struck the Atlantic Ocean about 10 miles from Key West while being flown in dark-night conditions.								
10/31/99	Boeing 757-300ER	EgyptAir	North Atlantic Ocean	Scheduled passenger	217	0	0	Destroyed
After the aircraft had reached its initial cruise altitude of FL 330 following takeoff, radar showed the aircraft descending in a steep, high-speed dive. It struck the sea and was destroyed. The U.S. National Transportation Safety Board (NTSB) determined that the probable cause of the accident was a relief first officer's control inputs, which reduced power and initiated the dive. The Egyptian Civil Aviation Authority disputed NTSB's finding of probable cause.								
11/11/99	Beech 200 King Air	Jaymar Ruby	Chicago, Illinois, U.S.	Personal	3	0	0	Destroyed
The aircraft struck Lake Michigan, about 300 feet from the departure end of the runway. During the takeoff roll, the aircraft did not appear to rotate and did not become airborne.								
11/24/99	Cessna U206A	NA	Queensland, Australia	Unscheduled passenger	6	0	0	Destroyed
Soon after departure, the pilot reported that he was encountering adverse weather and was diverting the flight. No further radio transmissions were heard, and a subsequent search found numerous small items from the aircraft floating on the water.								
11/27/99	De Havilland DHC-2 Beaver	NA	Washougal, Washington, U.S.	Personal	4	0	0	Substantial
Witnesses reported that after taking off from the Columbia River and climbing about 100 feet to 400 feet above the water, the airplane entered a left turn of about 45 degrees bank. Most witnesses said that after the airplane had turned about 180 degrees when the nose abruptly dropped and the airplane struck the water. The airplane became inverted and the cabin submerged. Efforts to enter the cabin to provide assistance were unsuccessful because of airplane damage. Rescue divers found the deceased occupants in the airplane. Autopsies indicated that they had drowned.								
12/5/99	Osprey 2	NA	Chula Vista, California, U.S.	Personal	1	0	0	Destroyed
The pilot exceeded the design stress limits of the airplane, resulting in wing overload and separation. The airplane struck Lower Otay Lake Reservoir.								
12/29/99	Antonov An-28	Guinee Ecuatorial Airlines	Inebolu, Turkey	Ferry	6	0	0	Destroyed
Contact was lost with the crew while the aircraft was en route; the aircraft was believed to have struck the Black Sea some 50 kilometers off Inebolu, 250 kilometers from its destination.								
1/5/00	Cessna 172	Airline Training Academy	St. Augustine, Florida, U.S.	Instructional	1	0	0	Destroyed
The airplane struck the Atlantic Ocean about four miles east of the St. Augustine airport. In his last radio transmission, the pilot said, "I haven't any direction finder. I don't see anything."								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

<table>
<tr><th rowspan="2">Date: Month/Day/ Year</th><th rowspan="2">Aircraft</th><th rowspan="2">Operator</th><th rowspan="2">Location</th><th rowspan="2">Nature of Flight</th><th colspan="3">Injury to Occupants</th><th rowspan="2">Damage to Aircraft</th></tr>
<tr><th>Fatal</th><th>Serious</th><th>Minor/ None</th></tr>
<tr><td>1/13/00*</td><td>Shorts 360-300</td><td>AVISTO</td><td>Marsa el Brega, Libya</td><td>Unscheduled passenger</td><td>22</td><td>13</td><td>6</td><td>Destroyed</td></tr>
<tr><td colspan="9">During an approach, as the aircraft was descending through about 2,000 feet about 4.5 miles from the airport, the left engine flamed out. About 30 seconds later, the right engine flamed out. The pilot conducted a forced landing in the sea some distance from the coast. The airplane was substantially damaged on impact and sank within minutes.

The airplane was not equipped with life vests; the seat cushions were intended for use as flotation aids. Nevertheless, the passenger briefing cards aboard the airplane described the use of life vests, and there was a placard on each seat stating, "Life Vest Under Your Seat." The passengers were not told that the airplane was being ditched.</td></tr>
<tr><td>1/21/00*</td><td>Cessna 182Q</td><td>NA</td><td>Verona Sands, Tasmania, Australia</td><td>Unscheduled passenger</td><td>0</td><td>0</td><td>4</td><td>Destroyed</td></tr>
<tr><td colspan="9">The engine failed during cruise flight. The pilot was unable to restart the engine. There was no suitable landing area on a nearby island, so the pilot ditched the aircraft about one kilometer from shore. Three of the four occupants exited the aircraft, and the fourth occupant was pulled out by the pilot. All then made their way to the shoreline.</td></tr>
<tr><td>1/30/00</td><td>Airbus A310-300</td><td>Kenya Airways</td><td>Abidjan, Ivory Coast</td><td>Scheduled passenger</td><td>169</td><td>0</td><td>10</td><td>Destroyed</td></tr>
<tr><td colspan="9">During takeoff, the aircraft crew used more of the runway than normal and the aircraft was "still very low" as it flew over the sea wall some 500 meters beyond the runway end. The aircraft apparently did not gain altitude and struck the water about one mile offshore.</td></tr>
<tr><td>1/31/00</td><td>McDonnell Douglas MD-83</td><td>Alaska Airlines</td><td>Point Mugu, California, U.S.</td><td>Scheduled passenger</td><td>88</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">Loss of control occurred and the aircraft struck the Santa Barbara Channel some 20 miles south of Point Mugu while being vectored for an approach to Los Angeles (California, U.S.) International Airport. The U.S. National Transportation Safety Board determined that inadequate lubrication during maintenance had led to failure of the jackscrew assembly in the aircraft's horizontal-stabilizer-trim system. The failure caused the horizontal stabilizer to jam in a position that caused the aircraft to enter a nose-down pitch attitude from which recovery was not possible.</td></tr>
<tr><td>2/3/00</td><td>Boeing 707-320C</td><td>Trans Arabian Air Transport</td><td>Mwanza, Tanzania</td><td>Ferry</td><td>0</td><td>0</td><td>5</td><td>Destroyed</td></tr>
<tr><td colspan="9">The aircraft crew apparently undershot the runway on the approach to Mwanza, striking Lake Victoria about two nautical miles short of the runway threshold.</td></tr>
<tr><td>2/21/00</td><td>Piper PA-31</td><td>Cape Smythe Air Service</td><td>Chukchi Sea</td><td>Scheduled passenger</td><td>0</td><td>1</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">The aircraft apparently undershot the runway during the final stage of a GPS approach to Kotzebue, Alaska, U.S., striking the sea some four miles short of the runway.</td></tr>
<tr><td>3/8/00*</td><td>Cessna P206C</td><td>NA</td><td>Kingscote, South Australia, Australia</td><td>Personal</td><td>1</td><td>0</td><td>1</td><td>Destroyed</td></tr>
<tr><td colspan="9">The pilot advised ATC of an engine failure and that the airplane would be ditched. ATC requested that the crew of a Royal Australian Air Force aircraft divert to the area to assist with SAR. The air force aircraft remained in the area, about 104 kilometers east-southeast of Kingscote, until a rescue helicopter arrived and winched the passenger aboard.</td></tr>
<tr><td>3/18/00*</td><td>Cessna 210E</td><td>NA</td><td>Moorabbin, Victoria, Australia</td><td>Personal</td><td>1</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">The aircraft was observed to climb briefly after liftoff and then to slowly descend. The pilot ditched the aircraft in a disused quarry. A passenger drowned after leaving the aircraft.</td></tr>
<tr><td>3/26/00</td><td>SeaRey</td><td>Tail Feather</td><td>Kill Devil Hill, North Carolina, U.S.</td><td>Personal</td><td>0</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">The airplane stalled during final approach and entered an uncontrolled descent into the water.</td></tr>
<tr><td>3/26/00</td><td>Piper PA-24-260</td><td>NA</td><td>Panama City, Florida, U.S.</td><td>Personal</td><td>1</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">The airplane struck water when the pilot experienced spatial disorientation while reversing course on a dark night.</td></tr>
</table>

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
4/3/00	Beech M35	Fisher Global Development	Near Lake Charles, Louisiana, U.S.	Personal	1	0	0	Destroyed
The airplane was flown into severe weather conditions over the Gulf of Mexico. Recorded ATC radar data indicated that there were excursions in altitude and airspeed consistent with flight in moderate to severe turbulence. Radio contact and radar contact were lost, and an extensive sea and air search for the airplane was unsuccessful.								
4/12/00	Piper PA-28	Pilot/owner	Aleknagik, Alaska, U.S.	Ferry	0	0	2	Substantial
The pilot said that during cruise flight at 500 feet AGL, the horizon became indistinguishable from the snow-covered mountains and ground. The airplane descended into a snow-covered lake.								
4/15/00	Cessna 172S	NA	Muskegon, Michigan, U.S.	Personal	0	0	2	Substantial
The non-instrument-rated pilot became disoriented while flying the airplane over Lake Michigan and was issued a heading by ATC to return to the airport. The pilot said that he was trying to keep the airplane level and was looking for VMC when the airplane "belly flopped" into the lake. The pilot and his son sat in the airplane for about one minute before it started to sink. They exited the airplane through the left-side window and held on to a floating tire until they were rescued by the Coast Guard. They were treated for hypothermia.								
4/28/00	Cessna 172P	Pacific Flight Services	Chester, California, U.S.	Personal	4	0	0	Destroyed
The airplane struck the surface of Lake Alamanor and sank. There were no witnesses. Investigators determined that the airplane had encountered wind shear at a low altitude, which resulted in loss of control and a stall/spin.								
4/30/00	McDonnell Douglas DC-10-30F	DAS Air	Entebbe, Uganda	Unscheduled cargo	0	0	7	Destroyed
During the landing roll, the crew apparently saw that the aircraft could not be stopped on the remaining runway. The pilot steered the aircraft to the left to avoid striking the ILS antenna and the approach lights. The aircraft continued across grass for some 100 meters before falling down a steep bank into Lake Victoria.								
5/19/00*	Aero Commander 500-S	NA	Horn Island, Queensland, Australia	Unscheduled passenger	0	0	5	Substantial
When the aircraft was approximately three nautical miles from the runway, both engines surged and the aircraft yawed right. The pilot began engine failure procedures and retracted the flaps. He tried several times to determine which engine was failing by retarding the throttle for each engine. He decided that the right engine was failing. The pilot shut down that engine and feathered the propeller. Soon thereafter, when the aircraft was approximately 200 feet above the water, the left engine failed. The pilot established the aircraft in a glide, advised the passengers to prepare for a ditching and declared mayday before the aircraft struck the sea. During impact, the passenger in the rear seat was thrown over the center seats into the right front seat, which was unoccupied. The passenger in the center right seat received a back injury. Both windshields were shattered. The cabin rapidly filled with water. The four other occupants then swam ashore, assisting the injured passenger to shore. The aircraft quickly filled with water, sank and settled on the seabed.								
5/23/00*	Beech King Air 200	Calico Ventures	Near San Diego, California, U.S.	Personal	0	0	1	Destroyed
The pilot ditched the airplane in the Pacific Ocean about 160 miles southwest of San Diego after he became ill from the delayed effects of pesticide he had sprayed. The Coast Guard rescued the pilot, and the aircraft sank.								
5/31/00*	Piper PA-31-350	Whyalla Airlines	Whyalla, South Australia, Australia	Scheduled passenger	8	0	0	Destroyed
Soon after beginning a descent to Whyalla, the pilot declared mayday and advised ATC that both engines had failed. The aircraft was ditched and sank in Spencer Gulf, about 28 kilometers southeast of Whyalla Airport.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/3/00	DHC-6 Twin Otter 300	Maxwell W. Ward	Yellowknife, Northwest Territories, Canada	Personal	0	0	4	Destroyed
During a crosswind landing, the aircraft "porpoised" on touchdown and became airborne again. The aircraft bounced twice more and, on the third touchdown, its left float dug into the water. The aircraft veered to the left, and then its right wing struck the water and was torn away. The aircraft eventually came to rest on its floats.								
6/14/00	Piper PA-31	Air Navigation	Liverpool, England	Air ambulance	5	0	0	Destroyed
The aircraft struck the River Mersey during an ILS approach to Runway 9 at Liverpool.								
6/24/00*	Cessna 172N	NA	Near Freeport, Bahamas	Personal	0	0	4	Substantial
During descent to land in Freeport, the engine failed. The pilot ditched the airplane near a commercial boat.								
6/30/00	Cessna 337C	Missionary Aviation Repair Center	Marshall, Alaska, U.S.	Positioning	1	0	0	Destroyed
Before takeoff, the pilot was unable to start the rear engine but said that he had conducted single-engine takeoffs. He selected a point on the runway where he would reject the takeoff if the airplane was not airborne. A witness said that as the airplane passed the abort point, the nosewheel was lifting off the runway The airplane climbed about 50 feet, the wings rocked slightly, and the airplane descended into a lake.								
7/14/00	Aeronca 11BC	NA	Wasilla, Alaska, U.S.	Personal	0	0	1	Substantial
Following a takeoff from Three Mile Lake, the airplane was observed "doing a U-turn and dropping straight down into the lake." The pilot said that the engine was producing only partial power and that as he turned the airplane left, the nose dropped and the airplane struck the water in a nose-low, upright attitude.								
8/1/00	SeaRey	NA	Tulsa, Oklahoma, U.S.	Personal	0	1	0	Substantial
The pilot reported that during cruise flight at 1,100 feet to 1,200 feet in the vicinity of a lake, she "blacked out." Her medical records indicated that she had a heart condition. The experimental amphibious airplane struck the lake and came to rest floating upside down.								
8/12/00*	Cessna 150	NA	Carlsbad, California, U.S.	Aerial observation	0	0	1	Destroyed
During a fish-spotting flight, the engine failed and the aircraft was ditched in the Pacific Ocean about 20 miles offshore.								
8/14/00	Cessna 208 Caravan	Royal Canadian Mounted Police	Teslin Lake, British Columbia, Canada	Public	2	0	0	Destroyed
The amphibious airplane was being used to transport members of an emergency-response team to a site on the south end of Teslin Lake. Soon after takeoff, the airplane was observed to pitch up into a steep climb, stall and then descend at a steep angle into the water.								
8/15/00	Cessna 208 Caravan I	Royal Canadian Mounted Police Air Service	Teslin Lake, British Columbia, Canada	Ferry	2	0	0	Destroyed
During the previous afternoon, the aircraft had brought a number of police officers to Teslin Lake and had landed near the mouth of the Jennings River. While being maneuvered for takeoff on the accident flight, the aircraft became stuck on a sand bar. The aircraft was freed and the takeoff was conducted. Shortly afterward, the aircraft was seen in a steep descent which continued until impact with the water.								
8/17/00	Cessna 185	Whistler Air Services	Green Lake, British Columbia, Canada	Sightseeing	0	0	5	Substantial
The floatplane remained low over the surface of Green Lake after liftoff. As it approached the end of the lake, it was turned right to avoid trees on the shoreline. Soon thereafter, it was turned right again to avoid the shoreline. During the second turn, the floatplane descended into the water.								
8/18/00*	Piper PA-32R-301	Pilot/owner	Kennebunkport, Maine, U.S.	Personal	2	2	1	Substantial
The airplane was in cruise flight at 9,000 feet when a loud bang was heard from the engine compartment and the windshield became covered with oil. The pilot said that the engine then produced partial power before failing. The pilot ditched the airplane in the ocean.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
8/18/00*	Fairchild 24G	Pilot/owner	Cascade Locks, Oregon, U.S.	Personal	0	0	2	Substantial
After takeoff, the engine began to run roughly, and the pilot began a turn back toward the runway. After about 90 degrees of turn, the engine failed. Knowing that he could not land at the airport, the pilot rolled out of the turn and set up to ditch the airplane near the shore of a river. After the airplane touched down, the pilot and his passenger exited through the pilot-side door and were rescued by a passing boat.								
8/18/00	Aero L29 Delfin	NA	Eastbourne, England	Aerobatic display	1	0	0	Destroyed
The aircraft was in a vertical, rolling climb when it stalled and then spun into the water.								
8/23/00	Airbus A320-210	Gulf Air	Manama, Bahrain	Scheduled passenger	143	0	0	Destroyed
Following a go-around, ATC instructed the flight crew to turn left to a heading of 300 degrees and to climb to 2,500 feet. The aircraft's landing gear was retracted and engine thrust was increased to maximum. The aircraft began a left turn and climbed to about 1,000 feet in a five-degree nose-up attitude. The airspeed exceeded 185 knots and the master warning sounded. The first officer said "Overspeed limit," and apparently this callout quickly was followed by a forward movement of the captain's side stick. The aircraft's pitch gradually decreased to 15 degrees nose-down. The aircraft descended rapidly and struck shallow water about one mile north of the runway.								
8/25/00*	Piper PA-31-350	Big Island Air	Hilo, Hawaii, U.S.	Unscheduled passenger	1	0	8	Substantial
The engine failed during cruise flight, and the airplane was ditched in the ocean. The airplane began to take on water immediately. After exiting, the pilot moved to the rear-main cabin door to assist the passengers. The right-front seat passenger remained by the left cockpit door to assist any passengers who might use that exit. A passenger reported that water pressure against the right emergency window exit prevented its use. As the nose sank first, the airplane began a gradual roll to the right, disappearing below the water within 60 seconds. The pilot attempted to dive below the water to check for any remaining passengers but reported that the murky water impaired his vision. The pilot signaled for the passengers to remain in a group. Within about 15 minutes, a Hilo fire department helicopter and rescue personnel arrived. One passenger was missing. Subsequently, the body of the missing passenger was located in the airplane.								
9/11/00	Piper PA-18	Anderson Wilderness Guide Service	Sleetmute, Alaska, U.S.	Business	0	1	1	Substantial
The pilot said that immediately after takeoff, he had difficulty lowering the float-equipped airplane's nose. The airplane stalled and struck the water.								
9/23/00	De Havilland DHC-2 Beaver	NA	Gosford Broadwater, New South Wales, Australia	Unscheduled passenger	1/1/04	0	1	Substantial
On touchdown, the floatplane's left sponson dipped into the water, causing the aircraft to slew left. The left wing tip struck the water, causing substantial wing damage. The aircraft remained afloat, and the pilot exited the aircraft uninjured.								
10/23/00	Cessna P210N	Kampala Aero Club	Entebbe, Uganda	Personal	5	0	0	Destroyed
The aircraft struck the water of Lake Victoria, about 300 meters from the shore, during the final stage of an approach.								
11/1/00	De Havilland DHC-6 Twin Otter	West Coast Air	Vancouver, British Columbia, Canada	Scheduled passenger	0	0	17	Destroyed
The aircraft was on a flight from Vancouver to Victoria, British Columbia. Soon after takeoff, there was a loud bang and a noise similar to gravel hitting the aircraft. Simultaneously, flame emerged from the no. 2 engine, which then lost power. The aircraft struck the water about 25 seconds later in a nose-down, right-wing low attitude. The aircraft remained upright and partially submerged while the occupants exited through the main door and the two pilot doors. They were taken ashore by several maritime vessels that arrived at the scene within minutes. The aircraft subsequently sank.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
11/11/00*	Airparts Fletcher FU-24	NA	Myanmar	Ferry	0	0	1	Destroyed
The pilot declared an emergency as a result of engine surging during a flight from Malaysia to India. The pilot activated the aircraft's ELT and the ELT attached to his life vest. He prepared the aircraft and himself for a water landing. The aircraft was ditched in Myanmar territorial waters. The pilot later was rescued by a naval patrol vessel.								
11/15/00	Beech 23	NA	Everglades City, Florida, U.S.	Personal	0	0	3	Substantial
The pilot said that he encountered strong, gusty winds that forced the airplane to bounce on the runway during landing. The pilot said that he began to conduct a go-around with full power, but the airplane would not attain flying speed and settled into the bay at the end of the runway.								
1/6/01	Cessna 152	Pilot/owner	Spanish Fork, Utah, U.S.	Personal	0	1	1	Destroyed
The non-instrument-rated pilot continued VFR flight into IMC and became disoriented. The airplane struck a frozen lake, skidded about 300 feet and fell through the ice. While the pilot clung to the airplane's wing, which remained above the water, the passenger walked across the lake's thin ice and eventually reached the Provo, Utah, airport. When the pilot was rescued, he was suffering from hypothermia, had fractured both ankles and had sustained a serious head injury.								
1/13/01*	Mooney M20C	NA	Somerset, Massachusetts, U.S.	Personal	0	1	0	Substantial
The airplane struck high-tension cables while flying above a river. The vertical stabilizer and the rudder separated, and the pilot ditched the airplane in the river.								
1/14/01	Beech King Air A90	Skydive Salt Lake	Lake Point, Utah, U.S.	Personal	9	0	0	Destroyed
The pilot and eight parachutists were returning from a skydiving competition. The pilot obtained a weather briefing, which advised of IMC at the destination, and filed a VFR flight plan that was never activated. Witnesses heard, but did not see, a twin-turboprop airplane fly over the airport, heading north over the Great Salt Lake. They said that weather conditions included a low ceiling and 0.25-mile visibility in light snow, haze and fog. The airplane struck the water about 0.5 mile offshore.								
1/15/01	Piper PA-22-108	NA	Falmouth, Massachusetts, U.S.	Personal	1	0	0	Destroyed
The airplane departed from Norwood, Massachusetts, and was last observed in the vicinity of Falmouth. The body of the pilot was found in Buzzards Bay, about three miles north of Cuttyhunk Island. IMC prevailed, and no flight plan had been filed for the flight.								
2/1/01	Piper PA-32-300	Aerolease of America	Marathon, Florida, U.S.	Public use	2	0	0	Destroyed
The pilot was conducting a night intercept training mission with a Coast Guard airplane when the airplane struck Florida Bay, 12.7 nautical miles from Marathon.								
2/6/01	Cessna 152	Southeastern Oklahoma State University	Platter, Oklahoma, U.S.	Instructional	2	0	0	Destroyed
The airplane collided with a Cessna 172P and descended into Lake Texoma.								
2/18/01	Beech 36	P S and W Enterprises	Tybee Island, Georgia, U.S.	Personal	4	0	0	Destroyed
The airplane entered a descending right turn for undetermined reasons and struck the ocean.								
2/24/01	Cessna 206	Josua Rojas	Higuerote, Venezuela	Parachuting	7	0	0	Destroyed
The aircraft lost altitude and struck the sea just off the coast shortly after takeoff.								
2/27/01*	Shorts 360	Loganair	Edinburgh, Scotland	Scheduled cargo	2	0	0	Destroyed
After takeoff from Edinburgh, the pilot declared mayday and reported that both engines had flamed out. Soon thereafter, he said that he would ditch the airplane. The airplane struck the Firth of Forth hard in a nose-down attitude about 65 meters offshore.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
3/3/01	Piper PA-32RT-300T	S. and E. Aviation	Gulfport, Mississippi, U.S.	Personal	1	0	0	Destroyed
While en route, the pilot was advised by ATC not to continue VFR flight. The pilot accepted the advice, and ATC recommended a heading. ATC radar indicated that the airplane was turned to a different heading and began a rapid descent. Communications ceased, and the crew of a Coast Guard helicopter sighted wreckage in the Gulf of Mexico.								
3/21/01	De Havilland DHC-2 Beaver	NA	Hayman Island, Queensland, Australia	Unscheduled passenger	0	0	1	Substantial
When the amphibious aircraft arrived at the island, the pilot saw several yachts, small sailing craft and powerboats operating in the usual landing area. The pilot elected to land shorter than normal. The pre-landing checks were not fully completed, and the aircraft touched down on the water with the landing gear still extended from the floats. The aircraft decelerated rapidly and capsized, but the pilot evacuated the aircraft unharmed.								
3/31/01*	Cessna 150J	NA	Fortuna, California, U.S.	Personal	0	0	1	Substantial
The engine failed, and the pilot ditched the airplane about 20 yards offshore.								
4/4/01*	Douglas DC-3A	Roblex Aviation	San Juan, Puerto Rico, U.S.	Crew training	0	0	2	Major partial
Following a practice ILS approach, as part of a crew-training exercise, the right engine was failed as power was being increased to initiate a go-around. The pilot conducted the emergency procedures for engine failure and noticed that the left engine was not producing power. He then elected to conduct a forced landing in a shallow lagoon.								
4/5/01	Cessna 150L	NA	Near Port Davey, Tasmania, Australia	Personal	1	0	0	Destroyed
The aircraft departed for a flight around Tasmania. It was observed in deteriorating weather. Wreckage consistent with that of the missing aircraft was subsequently washed ashore at Port Davey.								
5/11/01	Beech 76	Wings of Denver	Gunnison, Colorado, U.S.	Personal	2	0	0	Destroyed
The airplane struck power lines and descended into the Blue Mesa Reservoir.								
5/11/01*	Piper PA-30 Twin Comanche	NA	Morecambe Bay, England	Ferry	0	0	1	Destroyed
Both engines failed and were secured. Committed to a ditching, the pilot conducted the necessary checks, including preparation of survival equipment and emergency exits. During the descent, he donned his life vest and placed a second vest on the seat beside him. ATC initiated emergency action. Seconds before the airplane struck the sea, the pilot unlatched the cabin door/emergency exit and again confirmed that both engines were secure and that the propellers were feathered. He reported that the impact with the sea was "remarkably light, with the aircraft settling slightly nose-down in the water with the fuselage and wings intact and above the surface." The pilot exited the aircraft, inflated both life vests and walked along the wing. The aircraft remained afloat three minutes to four minutes, at which time the pilot entered the water. The pilot was located by helicopter and was rescued 15 minutes after entering the water.								
5/12/01	Avid Magnum	NA	Lake Shasta, California, U.S.	Personal	0	0	2	Substantial
The pilot encountered light to moderate turbulence on approach to the lake in his experimental seaplane. About 50 feet above the water, he experienced a strong downdraft and applied engine power to decrease the 1,000-fpm descent rate. The airplane pitched down and struck the water.								
5/25/01	Cessna U206F	NA	Lowendal Island, Western Australia, Australia	Business	0	0	3	Substantial
During a landing on calm water, the aircraft bounced as it touched down. The pilot realized that the landing gear probably was extended and attempted to conduct a go-around. Airspeed, however, was insufficient, and the aircraft descended and bounced several more times. On the third touchdown, the left wheel struck the water, and the aircraft flipped over, coming to rest inverted. The pilot and two passengers evacuated and swam to the surface, where they were rescued by boaters.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
5/31/01	De Havilland DHC-2 Beaver	NA	Whitehaven, Queensland, Australia	Unscheduled passenger	0	0	1	Substantial
During approach for a water landing, the pilot was distracted by strong, gusty winds. He neglected the pre-landing checks and landed with the landing gear extended. The aircraft overturned on touchdown.								
6/3/01	Noorduyn Aviation UC-64A	Bear Lake Air	Seward, Alaska, U.S.	Unscheduled passenger	0	0	6	Substantial
After takeoff, the airplane was about 150 feet above the water when a very strong gust pushed the nose left. The pilot applied full right rudder, but the nose continued moving left, and the airplane descended into the lake.								
6/6/01	Beech 58 Baron	NA	Isle of Man, U.K.	Business	1	0	0	Destroyed
The pilot reported a problem with the compass. Radar contact ended, and a search located only a small amount of floating debris.								
6/26/01*	Piper PA-32-300	NA	Watch Hill, Rhode Island, U.S.	Unscheduled passenger	0	0	2	Substantial
The engine failed for an undetermined reason, and the airplane was ditched.								
7/4/01	Piper PA-18	NA	Clacton, England	Personal	0	0	2	Substantial
The aircraft overturned into the sea during a forced landing on a beach.								
7/6/01*	Cessna 208B	Maxfly Aviation	Near Fort Lauderdale, Florida, U.S.	Positioning	0	0	2	Destroyed
Approximately 10 minutes after cruise flight was established at 6,500 feet, the engine "jolted" and began making a very loud noise. The propeller stopped rotating and feathered itself, and engine oil temperature increased rapidly. The pilot shut down the engine, and the noise stopped. After several unsuccessful attempts to restart the engine, the pilot declared an emergency and ditched the aircraft 20 miles east of Fort Lauderdale.								
7/7/01	Cessna 172P	NA	Cedar Key, Florida, U.S.	Personal	0	0	4	Substantial
The airplane encountered a tail wind on final approach, causing the pilot to overshoot the runway. The pilot attempted a go-around, but the airplane struck water 125 feet from the end of the runway.								
7/8/01*	Pilatus PC-12	Access Air Co.	Makarov, Sakhalin Island, Russia	Personal	0	0	4	Destroyed
The aircraft was being used for an around-the-world trip and was en route between Hakodate, Japan, and Magadan, Russia. About 4.5 hours after takeoff, while in normal cruise flight at 26,000 feet, the pilot felt a vibration and noticed a rapid increase in the engine's turbine-temperature indication. A compressor stall then occurred. The pilot shut down the engine and feathered the propeller. The aircraft descended through overcast cloud layers until breaking out of clouds at about 100 feet above the water. The pilot ditched the aircraft on the crest of a swell and the aircraft came to rest floating upright. The pilot and passengers evacuated into a life raft and were rescued some 15 hours later by the crew of a ship.								
7/18/01*	Cessna 172M	NA	Near Freeport, Bahamas	Ferry	0	0	2	Substantial
During descent from 5,500 feet to 4,500 feet, engine power decreased. The pilot conducted emergency procedures to regain full power, but the engine did not respond. The pilot ditched the airplane in the ocean.								
7/22/01	Max Air Drifter ARV 582	NA	Collington, North Carolina, U.S.	Personal	0	1	1	Substantial
The experimental amphibious airplane struck water while being maneuvered to avoid a bridge after the engine failed.								
7/23/01	Consolidated PBY-5A Catalina	Buffalo Airways	Inuvik, Northwest Territories, Canada	Fire suppression	0	0	2	Destroyed
During a water pickup from a lake, loss of control occurred and one of the aircraft's wings dug into the water. The aircraft came to rest nose-down on the lake and eventually sank in 100 feet of water.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
7/23/01*	Piper PA-28	NA	Guernsey, Channel Islands, U.K.	Personal	0	0	3	Destroyed
About 12 miles from the destination, Guernsey, the engine began to run very roughly and all efforts to restore power were ineffective. A ditching became inevitable, and the passengers donned life vests. The pilot could not don a life vest because he was busy flying the aircraft. During the wheels-up ditching in a calm sea, the pilot struck his head on the control column but remained conscious. Evacuation and rescue were successful.								
7/26/01*	Rutan LongEze	NA	Shoreham, England	Flight permit test	0	0	1	Substantial
The engine failed, and the pilot told ATC that he intended to ditch the airplane near Shoreham Harbor. The aircraft struck the water at about 60 knots in a nose-up attitude, but when the main landing gear touched the water, it was ripped off, causing the aircraft to pitch nose-down. The fuselage remained intact, and the aircraft floated upright.								
8/5/01	Cessna A185F	NA	Crane Lake, Minnesota, U.S.	Personal	0	1	2	Substantial
The floatplane sustained substantial damage on impact with water during takeoff.								
8/9/01*	Piper PA-32-260	Fly Key West	Key West, Florida, U.S.	Sightseeing	2	0	1	Substantial
During cruise flight, a passenger entered the cockpit, brandished a knife, turned off the radios and transponder, and demanded to be flown to Cuba. In an attempt to thwart the hijacking, the pilot pitched the airplane nose-down and turned toward Key West. In the ensuing struggle, the hijacker fell against and bent the retarded throttle lever. Attempts to straighten the throttle lever snapped it off, and an idle-power ditching was conducted. During impact, forward motion was stopped violently, and the lap-belted passengers appeared to lose consciousness. The pilot exited from the cockpit door, inflated his life vest and swam to the passenger door to extricate the passengers; however, the aircraft began to sink before he could open the door. The passengers went down with the aircraft. The pilot was rescued by a U.S. Navy helicopter.								
8/21/01	De Havilland DHC-2 Beaver	Alaska Air Taxi	Nondalton, Alaska, U.S.	Unscheduled passenger	0	0	5	Substantial
The pilot reported that after a water takeoff, at about 100 feet, a very strong gust rolled the wings of the float-equipped airplane about 90 degrees left. The pilot attempted to regain control, but the airplane descended, and the left wing struck the water. The wing separated from the fuselage and pivoted the airplane 90 degrees left, causing the right wing to strike the water. Both floats were torn from the fuselage, and the airplane sank.								
8/28/01	Denney Kitfox	NA	Beauly Firth, Scotland	Personal	0	0	2	Substantial
The pilot of the amphibious airplane neglected to retract the landing gear before a water landing. The front wheels struck the water, and the airplane slowly overturned. The cabin began to fill with water. The pilot and observer evacuated without injury and stood on the inverted floats until they were rescued eight minutes later.								
9/12/01	DHC-3 Turbo Otter	Labrador Airways	Otter Creek, Newfoundland, Canada	Unscheduled passenger	0	0	4	Major partial
The pilot was conducting a takeoff from Otter Creek in the float-equipped aircraft. After liftoff, the control column "pitched violently forward and then back before returning to the neutral position." The aircraft pitched down and struck the water. The pilot and passengers evacuated before the aircraft sank in 55 feet of water.								
9/27/01	Cessna 208	NA	Aurora, Minnesota, U.S.	Corporate/ executive	0	0	7	Substantial
The floatplane was substantially damaged on impact with water and a dock during a hard landing on a lake.								
10/4/01	Tupolev Tu-154M	Sibir Airlines	Black Sea	Unscheduled passenger	78	0	0	Destroyed
Loss of control occurred; the aircraft struck the Black Sea and was destroyed. The pilot of another aircraft reportedly saw "an explosion on the plane." Unconfirmed reports said that the aircraft accidentally was struck by a surface-to-air missile that had been launched during exercises being conducted by Ukrainian defense forces.								

Table 1

Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

<table>
<tr><th rowspan="2">Date:
Month/Day/
Year</th><th rowspan="2">Aircraft</th><th rowspan="2">Operator</th><th rowspan="2">Location</th><th rowspan="2">Nature of Flight</th><th colspan="3">Injury to Occupants</th><th rowspan="2">Damage to Aircraft</th></tr>
<tr><th>Fatal</th><th>Serious</th><th>Minor/
None</th></tr>
<tr><td>10/5/01</td><td>Cessna 185</td><td>NA</td><td>Port Alsworth, Alaska, U.S.</td><td>Personal</td><td>0</td><td>0</td><td>1</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot was landing the float-equipped airplane on a remote lake with a smooth, glassy surface. The pilot said that he touched down too fast, and the airplane overturned. The pilot, who was wearing an inflatable jacket, exited the inverted airplane and climbed onto the floats. The airplane sank in about two minutes. The pilot then swam for about 40 minutes to reach the shore.</td></tr>
<tr><td>10/10/01</td><td>Fairchild SA-226AT Merlin</td><td>Flightline</td><td>Castellon, Spain</td><td>Unscheduled passenger</td><td>10</td><td>0</td><td>0</td><td>Destroyed</td></tr>
<tr><td colspan="9">The aircraft was believed to have struck the sea while en route between Barcelona, Spain, and Oran, Algeria. The last contact with the aircraft crew was when the crew told ATC that the aircraft was being diverted from the planned route because of poor weather.</td></tr>
<tr><td>10/11/01*</td><td>Cessna T206H</td><td>Longleaf</td><td>Lake Lanier Islands, Georgia, U.S.</td><td>Personal</td><td>0</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">The engine failed, and the pilot ditched the airplane in Lake Lanier.</td></tr>
<tr><td>10/16/01</td><td>Antonov An-12</td><td>Air Bridge</td><td>Honiara, Solomon Islands</td><td>Ferry</td><td>0</td><td>0</td><td>5</td><td>Major partial</td></tr>
<tr><td colspan="9">Apparently, during the final stage of a nonprecision approach, the aircraft undershot the runway and struck the surface of the sea, tearing off the right main landing gear. The pilot maintained control and the aircraft then was landed safely on the runway.</td></tr>
<tr><td>10/29/01*</td><td>Cessna 177 Cardinal</td><td>NA</td><td>Guernsey, Channel Islands, U.K.</td><td>Personal</td><td>0</td><td>0</td><td>1</td><td>Destroyed</td></tr>
<tr><td colspan="9">During cruise flight at 2,000 feet, the engine began to backfire and run roughly. Unable to maintain altitude, the pilot declared mayday and told ATC that he would have to ditch the aircraft. The aircraft struck the sea in a level attitude, stopped abruptly and pitched forward. The left wing dipped into the sea, and the cabin rapidly filled with water. The pilot initially was unable to open either door, but when the cabin was nearly filled with water, he was able to kick open his door and exit the aircraft under water. He was rescued by a fisherman.</td></tr>
<tr><td>11/23/01</td><td>Cessna 172M</td><td>NA</td><td>Barceloneta, Puerto Rico, U.S.</td><td>Personal</td><td>0</td><td>0</td><td>2</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot failed to maintain control of the aircraft, which descended and struck the water.</td></tr>
<tr><td>11/27/01*</td><td>Let 410UVP Turbolet</td><td>Aeroferinco</td><td>Playa del Carmen, Mexico</td><td>Ferry</td><td>0</td><td>0</td><td>4</td><td>Destroyed</td></tr>
<tr><td colspan="9">During a short positioning flight from Cozumel, Mexico, to Playa del Carmen, both engines failed, and the crew ditched the airplane.</td></tr>
<tr><td>12/6/01*</td><td>Convair 580</td><td>Trans-Air-Link</td><td>Sunny Isles, Florida, U.S.</td><td>Ferry</td><td>0</td><td>0</td><td>2</td><td>Destroyed</td></tr>
<tr><td colspan="9">After takeoff from Fort Lauderdale, Florida, the crew heard a change in engine noise. The copilot observed that the right engine rpm indication was fluctuating and no longer in the "green," and that the fuel-quantity indication for the right tank also was fluctuating, decreasing to zero before returning to the original reading.

The crew decided to shut down the right engine and to crossfeed fuel from the right tank to the left tank. The flight continued toward Opa Locka, Florida, but the rpm indication for the left engine began to fluctuate. Power was lost on the left engine, and the crew decided to turn back toward the sea and ditch the airplane. After crossing the coastline, the pilot ditched the airplane just off the beach at Sunny Isles, a few miles east of Opa Locka. The crew evacuated without serious injury and were later rescued. The airplane was destroyed when it was washed ashore.</td></tr>
<tr><td>12/8/01</td><td>Piper PA-32-260</td><td>NA</td><td>Rottnest Island, Western Australia, Australia</td><td>Unscheduled passenger</td><td>0</td><td>0</td><td>6</td><td>Substantial</td></tr>
<tr><td colspan="9">The pilot was unable to maintain directional control during a takeoff in strong, gusty winds. The aircraft veered right, and the right main landing gear struck a tree stump on the edge of a shallow saltwater lake adjacent to the airport. The aircraft briefly became airborne before coming to rest in the lake.</td></tr>
</table>

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
12/26/01	PBN PN-2B Islander	BAL Bremerhaven Airline	Bremerhaven, Germany	Scheduled passenger	8	1	0	Destroyed
The aircraft struck the River Weser shortly after takeoff from Bremerhaven.								
12/29/01	Cessna A185F	NA	Strahan, Tasmania, Australia	Unscheduled passenger	0	0	5	Substantial
The pilot evaluated sea conditions as marginal for takeoff. He was water-taxiing the floatplane back toward the wharf when a cruise catamaran passed by, generating a powerful wake. After navigating through the wake, the pilot resumed course back to the wharf. He then became concerned about the buoyancy of the right float. He increased power and applied left aileron and aft elevator to counter an increasing list to the right, but the floatplane overturned.								
1/5/02	Cessna U206F	NA	Shoal Bay, New South Wales, Australia	Unscheduled passenger	0	0	4	Substantial
During the takeoff run, the floatplane encountered wind shear, causing the aircraft to yaw and roll. The right wing struck the water, causing the aircraft to cartwheel. The aircraft recovered to the upright position.								
1/16/02*	Boeing 737-300	Garuda Indonesia	Yogyakarta, Java, Indonesia	Scheduled passenger	1	5	56	Destroyed
According to press reports, while in descent from FL 320 to FL 230 inbound to Yogyakarta, the aircraft penetrated an area of very heavy rain and, shortly afterward, both engines flamed out. The aircraft continued toward Yogyakarta while the crew attempted to restart the engines, but apparently without success. Eventually, the pilot elected to execute a forced landing in the Bengawan Solo River about 25 kilometers northeast of the flight's destination. During the ditching, the aircraft's rear fuselage apparently struck the water first, and part of the structure in that area was separated. The aircraft then pitched down and "pancaked" onto the water. It eventually came to rest in shallow water close to the bank. Passengers and crew, other than a flight attendant who had been killed during the first water strike, evacuated and were helped to the bank by villagers.								
1/17/02*	Let 410UVP Turbolet	Djibouti Airlines	Djibouti City, Djibouti	Positioning	4	0	0	Destroyed
The aircraft was ditched during a flight from Mogadishu, Somalia, to Djibouti.								
1/27/02	Piper PA-18-150	Pilot/owner	Eagle Point, Oregon, U.S.	Personal	0	0	2	Substantial
The pilot reported that after takeoff from a private airstrip, he forgot to retract the amphibious airplane's landing gear. During a subsequent landing in a river, the airplane overturned.								
2/12/02	Piper PA-18	Pilot/owner	Winter Haven, Florida, U.S.	Personal	0	0	1	Substantial
During a landing on glassy water, the pilot misjudged the float-equipped airplane's height and flared prematurely. The left wing struck the water, and the airplane cartwheeled.								
3/17/02	Beech B100 King Air	Djibouti Airlines	Djibouti City, Djibouti	Unscheduled passenger	4	0	0	Destroyed
During the night approach, while in a left turn at a low altitude, the aircraft struck the sea.								
3/28/02*	Boeing S-307 Stratoliner	National Air & Space Museum/ The Boeing Co.	Seattle, Washington, U.S.	Test	0	0	4	Substantial
The crew flew the airplane from Seattle to Everett, Washington, to conduct practice takeoffs and landings. After the first takeoff at Everett, the no. 3 engine briefly surged before returning to normal operation. The crew decided to return to Boeing Field in Seattle. During approach, the left main landing gear did not extend fully. The approach was rejected, and the crew circled while an engineer manually extended the landing gear. The crew resumed the approach and observed a low-fuel-pressure warning for the no. 3 engine, which then lost power. The no. 3 propeller was feathered. Then, the crew observed low-fuel-pressure warnings for the other three engines, which also lost power. The crew ditched the airplane in Elliot Bay, close to shore.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants			Damage to Aircraft
					Fatal	Serious	Minor/ None	
4/2/02	Piper PA-23-250	Aquarius Group	Palm Bay, Florida, U.S.	Personal	1	0	0	Destroyed
IMC prevailed when the airplane struck a marsh during a VFR flight.								
4/19/02	Aircam	Pike Aviation	Troy, Alabama, U.S.	Personal	0	1	0	Destroyed
Witnesses said that the homebuilt airplane had been flown around the area for about 45 minutes at a low level before it struck power lines about 70 feet above a lake and then descended into the water. A witness rescued the pilot from the submerged wreckage.								
4/27/02	Buccaneer 2	NA	Estero Bay, Florida, U.S.	Personal	1	0	0	Destroyed
Witnesses observed the experimental airplane flying overhead between 150 feet and 200 feet. The airplane began a steep right turn, estimated at more than 45 degrees of bank, into a strong wind. The right wing dropped, the nose pitched down, and the airplane began spinning and descended into the water.								
5/7/02	McDonnell Douglas MD-82	China Northern Airlines	Dalian, China	Scheduled passenger	112	0	0	Destroyed
The aircraft was destroyed when it struck the sea off Dalian. According to press reports, the pilot had reported a fire in the cabin during the last communication with ATC.								
5/21/02*	Douglas DC-3A	Aero JBR	Laredo, Texas, U.S.	Instructional	0	0	3	Destroyed
The crew was conducting a series of touch-and-go landings. Soon after becoming airborne, the aircraft had engine problems. The pilot elected to ditch the aircraft in Lake Casa Blanca, close to the airfield. The DC-3 remained floating, partially submerged, and the crew was able to escape without injury.								
5/25/02	Boeing 747-200B	China Airlines	Pengu Islands, Taiwan, China	Scheduled passenger	225	0	0	Destroyed
About 20 minutes after takeoff from Taipei, Taiwan, China, just after reaching its en route altitude of FL 350, a structural breakup occurred and the aircraft struck the sea. Metallurgical examination of the wreckage revealed a region of fatigue cracking.								
6/15/02*	Cessna 175	Pilot/owner	Salt Lake City, Utah, U.S.	Personal	0	0	3	Destroyed
During cruise flight at 5,600 feet, engine rpm decreased and oil temperature increased. The engine began to vibrate, and the upper cowling separated, exposing a breach in the top of the casing aft of the no. 3 cylinder. White smoke filled the cockpit, the engine seized, and the propeller stopped rotating. After declaring a mayday, the pilot ditched the airplane in Great Salt Lake. The crew of a Civil Air Patrol airplane soon found the occupants swimming near the submerged airplane.								
6/24/02	De Havilland DHC-2 Beaver	Alaska West Guides and Outfitters	Nikilski, Alaska, U.S.	Positioning	0	0	2	Substantial
During landing, the left float dug into the water and was crushed against the fuselage. The airplane floated nose-down about 15 minutes, then overturned.								
7/12/02	De Havilland DHC-2 Beaver	Wings Airways	Juneau, Alaska, U.S.	Positioning	0	0	1	Destroyed
The pilot landed the airplane hard in a quartering tail wind. The airplane water-looped, and the right float separated. The airplane settled into the water and overturned.								
7/17/02	Luscombe 8A	NA	Cordova, Alaska, U.S.	Personal	0	0	2	Substantial
The pilot reported that he rejected the takeoff when the airplane failed to become airborne in time to clear obstacles at the end of the runway. During the next takeoff attempt, in a different direction, the airplane lifted off but failed to climb. As the airplane crossed the end of the runway, it settled into a river and overturned.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/20/02	Piper PA-32RT-300 Turbo Lance	Lexanna Aircraft	Freeport, Bahamas	Personal	5	0	0	Destroyed
Loss of ATC contact with the airplane occurred 25 minutes after its departure from Freeport. Three bodies and a quantity of floating wreckage were recovered.								
8/13/02	Champion II	NA	Foxboro, Massachusetts, U.S.	Personal	0	0	1	Substantial
The pilot said that during a landing on Mirimichi Lake, a light gust of wind lifted the left wing when the floatplane was about one foot above the water. The pilot did not correct for the wind, and the right float struck the water. The floatplane overturned and sank.								
8/15/02	Pilatus PC6 B2-H2 Turbo Porter	SARL Europlane	Forte dei Marmi, Italy	Parachuting	1	0	0	Destroyed
The aircraft was returning to its base at Cinquale after releasing skydivers when it suddenly departed from controlled flight and struck the sea near the beach.								
8/23/02*	Piper PA-14	Pilot/owner	Eastsound, Washington, U.S.	Personal	0	0	1	Destroyed
The pilot said that he flew the airplane about 15 minutes to warm the oil for an oil change and was returning to the airport when the engine failed. The pilot was unable to restart the engine and ditched the airplane, which sank in 60 feet of water.								
8/28/02	De Havilland DHC-2 MK3	General Communications	Aleknagik, Alaska, U.S.	Business	1	0	2	Substantial
During cruise flight, the pilot observed that the airplane would not attain its normal cruise airspeed and attitude. Believing that the airplane was tail-heavy, the pilot asked the aft-cabin passenger to move forward. Upon touchdown on the lake at the destination, the airplane pitched nose-down. Unsecured supplies in the aft cabin moved forward and pinned the pilot and front-seat passenger against the instrument panel. The other passenger lifted as many supplies as he could off the pilot and front-seat passenger before he had to exit the sinking airplane. Both the pilot and the front-seat passenger also exited the submerged airplane, but the pilot drowned. Postaccident inspection of the airplane indicated that the wheels had not been retracted after takeoff and that the airplane had landed on the lake with the wheels fully extended.								
11/11/02	Fokker F.27-600	Laoag International Airways	Manila, Philippines	Scheduled passenger	19	4	10	Destroyed
The aircraft descended and struck Manila Bay about 12 kilometers from shore about three minutes after takeoff. Survivors reported that the cabin immediately filled with water.								
12/21/02	ATR 72-200F	TransAsia Airways	Makung, Penghu Islands, Taiwan, China	Scheduled cargo	2	0	0	Destroyed
The aircraft struck the sea while en route from Taipei, Taiwan, China,, to Macau.								
12/24/02	Cessna 208B Caravan I	Telford Aviation	Manteo, North Carolina, U.S.	Ferry	1	0	1	Destroyed
The aircraft struck Croatan Sound during an NDB approach to Dare County Regional Airport, Manteo. The accident occurred about two statute miles west of the airport.								
12/27/02	Cessna 208B Caravan I	Tropic Air	San Pedro, Belize	Scheduled passenger	0	0	15	Destroyed
During an approach to San Pedro, the airplane was at about 400 feet and 2.5 statute miles from the runway, when the pilot reduced power and extended the flaps. The aircraft's rate of descent suddenly increased. The pilot increased power and attempted to climb, but the aircraft continued to descend and struck Ambergris Cay.								

Table 1
Airplane Water-contact Accidents, 1976–July 8, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/9/03	DHC-3 Turbo Otter	Harbour Air	Eden Lake, British Columbia, Canada	Ferry	0	0	2	Destroyed
During the landing on Eden Lake, the aircraft's left float broke away on touchdown. The aircraft decelerated rapidly and came to rest upright but in a left-wing-low attitude. The water conditions at the time were described as "glassy."								
1/11/03	Cessna 150K	NA	Everglades City, Florida, U.S.	Instructional	0	1	1	Substantial
After a rejected landing, the instructor took control of the aircraft. The aircraft stalled because of inadequate airspeed, entered a spin and struck water at the departure end of the runway. The student and instructor exited the airplane through the broken windshield.								
2/16/03*	Cessna 172N	NA	Bruny Island, Tasmania, Australia	Personal	0	0	2	Substantial
While the airplane was in cruise flight over water at 500 feet AGL, engine power decreased. The pilot attempted a forced landing on a beach, but the airplane struck the water about 30 meters from the shore.								
3/6/03	De Havilland DHC-2 Beaver	NA	Whitehaven, Queensland, Australia	Positioning	0	0	1	Destroyed
When the aircraft touched down, the pilot did not maintain directional control, and the aircraft overturned.								
3/24/03	Mitsubishi Mu-300 Diamond IA	Set Sul Taxi Aéreo	Santos, Brazil	Unscheduled passenger	0	0	3	Major partial
The aircraft overran the runway on landing and fell into the Canal da Bertioga. The runway was wet and reports suggested that the aircraft may have aquaplaned.								
4/8/03	Dassault Falcon 20	Grand Aire Express	St. Louis, Missouri, U.S.	Unscheduled cargo	0	2	0	Destroyed
En route from Del Rio, Texas, the crew was conducting an ILS approach to Lambert–St. Louis International Airport. Because of deteriorating weather conditions, ATC told the crew to go around. While being vectored for another ILS approach, the crew told ATC that they had a "fuel limitation." ATC issued a vector to the final approach course and cleared the crew to conduct the ILS approach. The crew then declared mayday and told ATC that the left engine had flamed out. The right engine then flamed out, and the crew ditched the airplane in the Mississippi River.								
5/18/03*	Piper PA-31	NA	Caribbean Ocean	Personal	2	0	0	Destroyed
The pilot declared mayday because of an engine failure and ditched the aircraft. Both occupants are presumed to have drowned.								
6/5/03	DHC-6 Twin Otter 300	Ontario Ministry of Natural Resources	Hornepayne, Ontario, Canada	Fire suppression	0	0	1	Destroyed
The aircraft was equipped with amphibious "water bombing" floats. While picking up water at Wicksteed Lake, the aircraft nosed over and cartwheeled, coming to rest inverted 100 meters from the lake shore in three meters of water.								
7/8/03	Cessna 402C	M and N Aviation	Vieques, Puerto Rico, U.S.	Unscheduled cargo	1	0	0	Destroyed
On a flight from San Juan, Puerto Rico, to St. Croix, U.S. Virgin Islands, the airplane entered an uncontrolled descent for undetermined reasons and struck the ocean. The depth of the ocean at the accident site was reported by the Coast Guard to be about 6,000 feet.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
1/14/80*	Hughes 259B	NA	Lake Manapouri, New Zealand	Hunting	1	2	0	Destroyed
Shortly after crossing the shoreline, the "ENGINE OUT" light flashed and the pilot initiated an autorotative descent. The helicopter was ditched before the pilot had time to check on engine-instrument indications. The pilot and two other occupants escaped from the helicopter, but one of the passengers drowned while attempting to swim to shore.								
7/31/80*	Sikorsky S-61	BA Heli	Aberdeen, Scotland	Unscheduled passenger	0	0	15	NA
The main-gearbox oil-cooler fan belts failed, resulting in loss of cooling air to the gearbox. The helicopter was ditched in the North Sea.								
4/9/81	Bell 47G-3B1	NA	Nourlangie, South Australia, Australia	NA	0	0	3	Substantial
During the power-on descent, the pilot made a steeper-than-normal approach for a hover position over a swamp. The engine failed to respond when the pilot tried to increase the power setting. The rotor rpm decayed and the helicopter struck water.								
7/15/81	Enstrom F28	NA	Frimley, England	Personal	0	0	2	Substantial
Following an approach over a lake, the helicopter gently entered the water while transiting to a grass helipad following a turn to the right.								
8/12/81	Bell 212	Bristow	North Sea	Unscheduled passenger	1	2	11	Destroyed
While being flown over the North Sea, the helicopter encountered an area of reduced visibility and a decision was made to return to the takeoff field. During the turn, control of the helicopter was lost after it pitched 20 degrees nose-up and climbed to 300 feet with zero airspeed. The helicopter yawed rapidly to the right, descended and struck the sea in a level attitude.								
8/13/81*	Wessex	Bristow	North Sea	Unscheduled passenger	13	0	0	Destroyed
While flying at 1,500 feet, the pilot reported that he would be ditching the helicopter because of engine failure. An uncontrolled water impact followed.								
2/4/82*	Bell 206-1	NA	Gulf of Mexico	Unscheduled passenger	0	0	1	Substantial
The helicopter was landed on an oil drilling platform for refueling. The pilot said that after refueling, takeoff was conducted and after clearing the platform, the helicopter yawed left and pitched nose-down. The pilot raised the collective to cushion the landing and deployed the emergency floats. After touchdown in five-foot seas, the main rotor severed the tail boom and the helicopter rolled inverted. The pilot was unable to exit through the right-front door, but after some difficulty, he exited through a rear door.								
3/2/82	Bell 206B	NA	Gulf of Mexico	Unscheduled passenger	2	0	0	Substantial
The helicopter was low on the approach and during the flare, the vertical fin and tail boom contacted the safety netting extending beyond the boundaries of the platform landing area. The helicopter then settled back off the platform with one main-rotor blade striking flat on the landing area prior to the helicopter coming to rest in the water.								

Note: The water-accident data in this table were compiled from several sources, but completeness cannot be claimed. Information has been transcribed faithfully from the sources, but some information may not be accurate. Military accidents have been excluded.

***Ditching accident.**

AMSL = above mean sea level ATC = air traffic control EGT = exhaust-gas temperature ELT = emergency locator transmitter
FAA = U.S. Federal Aviation Administration FARs = U.S. Federal Aviation Regulations IFR = instrument flight rules ILS = instrument landing system
IMC = instrument meteorological conditions MDA = minimum descent altitude MEL = minimum equipment list mph = miles per hour
NDB = nondirectional beacon PIC = pilot-in-command rpm = revolutions per minute SAR = search and rescue VFR = visual flight rules
VMC = visual meteorological conditions VOR-DME = very high frequency omnidirectional radio–distance-measuring equipment

Source: Airclaims *World Aircraft Accident Summary*; Australian Transport Safety Bureau; The Boeing Co.; Civil Aviation Authority of New Zealand; New Zealand Transport Accident Investigation Commission; Robert E. Breiling Associates; Transportation Safety Board of Canada; U.K. Civil Aviation Authority; U.S. Federal Aviation Administration National Aviation Safety Data Analysis Center; U.S. National Transportation Safety Board.

Table 2

Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
4/22/82*	Bell 212	NA	Gulf of Mexico	Unscheduled passenger	2	1	9	Destroyed
The helicopter was in cruise flight when a sudden and severe right yaw occurred. Subsequently, it was autorotated to a ditching in rough water. Touchdown was made on top of a wave, then the helicopter rolled over. The survivors did not deploy the life raft. Another helicopter arrived but the pilot could not land in the rough sea. A life raft was dropped, but it was blown downwind by the time a survivor (the copilot) swam to it and inflated it. The copilot was unable to paddle against the wind to the other survivors. The helicopter sank before a rescue boat arrived; the helicopter later was recovered.								
4/29/82*	Bell 206L	NA	New York, New York, U.S.	NA	6	0	0	Substantial
During a sightseeing flight, the pilot heard the low-rpm audio signal. He lowered the collective and rotor rpm returned to the green. While turning to the East River the "GENERATOR-OUT" and "ENG-OUT" lights illuminated. The emergency floats were inflated and the helicopter contacted the water in a level attitude. The nose then contacted the water and the chin bubble broke. Water entered the helicopter and it rolled right to an inverted position.								
5/29/82*	Bell 206L-1	NA	Gulf of Mexico	Unscheduled passenger	0	0	5	Destroyed
While approaching the landing platform, the pilot heard a loud bang and conducted an autorotation to the water. The helicopter rolled inverted and was damaged by waves that pushed it against the platform.								
8/21/82*	Bell 206B	NA	Port Mansfield, Texas, U.S.	Ferry	0	0	1	Substantial
The helicopter was being ferried to shore from an oil platform when the tail-rotor gearbox failed and separated from the helicopter. The pilot conducted an autorotation to the water. Upon water contact, the helicopter rolled over. The pilot had deployed the emergency floats upon landing and waited for rescue after he exited the helicopter.								
9/14/82	Bell 212	Bristow	North Sea	Search and rescue	6	0	0	Destroyed
The helicopter had been sent to lift by winch an injured man from a ship, and was seen to pass close to an oil platform at a low altitude, flying northeast. The helicopter entered an area of rain and poor visibility and struck the water. Wreckage was located on the sea bed at a depth of about 1,120 feet.								
10/21/82	Bell 47G-3B2	NA	Lake Argyle, Western Australia, Australia	Aerial application	0	1	0	Destroyed
The helicopter struck water 25 minutes after departure for undetermined reasons.								
11/19/82	Bell 206B	NA	Port O'Connor, Texas, U.S.	Unscheduled passenger	0	0	3	Substantial
Crossing a bay, the pilot encountered severe turbulence and rain associated with a thunderstorm. The pilot made a 180-degree turn and attempted to proceed to a beach to land. At about 100 feet AGL, during approach to landing, a severe downdraft was encountered. The pilot applied full power, but the descent continued and the helicopter struck the water in a near-level attitude.								
3/11/83*	Sikorsky S-61	BA Heli	North Sea	Unscheduled passenger	0	0	17	Destroyed
Shortly after the helicopter departed from an oil platform, an uncontained failure of the main rotor gearbox occurred. A mayday call was transmitted and a ditching was conducted. The helicopter stabilized on its emergency floats. During deployment, both life rafts were punctured and rendered unusable by sharp projections on the helicopter's hull.								
3/14/83	Aerospatiale SA350 Ecureuil	Colt	Humber Estuary, England	Aerial photography	2	0	1	Destroyed
The helicopter was being used for film work. To obtain the required shot, the pilot flew the helicopter backward and sideways. During this maneuver, film magazines, maps and the technical log fell off the director's knee, jammed the collective lever and pulled the pilot's headset askew. The helicopter accelerated backwards, striking the mast of a vessel, and fell into the sea.								
7/13/83	Bell 206 JetRanger	PLM Heli	Crieff, Scotland	Construction work	0	1	0	Destroyed
The helicopter struck the River Almond while engaged in a lifting operation.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
7/16/83	Sikorsky S-61	BA Heli	St. Mary's, Isles of Scilly, U.K.	Scheduled passenger	20	2	4	Destroyed
During an approach in low-visibility conditions, the helicopter struck the sea in an approximately level attitude and a constant heading. After three impacts with a calm sea, the helicopter rolled over and sank almost immediately.								
7/17/83	Bell 206B	NA	Lake Burragorang, New South Wales, Australia	Personal	1	1	0	Destroyed
Operating about 10 feet above the water, the pilot began a climbing turn. The helicopter struck the water surface and pitched forward into the water. The passenger's body was found 12 hours later. The pilot had misjudged the altitude over the glassy water.								
9/20/83	Hughes 269C	NA	Adelaide River, Northern Territories, Australia	NA	0	0	1	Substantial
The pilot was mustering buffalo when some of the animals doubled back. The pilot descended to a lower altitude, the tail rotor inadvertently entered the water and the helicopter sank.								
9/24/83	Hughes 500C	NA	Pelican, Alaska, U.S.	Business	0	0	3	Destroyed
The helicopter struck glassy water during an approach to land in marginal weather on a dark night. The helicopter was damaged and sank in water 60 feet deep; the occupants escaped with no injuries.								
11/22/83	Bell 206B	Air Logistics	Gulf of Mexico	Unscheduled passenger	1	0	0	Substantial
The helicopter was found floating inverted about 1.5 miles from the point of departure. The tail boom had separated and there was evidence that the main-rotor blades had struck the tail boom.								
12/24/83	Bell 212	Bristow	Brent, North Sea	Commercial training	0	1	1	Destroyed
During practice winching to the deck of a vessel, the winch hook was caught in the ship's railing, causing loss of control and water impact.								
1/4/84	Aerospatiale AS355F	NA	Morgan City, Louisiana, U.S.	Positioning	2	0	0	Destroyed
The pilots encountered fog and struck a lake about four miles from the departure point. A fisherman who witnessed the accident said that the helicopter descended into the water in a nose-low attitude. The helicopter skipped and tumbled for about 100 yards before it sank.								
2/5/84	Hughes 269A	NA	Lake Whangape, New Zealand	Ferry	0	0	NA	Substantial
While in a turn near the shore of Lake Whangape to position for landing, the helicopter struck the surface of the lake and sank in shallow water.								
4/4/84	Aerospatiale AS355F	NA	Gulf of Mexico	Unscheduled passenger	4	0	0	Destroyed
While the pilot was conducting the takeoff from an unmanned platform, the tail section of the helicopter contacted a rotating-beacon support bracket on a crane. The helicopter then struck the water.								
5/1/84*	Sikorsky S-76A	NA	Gulf of Mexico	NA	0	0	2	Substantial
During cruise flight at 500 feet, the left engine sustained a massive, uncontained failure. Shrapnel penetrated the AC and DC junction boxes, causing complete electrical failure. Using the copilot's side window to see the water surface, the pilot conducted an autorotation. The helicopter rolled over and sank when the emergency floats, which were electrically operated, failed to deploy. After evacuation, the pilot returned to the inverted helicopter and deployed life rafts.								
5/2/84*	Boeing CH-47 Chinook	BA Heli	North Sea	Unscheduled passenger	0	0	47	Substantial
Shortly after takeoff, the helicopter developed a hydraulic problem that caused serious handling difficulties. The pilot conducted a precautionary landing on the sea with a gentle touchdown in spite of control difficulties. Ten minutes after landing, the helicopter began taking on water. The pilot conducted an evacuation; the helicopter then capsized and floated inverted until recovery.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/8/84*	Bell 206B	NA	Gulf of Mexico	Unscheduled passenger	0	0	4	Substantial
While cruising at 550 feet above the Gulf of Mexico, the helicopter experienced loss of N1 rpm and engine failure. An autorotation was initiated, which terminated in a hard landing in five-foot waves. One emergency float separated during the landing and the helicopter rolled over, but continued to float.								
7/4/84*	Bell 47G-2	NA	Detroit, Michigan, U.S.	NA	0	3	0	Destroyed
The pilot landed the helicopter in the Detroit River after the engine sputtered and abnormal vibration was felt. Passengers said that the pilot did not mention the problem to them and the helicopter seemed under control before entering the water.								
7/21/84*	Bell 206L-1	NA	Gulf of Mexico	Unscheduled passenger	0	0	4	Substantial
A helicopter skid contacted a net fence around the landing platform on an oil platform. The safety net broke and the helicopter rocked over the side of the platform. The pilot attempted an autorotation into the water. The landing was hard and one float separated. The helicopter rolled over and later sank in 200 feet of water.								
7/24/84*	Bolkow 105	Bond Helicopters	North Sea	Unscheduled passenger	0	0	3	Destroyed
The helicopter was ditched in the sea following a tail-rotor driveshaft-coupling failure. After the helicopter contacted the water, it rolled onto its side and the occupants escaped. Very shortly after that, the helicopter rolled upside down.								
10/12/84	Robinson R22	NA	Hueytown, Alabama, U.S.	Personal	0	0	1	Destroyed
The pilot reported that he allowed engine rpm to drop and at the same time increased collective pitch. The helicopter struck the water in a steep descent.								
10/19/84	Hughes 369D	NA	St. Thomas, U.S. Virgin Islands	Business	3	0	0	Destroyed
The helicopter was being flown at 50 feet above the water at 15 knots for the purpose of photographing a sailboat. Witnesses reported hearing a loud pop and seeing a puff of black smoke from the engine exhaust. Engine noise ceased and the helicopter rolled about 90 degrees onto its left side and descended into the water.								
11/12/84*	Bell 206L-1	NA	Gulf of Mexico	Unscheduled passenger	0	1	4	Substantial
Total loss of power occurred just after liftoff from a 130-foot-high drilling platform. The pilot entered autorotation but touchdown was hard during the ditching, resulting in a rollover. Emergency floats did not inflate fully until the helicopter rolled over.								
11/20/84	Bell 212	Bristow	North Sea	Unscheduled passenger	2	0	0	Destroyed
The helicopter was being flown to an oil platform to pick up workers. The helicopter was seen to fall into the sea.								
1/5/85	Agusta Bell 206	Bristow	Weddell Sea, Antarctica	Construction work	0	0	1	Substantial
The helicopter was moving fuel drums from a ship to a depot six miles away on an ice shelf. In deteriorating visibility and deteriorating contrast over the ice, the pilot flew the helicopter into the frozen sea.								
2/25/85	Robinson R22A	NA	Santa Barbara, California, U.S.	Instructional	0	1	0	Destroyed
The student pilot said that during the last leg of a solo cross-country flight, he was flying along the coast at 50 feet to 75 feet when he diverted his attention to look at a man on the beach. When he looked back at the instruments he noticed that the helicopter was descending. Before the descent could be stopped, the helicopter struck the Pacific Ocean.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
3/20/85*	Sikorsky S-61	Okanagan Helicopters	Halifax, Nova Scotia, Canada	Unscheduled passenger	0	0	14	Destroyed
While en route from an offshore oil platform to Halifax, the crew of the helicopter noticed that the main-rotor transmission oil pressure was decreasing and that the torque indication was zero. The pilot conducted ditching about six miles from land. After the helicopter was ditched, the 17 occupants boarded two life rafts. Although they were all rescued about one hour later by Canadian Forces helicopters, three passengers suffered hypothermia and were hospitalized.								
4/10/85	Bell 47G-2	NA	Panama City Beach, Florida, U.S.	Sightseeing	0	2	1	Substantial
The pilot was carrying two paying passengers on a sightseeing flight after takeoff two minutes earlier from a helicopter pad at the beach. He said that he had felt the engine sputtering and the cyclic stick shaking, followed less than 10 seconds later by the helicopter striking the water in a level attitude at a very high rate of descent. The pilot did not possess a pilot's certificate.								
4/20/85	Sikorsky S-58ET	NA	Gulf of Mexico	Positioning	3	0	0	Destroyed
The helicopter struck the water during an overwater flight from Key West, Florida, U.S., to Ft. Pierce, Florida, U.S. One occupant and the wreckage of the helicopter were subsequently recovered from the Gulf of Mexico. The pilot and the other occupant were not located and were presumed dead. Prior to departure, one of the crewmembers was overheard to say, "That didn't sound good," referring to an unusual sound at the time of shutdown. The pilot told a witness that a mechanical problem was to be corrected in Ft. Pierce.								
4/26/85	Aerospatiale SA360C Dauphin	NA	New York, New York, U.S.	Scheduled passenger	1	0	6	Substantial
During climb over the east edge of the heliport, the pilot-in-command noted a popping sound, loss of engine power, loss of main-rotor rpm and rise in EGT. The helicopter began settling and the pilot tried to deploy emergency floats, but did not have time. The helicopter struck water, rolled over and sank. One passenger did not egress and drowned with his seat belt fastened.								
6/15/85*	Bell 206B-3	NA	Lahaina, Hawaii, U.S.	Sightseeing	0	0	4	Substantial
The pilot reported that the engine failed at an altitude of 800 feet during climb. The helicopter was landed in the surf of the Pacific Ocean and the tail rotor was damaged.								
6/16/85	Robinson R22	NA	Manhattan Beach, California, U.S.	Business	0	0	2	Substantial
The helicopter was to fly in formation with a banner tow. Numerous witnesses along a 20-mile stretch of beach saw the helicopter "flying erratically" and "buzzing the beach" just prior to the accident. Witnesses saw the helicopter enter a near-hover at 70 feet, turn 270 degrees toward the beach and then descend into the water.								
7/7/85	Robinson R22A	NA	Summit Lake, Alaska, U.S.	Business	0	0	2	Substantial
The helicopter struck the glassy water surface of a lake during a low-altitude turn.								
7/16/85*	Aerospatiale AS350D	NA	Hoonah, Alaska, U.S.	Unscheduled passenger	0	0	3	Substantial
The pilot heard a loud noise from the rear of the helicopter with a corresponding left yaw. The engine was shut down in flight and an autorotation was conducted to the water.								
7/21/85*	Bell 206L-1	NA	Gulf of Mexico	Unscheduled passenger	0	0	2	Destroyed
The pilot was conducting a takeoff from a hover off an offshore oil platform. As he lowered the nose for takeoff, he heard a loud noise from the tail-boom area and the helicopter began rotating to the right. The pilot continued to apply power and conducted an autorotation to the water. On impact, the main rotor struck the tail boom and severed it.								
8/1/85	Bell 47G-2	NA	Ochopee, Florida, U.S.	Business	1	0	0	Substantial
The pilot said that he dropped his passenger off at a water station in the Everglades, water-taxied away from the station and increased power to 3,100 rpm. Just before he increased collective pitch the transmission assembly departed the helicopter. The helicopter rolled to the right and came to rest inverted.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/25/85	Hughes 269C	NA	Elizabethtown, Kentucky, U.S.	Personal	0	0	3	Substantial
After takeoff from an off-airport landing zone, the helicopter encountered heavy rain showers. The pilot attempted to return to the landing zone. The pilot was unable to see the ground in low-visibility conditions, and the tail rotor contacted a lake adjacent to the landing zone. The helicopter then sank in the lake.								
9/24/85	Bell 206B	NA	Glendhu Bay, New Zealand	Aerial photography	0	5	NA	Destroyed
While hovering at 60 feet, the main-rotor blades struck telephone wires that were suspended across a cove. The helicopter descended into the water.								
1/9/86	Bell 206L-1	NA	Gulf of Mexico	Executive/ Corporate	0	1	0	Substantial
The helicopter descended into the Gulf of Mexico from a 100-foot hover after the pilot lost yaw control downwind of an offshore oil platform in 35-knot winds. As the helicopter transitioned to a hover, it began a turn to the right, even though it was headed into the wind. Full-left pedal did not stop the spin, according to the pilot, who tried to fly away rather than to initiate autorotation into 10-foot seas. The helicopter continued to spin and then lost altitude and contacted the water, where it rolled and started to sink. The pilot escaped through the broken windshield.								
4/5/86	Sikorsky S-76	NA	Safe Harbor, Pennsylvania, U.S.	Search and rescue	0	0	3	Substantial
The helicopter was maneuvering at low altitude and low airspeed while on a SAR mission at night, looking for a capsized boat, when it struck the water.								
5/6/86	Bell 47G-5A	NA	Gulf of Mexico	Fishery support	1	0	1	Destroyed
The helicopter struck the ocean when the pilot attempted to lift off from a tuna-fishing boat. Three of the four tiedown ropes that had secured the helicopter to the boat had been released before takeoff.								
5/15/86*	Bell 214	BCAL Heli	North Sea	Unscheduled passenger	0	0	20	Substantial
The helicopter was ditched because of a collective-control malfunction. During the evacuation, numerous difficulties were experienced with safety equipment (e.g., life rafts failed to deploy, doors were difficult to open and emergency-float bags were punctured).								
6/25/86	Enstrom F-28A	NA	New York, New York, U.S.	Unscheduled passenger	0	0	2	Substantial
The pilot conducted a go-around because of excessive groundspeed during the first landing attempt. The pilot reported that as he increased collective pitch to terminate the second landing approach over the helipad, the helicopter descended rapidly. The helicopter contacted the water in a level attitude, then rolled onto its left side. Gusty winds prevailed at the time of the accident.								
7/3/86	Bell 47G-3B1	NA	Coleman River, Queensland, Australia	NA	0	1	1	Destroyed
After descending the helicopter to 20 feet to gain speed, the pilot intended to climb over mangroves. The helicopter did not respond to control inputs and collective was raised. The rotor was overpitched and the helicopter flew into the water and sank.								
7/6/86	Hughes 500A	NA	Fall River, Massachusetts, U.S.	Personal	0	0	2	Substantial
The pilot encountered fog and haze during a return flight to New Bedford, Massachusetts. The pilot failed to maintain directional control and the helicopter struck water in the North Watuppa Pond.								
7/17/86*	Bell B-222A	NA	Staten Island, New York, U.S.	Unscheduled passenger	0	0	3	Substantial
The helicopter was in cruise flight at 900 feet when the pilot heard a loud bang and the helicopter yawed. Both crewmembers said that they reacted as instructed and, in the process, an engine failed. The pilots conducted a ditching.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
8/30/86	Bell 206L-1	NA	Grand Isle, Gulf of Mexico	Unscheduled passenger	0	1	0	Destroyed
The helicopter crashed into the Gulf of Mexico following a suspected engine failure shortly after liftoff from an offshore oil platform. The pilot said that after takeoff, while flying at 40 knots and 200 feet above the water, he heard a loud squeal followed by the low-rpm aural warning and a loss of engine power. He attempted two times or three times to inflate the emergency floats but was not successful. The helicopter landed hard, rolled over and sank. The pilot evacuated and swam back to the platform. The wreckage sank and was not recovered.								
11/1/86*	Bell 206B	NA	Mustang Island, Gulf of Mexico	Unscheduled passenger	0	1	1	Substantial
The helicopter experienced a power loss immediately after takeoff from an offshore oil platform. The pilot maintained the collective pitch to clear the platform and then inflated the floats and conducted an autorotation to the water. The helicopter was struck by a five-foot wave and rolled over. Both occupants exited without difficulty and the passenger swam to the platform. The pilot inflated his life vest and was swept away by the current. He swam ashore 14 hours later.								
11/6/86	Boeing CH-47 Chinook	Brintel Helicopters	North Sea	Unscheduled passenger	45	2	0	Destroyed
The helicopter struck the sea 1.5 miles off Sumburgh, Shetland Islands, Scotland, and sank.								
2/5/87	Bell 206L-1	Air Logistics	Gulf of Mexico	Unscheduled passenger	2	1	1	Substantial
The pilot conducted the takeoff from an offshore oil platform with three passengers on board. Shortly after departing, he transmitted a mayday call, but did not say the nature of the emergency. A passenger reported that the engine sound changed and the pilot told him to get the raft out. Subsequently, the helicopter struck rough water and sank. A shrimp boat arrived after about 30 minutes to 40 minutes and all occupants of the helicopter were retrieved; later, the pilot and one passenger died from injuries.								
2/8/87	Hughes 369D	Royal Helicopters	Honolulu, Hawaii, U.S.	NA	1	2	2	Destroyed
During takeoff climb, one of five main-rotor blades and the tail boom separated from the helicopter. The helicopter then struck the water and a submerged reef about 200 feet from the heliport.								
2/13/87	Hughes 269A	NA	Buford, Georgia, U.S.	Personal	1	0	0	Destroyed
The helicopter was seen to slow down, then continue out over a lake. A puff of smoke was observed around the rear of the engine area and the helicopter "fishtailed" as it almost transitioned to a hover. It then descended into the water nose-first and sank almost immediately. The pilot was a low-time helicopter pilot who could not swim.								
3/22/87*	Bell 47-D1	NA	Homosassa, Florida, U.S.	Personal	0	0	1	Substantial
The pilot said that just after takeoff, at about 50 feet, the engine lost power and he conducted a forced landing in a canal.								
3/29/87*	Bell 206B	Kona Helicopters	Kona, Hawaii, U.S.	Unscheduled passenger	1	3	1	Destroyed
At 200 feet and about 0.25 mile from the shoreline, the helicopter's engine power began to decrease. The pilot conducted an autorotation to the ocean. All of the occupants evacuated and the helicopter sank. The passengers were not wearing life vests and one passenger drowned. The helicopter was not equipped with any of the required flotation devices.								
4/15/87	Bell 206B	NA	Laupahoehoe, Hawaii, U.S.	Unscheduled passenger	0	1	2	Destroyed
The helicopter was carrying passengers to a beached barge. Two passengers exited the helicopter without incident. One of these passengers observed a wave break against the barge and water spraying upward onto the helicopter. Both passengers saw the helicopter roll left and strike the water. There was no evidence that flotation equipment was available to the crew or passengers.								
7/4/87	Aerospatiale AS355-F1	NA	Venice, Louisiana, U.S.	NA	1	0	0	Destroyed
Witnesses observed the helicopter break up in flight and strike the water.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants			Damage to Aircraft
					Fatal	Serious	Minor/ None	
7/23/87	Bell 47G-2	NA	Huntsville, Alabama, U.S.	Aerial observation	0	0	2	Substantial
The helicopter struck the water during a low-altitude turn over a river while showing an island to a police officer/traffic observer.								
7/28/87*	Aerospatiale AS350D	NA	Nantucket, Massachusetts, U.S.	Executive/ Corporate	0	0	1	Substantial
The pilot heard a loud bang followed by a severe vibration, loss of power to the main-rotor system and loss of hydraulic pressure. The pilot conducted an autorotation to the water, ditching near a fishing boat. The pilot exited with minor injuries and the helicopter sank into the Atlantic Ocean. The helicopter subsequently was recovered.								
8/5/87*	Robinson R22	NA	Burrville, Rhode Island, U.S.	Personal	0	0	2	Substantial
Engine power failed shortly after takeoff at about 200 feet. The pilot attempted to conduct an autorotation back to the lake, but during a turn to avoid collision with a boat, the helicopter struck the water.								
8/12/87	Hughes 369D	NA	Ketchikan, Alaska, U.S.	Geological survey	2	0	0	Destroyed
The helicopter collided in flight with a Cessna 185 amphibian and struck water.								
8/19/87	Aerospatiale AS355F-1	NA	Gulf of Mexico	Executive/ Corporate	0	2	1	Substantial
The helicopter experienced a tail-rotor driveshaft failure during takeoff from an offshore oil platform. The helicopter spun left and completed six revolutions to seven revolutions prior to water contact because centrifugal force prevented the single pilot from reaching the throttles to reduce torque to idle. The helicopter landed hard and the right emergency float deployed on touchdown. The left emergency float did not deploy and the helicopter rolled over. The occupants swam to the platform from which the takeoff had been conducted.								
8/21/87*	Bell 206B	NA	Washington, D.C., U.S.	Unscheduled passenger	3	1	0	Destroyed
While in a hover at about 200 feet above the Potomac River, the helicopter's engine lost power. The pilot initiated an autorotation and deployed the emergency floats. Subsequently, the helicopter struck the river and rolled over. The floats kept the inverted helicopter at the surface.								
9/16/87*	Bell 206B	NA	Gulf of Mexico	Positioning	0	0	1	Destroyed
While departing from an offshore oil platform, the helicopter lost engine power. The pilot initiated an autorotation and declared mayday, but did not inflate the emergency floats before touching down in the water. The helicopter sank and was not recovered.								
10/24/87*	Bell 47J-2	NA	Key Colony Beach, Florida, U.S.	Unscheduled passenger	0	0	2	Substantial
The helicopter departed on a sightseeing flight along the shoreline. While in cruise flight at about 500 feet, engine power failed. The pilot conducted an autorotative landing in the water with no damage to the helicopter. The pilot then rolled the helicopter to the right to stop the rotation of the main-rotor blades so the pilot and passenger could exit the helicopter. The helicopter was substantially damaged.								
12/7/87*	Bell 412	NA	Galveston, Texas, U.S.	NA	0	2	0	Destroyed
The helicopter landed hard during an autorotation that was entered following the separation of the 90-degree gearbox.								
1/15/88*	Kawasaki BK117-A4	NA	Balmoral Beach, New South Wales, Australia	Aerial work	0	0	3	Destroyed
The left-engine cowl unlatched in flight and was struck by rotor blades. The damage to rotor blades caused severe vibration and temporary loss of control. The pilot ditched the helicopter.								
2/11/88	Bell 206L-1	NA	Port Douglas, Queensland, Australia	NA	0	0	2	Substantial
The pilot lost visual references because of a fogged bubble and rain. The tail rotor struck the water surface and separated from the tail boom. The pilot lost directional control and the helicopter landed in 1.5 meters of water.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
3/28/88*	Bell 214ST	NA	Troughton Island, Western Australia, Australia	Unscheduled passenger	0	0	15	Destroyed
The helicopter began to vibrate severely while in cruise flight at 4,000 feet. The pilot conducted an autorotative landing in three-meter seas. During the landing, the main-rotor blades struck the sea and the fuselage. The helicopter rolled over on touchdown and floated inverted for several minutes. The crew and passengers evacuated and released one life raft. They were rescued by personnel on other helicopters.								
5/1/88*	Bell 206B	Island Helicopter	Long Island City, New York, U.S.	Unscheduled passenger	1	0	4	Destroyed
The helicopter was on a sightseeing flight around Manhattan Island when it experienced low rotor rpm. The pilot conducted a ditching in the East River. The pilot and three passengers exited the helicopter and held onto the emergency floats, which were inflated and had separated from the helicopter. One passenger did not escape and drowned.								
5/29/88	Bell 206B	NA	Honolulu, Hawaii, U.S.	Unscheduled passenger	0	0	5	Destroyed
During a sightseeing flight, just after takeoff, the helicopter began to spin to the right. The pilot recovered the helicopter from the spin, but by that time the helicopter was low over the water. A wave struck a skid and the helicopter entered the water and rolled to the left.								
6/25/88*	Bell 47J-2	NA	Newburyport, Massachusetts, U.S.	Business	0	1	2	Destroyed
The helicopter departed Runway 10 at Plum Island Airport, turned left over the Plum Island River and shortly thereafter engine power was lost without warning. The helicopter was autorotated into water. The occupants were rescued by a private citizen.								
7/13/88*	Sikorsky S-61	Brintel Helicopters	North Sea	Unscheduled passenger	0	0	21	Destroyed
An engine-fire warning was followed by smoke. Ditching and evacuation were completed as the cabin filled with dense smoke. The helicopter burned with an "intense white flame" in the area of the forward gearbox, eventually breaking up and sinking.								
7/14/88	Aerospatiale SA330J	Petroleum Helicopters Inc.	Gulf of Mexico	Unscheduled passenger	0	1	14	Destroyed
During liftoff from an oil platform, the helicopter began a slow uncommanded left turn. The pilot lowered the nose and raised the collective. After two turns, the helicopter settled and struck the water in a left-bank/nose-down attitude. The emergency floats were not inflated.								
8/5/88	Bell 47G-3B-1	NA	Oakland, Maine, U.S.	Aerial photography	0	0	2	Destroyed
The pilot was maneuvering at 30 feet and making a right turn over a lake when the nose of the helicopter swung to the right. The pilot realized that he had lost tail-rotor effectiveness and attempted to accelerate forward with cyclic before the helicopter struck water.								
9/1/88	Bell 206B	NA	Gulf of Mexico	Positioning	0	0	1	Destroyed
Before takeoff, the pilot removed the rotor-blade tiedown and the forward tiedowns, but not the aft tiedowns. After liftoff, the helicopter entered a nose-high attitude, settled back on the platform's safety fence and slid backward into the water.								
9/29/88*	Bell 212	NA	Deadhorse, Alaska, U.S.	Business	0	0	1	Destroyed
The pilot encountered a whiteout condition and conducted the landing on a frozen lake. After touchdown, the helicopter broke the ice and rolled over on its back. The helicopter was destroyed by ground fire.								
10/17/88	Sikorsky S-61	Bristow	Handa Island, Scotland	Search and rescue	0	0	2	Destroyed
While conducting a night SAR mission in fog, the helicopter began a significant rearward drift and a rate of descent that were undetected by the pilot. The helicopter struck the sea and rolled over. One crewmember became trapped in the flooding rear cabin and was unable to reach the emergency exit handle because of the buoyancy of his helicopter transport suit. He escaped when others opened the door from outside.								
11/10/88*	Sikorsky S-61	Brintel Helicopters	North Sea	Unscheduled passenger	0	0	13	Destroyed
A gearbox low-oil-pressure warning was accompanied by vibration. The pilot ditched the helicopter. After the ditching, the helicopter rolled right and overturned in 45-mph winds. The passengers and crew evacuated safely and were rescued by the SAR service.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
11/17/88*	Bell 206L-1	NA	Gulf of Mexico	Unscheduled passenger	0	3	0	Substantial
During an approach, the pilot heard a loud noise from the engine, which was followed by illumination of an "ENGINE OUT" warning light, aural warning and instrument indications of engine failure. The pilot initiated an autorotation and deployed the emergency floats. The helicopter landed hard in rough seas. During the hard landing, the three occupants were injured. The helicopter remained afloat until an attempt was made to tow it, when it sank and was not recovered.								
4/25/89*	Bolkow 105	Bond Helicopters	North Sea	Aerial photography	0	0	2	Substantial
Both engines failed while the helicopter was being maneuvered to land after encountering sleet showers. Autorotation was initiated and floats were inflated. The occupants were transferred to a life raft and were soon picked up by a car-ferry boat.								
5/7/89	Eurocopter MBB BO-105S	Air Logistics	Gulf of Mexico	NA	1	0	0	Destroyed
The helicopter was in cruise flight when it pitched nose-down and began an uncontrolled descent, striking the water in an inverted attitude.								
6/22/89	Robinson R22	NA	Terrigal, New South Wales, Australia	Personal	1	0	1	Destroyed
For undetermined reasons, the pilot lost control of the helicopter in a climbing turn. The helicopter was at a lower altitude than required and the pilot could not recover control before striking water. The passenger drowned after exiting the helicopter.								
6/24/89*	Bell 206B	NA	Ingham, Queensland, Australia	Unscheduled passenger	0	4	1	Destroyed
The pilot reported engine failure during approach to an island. The helicopter was ditched in water and sank. The emergency floats failed to inflate for undetermined reasons.								
7/3/89*	Bell 206B-3	NA	Sydney, New South Wales, Australia	Aerial work	0	0	3	Substantial
The helicopter's engine failed. The pilot ditched the helicopter in a harbor. Occupants were rescued by personnel of a barge.								
7/30/89	Robinson R22	NA	Brinnon, Washington, U.S.	Personal	0	0	2	Destroyed
During a pleasure flight, the pilot felt a low-frequency vibration and initiated a precautionary landing. Because of unsuitable terrain, the pilot maneuvered over glassy water to land on a beach area. The pilot misjudged the height above the water, resulting in the left skid contacting the water. The pilot said that the engine failed and that the helicopter settled softly in the water and sank.								
8/2/89	Schweizer 269C	NA	Philadelphia, Pennsylvania, U.S.	Instructional	0	0	2	Substantial
Shortly after departing the heliport, which was 20 feet above the water, the helicopter struck the water.								
8/16/89*	Enstrom 280-C	NA	Milbridge, Maine, U.S.	Personal	0	0	2	Substantial
Shortly after departing the private heliport, partial engine failure occurred. The pilot conducted an autorotation to a river.								
11/2/89	Sikorsky SK-70	NA	Marathon, Florida, U.S.	Law enforcement	1	0	5	Destroyed
While being maneuvered at night for surveillance of a boat, the helicopter descended and struck the ocean. The cabin filled with water. All of the occupants egressed from the helicopter, except for the copilot, who was presumed to have drowned.								
12/27/89	Bell 206L-1	Air Logistics	Gulf of Mexico	Unscheduled passenger	0	3	3	Destroyed
The pilot initiated a go-around during approach to an oil platform. The helicopter spun to the right and the nose dropped. The pilot tried to regain control, but could not. He deployed the emergency floats just before the helicopter struck the water, but one of the left floats separated on water entry and the helicopter rolled over.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
1/23/90	Aerospatiale AS355F-1	NA	Gulf of Mexico	Positioning	1	0	0	Destroyed
The pilot was flying from an offshore location to a company onshore base. The weather was IMC along the entire coast, with fog reported onshore and offshore. The pilot changed destinations several times. The last radio communication with the pilot indicated that the helicopter was offshore about 20 miles from its destination. The pilot and the helicopter were not recovered.								
1/30/90	Bell 206B	NA	Rotoroa Island, New Zealand	Passenger	0	1	NA	Destroyed
Visual references were lost when window transparencies became covered by mist shortly after takeoff. The helicopter descended, struck the sea and sank.								
2/10/90	Bell 206L	Island Helicopter Corp.	New York, New York, U.S.	Business	0	0	4	Substantial
The helicopter was lifted off the helipad and made a left-pedal turn. The pilot believed that he was taking off in a crosswind, when a tailwind actually was present. As the helicopter arrived at the end of the heliport platform and was moving slowly over the water, the helicopter settled in a nose-low attitude. The pilot could not stop the descent and the helicopter struck the river.								
3/8/90*	Aerospatiale AS350D	International Helicopter Corp.	Miami, Florida, U.S.	Unscheduled passenger	2	1	0	Destroyed
The engine failed over the ocean, and the pilot initiated autorotation. He told the passengers to don their life vests. About 100 feet above the water, he deployed the emergency floats, then ditched in the ocean about three miles from shore. A wave struck the helicopter and it rolled over. The passengers and pilot climbed onto the fuselage, and the pilot dove under water to retrieve the ELT. After he activated the ELT, another wave struck and the pilot dropped the ELT as he reached to help a passenger. The accident occurred about 1115 local time, the U.S. Coast Guard was notified about the ditching at 1530, and the pilot was rescued at 0430 the following morning. One passenger died eight hours after the accident, and the other died 15 hours after the accident; both deaths were caused by drowning.								
4/1/90*	Aerospatiale AS350B	Micronesian Aviation Corp.	Saipan, Pacific Ocean	Unscheduled passenger	0	0	2	Destroyed
The helicopter was in cruise flight when the pilot felt a strong vibration. The pilot made an emergency landing in the sea with seven-foot waves. The helicopter subsequently overturned and sank.								
4/17/90*	Bell 206L-1	NA	Gulf of Mexico	Unscheduled passenger	NA	1	4	None
During a flight over the Gulf of Mexico, the engine failed. Before touchdown, the pilot deployed the floats. One passenger received serious injuries during the ditching. After the pilot and passengers were rescued, the helicopter rolled over in the glassy, smooth water but did not sink.								
5/13/90*	Enstrom F-28A	NA	Marathon, Florida, U.S.	Sightseeing	0	0	3	Substantial
Shortly after takeoff at about 50 feet, tail-rotor effectiveness was lost. The pilot conducted a power-on ditching in the ocean.								
5/20/90	Robinson R22M	NA	Stevensville, Maryland, U.S.	Personal	0	0	2	Substantial
The pilot said that while he was water-taxiing the helicopter on a bay, he encountered a wave from a passing boat, causing the helicopter to nose down. The pilot unsuccessfully tried to regain control with cyclic input. The helicopter nosed over and sank.								
5/22/90	Hughes 269A	NA	Bremerton, Washington, U.S.	Personal	0	0	2	Substantial
During approach over a lake for landing at a private residence, the pilot experienced binding of the tail-rotor controls and loss of anti-torque control. He reduced power to maintain the heading and the helicopter settled into the water.								
6/23/90	Bell 47G-2A	NA	Dutch Harbor, Alaska, U.S.	Business	0	0	2	Destroyed
In heavy fog, the pilot saw a cliff appear in front of the helicopter and he turned to avoid it. Another cliff appeared, and as the pilot turned again, the helicopter struck the water and sank.								

Table 2

Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
7/19/90*	Bell 206A	NA	Lake Ozark, Missouri, U.S.	Business	0	0	4	Minor
Shortly after liftoff over water, the helicopter's engine failed. A ditching was conducted and the emergency floats failed to deploy. The helicopter sank; all four occupants escaped unharmed.								
7/25/90	Sikorsky S-61N	British International Helicopters	112 miles northeast of Sumburgh, Shetland Islands, Scotland	Unscheduled passenger	6	4	3	Destroyed
The helicopter was maneuvering to land on a permanently moored offshore storage and tanker-loading unit. As the helicopter hovered adjacent to the helideck, the tail-rotor blade tips struck a handrail surrounding a crane on the installation. The helicopter struck the helideck and fell over the side of the deck and into the sea. Seven survivors were rescued from the sea after they escaped from the sinking helicopter.								
8/13/90	Bell 206B-2	NA	San Francisco, California, U.S.	Aerial photography	0	0	3	Destroyed
The pilot was maneuvering the helicopter in a climbing right turn around a sailboat to provide an aerial platform for a movie film crew. About 100 feet above the water and a few feet from the sailboat mast, the helicopter began to spin to the right. The pilot reduced collective pitch and the spin stopped, but because of the collective-pitch reduction, the pilot was unable to regain control of the helicopter before it struck the ocean surface and sank.								
8/14/90	Hughes 269A	NA	Barramundi Lagoon, Queensland, Australia	NA	0	0	2	Destroyed
The helicopter experienced a tailwind gust during takeoff. The pilot overpitched the main rotor while attempting to counteract a descent, which resulted in the right skid contacting the lagoon surface. The helicopter rolled over and sank.								
9/8/90*	Aerospatiale AS350B Ecureuil	Canadian Helicopters	Ponita Lake, Alberta, Canada	Animal control	0	0	3	Substantial
The helicopter was being flown at low level over a lake to assist in the capture of live trumpeter swans. The method of capture involved hovering within four feet of the water to allow a biologist to scoop up a bird with a large fish net. While the helicopter was being maneuvered into position to capture a bird, the tail rotor struck the surface of the water. Directional control was lost immediately and the pilot ditched the helicopter to stop the uncontrolled rotation. The doors on the right side of the helicopter had been removed and water entered the cabin immediately. The helicopter sank in shallow water. All three of the occupants egressed from the helicopter as it sank and climbed up onto its left side. They were wearing life vests and swam to shore.								
9/12/90	Bell 206-L1	NA	Port O'Connor, Texas, U.S.	Unscheduled passenger	1	0	0	Destroyed
The helicopter departed at dawn for a VFR flight from a coastal base en route to an offshore oil platform during IMC. The helicopter penetrated a heavy rain shower. The pilot descended and attempted to maintain visual contact with an oil-platform light. The helicopter's right skid dipped into the water and the helicopter tumbled forward and struck the water.								
10/22/90	Bell 47G-5	NA	NA	Aerial observation	1	0	0	Destroyed
The pilot was operating from a ship at sea for fish spotting and herding. The helicopter was herding fish into the deployed net when a rotor struck a swell. The helicopter collided with the water, rolled inverted and sank.								
11/16/90*	Bell 212	Petroleum Air Services	Egypt	NA	0	0	1	Destroyed
During takeoff from an offshore oil platform, the pilot found that a bridge that had been jacked up for painting obstructed his normal departure path. The pilot then changed the departure route. While in a low hover and moving backwards, the helicopter's tail rotor struck a fence, which the pilot had not noticed. After impact, the helicopter began to vibrate and developed an uncontrollable yaw to the right. The pilot subsequently ditched the helicopter.								
11/24/90*	Hughes 269C	NA	Lethbridge, Victoria, Australia	Unscheduled passenger	0	1	2	Substantial
Shortly after takeoff, at about 20 feet and 30 knots, power decreased briefly and main-rotor rpm decayed. Attempting to fly to the bank, the pilot overpitched the main rotor and then ditched the helicopter.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
11/25/90	Aerospatiale SA330J Puma	Elitos SpA	Mirana di Ravinna, Italy	Unscheduled passenger	13	0	0	Destroyed
The helicopter was destroyed when the pilot lost control and the aircraft struck the sea about three minutes after takeoff. The accident was caused by the fatigue failure of a main-rotor-hub spindle and subsequent departure of the main-rotor blades.								
12/6/90*	Aerospatiale AS332L Super Puma	Pelita Air Service	Matak Island, Indonesia	NA	10	2	0	Destroyed
About two minutes after takeoff, the pilot reported that he was experiencing electrical problems and was returning. The crew declared mayday and said that they were ditching. The helicopter was seen descending through about 200 feet, with flames and black smoke coming from the vicinity of the main rotor head. It then rolled through 90 degrees and spun into the sea, striking the water in a nose-down attitude about 600 feet short of the runway.								
12/20/90	Bell 206B-3	NA	St. Marks, Florida, U.S.	Public use	0	0	1	Destroyed
While descending at night in VFR, the pilot lost outside visual reference and the helicopter struck the water. No mechanical failures or engine failure were identified after the accident.								
1/16/91*	Bell 206B-3	NA	Heron Island, Queensland, Australia	Unscheduled passenger	0	0	5	Substantial
During takeoff, at 200 feet, a loud bang was heard and the helicopter yawed to the right. The pilot activated emergency floats and ditched.								
1/27/91	Bell 206L-1	NA	Gulf of Mexico	Unscheduled passenger	2	0	0	Destroyed
The helicopter departed from an offshore oil platform en route to an onshore location. After takeoff, the pilot received a weather briefing, which included adverse conditions in the area. The pilot did not make a required 15-minute flight-following call after departure and was assumed to be missing. A search was initiated, but was hampered by bad weather. Neither the helicopter nor the occupants were found during SAR efforts. When the wreckage was located later, investigators determined that a high-speed impact with water had occurred.								
1/31/91	Aerospatiale SA341G Gazelle	French Aircraft Agency	Watson Island Helipad, Miami, Florida, U.S.	Aerial observation	0	3	0	Destroyed
During takeoff from a helipad, the pilot climbed to about 200 feet at about 90 knots before engine failure occurred. The helicopter lost height and struck the sea close to shore. The helicopter struck the water at a high rate of descent and came to rest upright.								
2/10/91*	Eurocopter MBB BO-105CBS	Heli-Lift	Valdez, Alaska, U.S.	NA	0	0	4	Destroyed
While en route, some 25 to 30 minutes after takeoff, the helicopter's no. 1 engine failed. The helicopter was apparently unable to maintain height and was ditched in the sea.								
2/14/91	Mil Mi-2	Aeroflot – Ukraine Directorate	Krasnopere-kopsk, Ukraine, Soviet Union (now Commonwealth of Independent States)	NA	1	2	0	Destroyed
During landing, the helicopter struck the water surface.								
2/14/91*	Hughes 369C	Alpromar SA	Manzanillo, Mexico	NA	0	0	2	Destroyed
Control of the helicopter was lost while it was being flown at a low altitude over the sea. The helicopter was ditched and sank.								
2/24/91*	Bell 212	Bristow Helicopters (Nigeria)	Eket, Nigeria	Unscheduled passenger	9	0	4	Destroyed
During the final stages of the approach to an offshore oil platform, as the helicopter descended through about 400 feet, a loud bang was heard and the helicopter began to yaw violently. The pilot conducted an immediate ditching. On touchdown the helicopter was not fully under control, pitched violently forward and rolled inverted. The helicopter came to rest floating inverted about half a mile from the platform.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
3/8/91*	Bell 206B	Kenai Air of Hawaii	Honolulu, Hawaii, U.S.	Unscheduled passenger	0	0	2	Destroyed
About 15 nautical miles south of Honolulu, engine failure occurred because of fuel exhaustion. The pilot conducted an autorotation to the water. After the touchdown, the right-forward emergency floats deflated, causing the helicopter to sink.								
4/1/91	Hughes 369C	NA	Papua, New Guinea	Aerial observation	0	0	2	Destroyed
The pilot was flying between two tuna-fishing vessels. As the pilot began a climb from about 100 feet above the water, he found that the cyclic control was binding longitudinally. The helicopter continued to climb until it reached a near-vertical attitude. The pilot applied rudder pedal to move the nose down. The helicopter then descended rapidly to the surface of the ocean, where a float attached to a skid contacted the water. The floats were torn off and the helicopter cartwheeled and sank.								
4/5/91	Sikorsky S-61N	Helivia Aero Taxi	Tesse, Brazil	Demonstration	0	0	2	Destroyed
During a demonstration of water landing on a river, the helicopter's approach speed was too high and control was lost on touchdown. The helicopter pitched up and its main rotors struck the tail and separated. The S-61 remained floating and was later towed toward the shore by a local fishing boat. Before it was recovered to a beach, the helicopter rolled inverted and sank in about 10 meters of water.								
4/14/91	Bell 206B-3 JetRanger	Polizia	Bari, Italy	NA	1	0	1	Destroyed
The helicopter was reported missing at sea. Details were not reported.								
4/23/91	Bell 206B JetRanger	Offshore Logistics	Gulf of Mexico	NA	1	0	0	Destroyed
The pilot did not make the required 15-minute radio position report after departure from an offshore oil platform; a radio search and an air search were initiated. About two hours later, debris was found floating about three miles from the departure point.								
4/29/91	Bell UH-1B	NA	Lake Seminole, Georgia, U.S.	Aerial observation	0	0	1	Destroyed
The helicopter was being used to observe previously sprayed aquatic plants. The flight proceeded along the river at a low level. No obstruction was seen but a bump was felt and the helicopter struck the river. The pilot and passenger exited the helicopter under water.								
5/12/91*	Aerospatiale SA330J	NA	Karratha, Western Australia	Unscheduled passenger	0	0	2	Substantial
The helicopter entered a vortex-ring state after descent through 480 feet during a stabilized approach, at night, to a ship's platform. The rate of descent increased from 800 feet per minute to 4,000 feet per minute in 6.6 seconds from 480 feet to 100 feet. The rate of descent was stopped just prior to ditching.								
5/18/91	Hughes 269C	NA	Tarpon Springs, Florida, U.S.	Personal	0	0	2	Substantial
The pilot climbed to a three-foot hover over a dock and, while he was transitioning to forward flight over a lake, the helicopter began to descend. The pilot said that he raised the collective and applied power to stop the descent but the skids struck the water. He then rolled the helicopter on its right side to stop the main rotor and both occupants exited the helicopter.								
5/29/91	Bell UH-1B	NA	Lake Seminole, Georgia, U.S.	Aerial observation	0	2	1	Destroyed
The takeoff occurred at dawn on a flight for aerial observation of previously sprayed aquatic plants. The helicopter was flown at a low level along a river. The pilot looked at the observer, then looked forward again. No obstruction was seen, but a bump was felt and the helicopter struck the river surface. The pilot and his passenger exited the helicopter under water.								
6/12/91	Enstrom F-28	NA	Snowdonia, Wales	Aerial photography	0	0	2	Substantial
While being hovered over a lake, the helicopter encountered a strong downdraft and settled into the water. Both occupants escaped before the helicopter sank.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/17/91	Sikorsky S-76A	Petroleum Helicopters Inc.	Gulf of Mexico	Unscheduled passenger	0	10	0	Destroyed
During takeoff from an oil platform, the pilot increased collective pitch. The helicopter responded by turning right. The copilot interpreted the right turn as a loss of directional control, so he took both engines offline. The action was taken without coordination or announcement to the pilot-in-command. The main rotor blades struck the platform and the helicopter descended uncontrolled to the water.								
6/25/91*	Aerospatiale AS350D	NA	South East Point, Victoria, Australia	Aerial work	0	1	0	Destroyed
The helicopter was being used to sling-load a fuel bladder to a lighthouse. The helicopter's engine-fire light illuminated and the engine stopped as if from fuel exhaustion. The pilot ditched the helicopter.								
7/3/91	Hughes 300C	NA	Whitehall, Michigan, U.S.	Personal	0	0	1	Substantial
The pilot said that he flew across Lake Michigan in dark night conditions. On arrival at the opposite shore, he entered a descending left turn toward the destination. The pilot lost visual reference during this maneuver, and the helicopter descended into the lake.								
7/12/91	Hughes 369	Guaradia di Finanza	Baseleghe, Italy	NA	1	1	0	Destroyed
The helicopter was reported missing at sea. Details were not reported.								
8/10/91*	Bell 47G	NA	Lake Ozark, Missouri, U.S.	Business	0	0	1	Substantial
Shortly after takeoff, the pilot heard a loud snap, which was followed by an uncommanded right yaw. An autorotation was conducted and the helicopter forcefully struck the water during the ditching.								
8/26/91*	Bell 412	Petroleum Helicopters Inc.	Gulf of Mexico, south of Cameron, Louisiana, U.S.	Unscheduled passenger	1	4	8	Destroyed
The helicopter was ditched during approach to a semi-submersible drilling platform. When about 500 yards from the platform and descending through 250 feet, directional control was lost. On touchdown, the helicopter rolled inverted because only one of the emergency floats inflated.								
9/15/91	Bell-K Copter 47D1	NA	Laurie, Missouri, U.S.	Personal	3	0	0	Destroyed
The pilot was seen consuming beer with a group of people before the flight. He and two others of the group were seen boarding the helicopter and the pilot was seen conducting the takeoff. A witness on a highway about 5.5 miles south of the departure point saw a helicopter flying at treetop level, turning toward a lake and disappearing from sight. Two witnesses saw the helicopter strike power-line cables, then strike the lake. Post-mortem tests showed that the pilot had a blood-alcohol level of 0.161 percent.								
9/17/91	Robinson R22	NA	Lewisville, Texas, U.S.	Ferry	0	0	1	Destroyed
The pilot experienced binding of the flight controls and landed the helicopter on a lake. When the pilot moved the controls while floating on the lake, the binding ceased. After conducting a takeoff, the pilot found that controls would not respond to inputs and were binding. The helicopter descended out of control and struck the water.								
9/23/91	Robinson R22	NA	Point Judith, Rhode Island, U.S.	Personal	1	0	0	Destroyed
The pilot departed Block Island, Rhode Island, on a dark night and was reported missing when he did not arrive at the destination. A search was initiated, but the pilot and helicopter were not found. The tail section of the helicopter was recovered by the U.S. Coast Guard on Dec. 8, 1991.								
9/24/91*	Bell 206B JetRanger	Celtic Helicopters	Dunquin, Ireland	Survey/Patrol	0	0	2	Substantial
The helicopter was ditched during the filming of a motion picture.								
10/14/91*	Kaman HH-43B/F	NA	Mt. Vernon, Alabama, U.S.	Positioning	0	0	2	Substantial
While in flight, the throttle rolled back uncommanded to flight idle. An autorotative landing was conducted to a shallow lake.								
11/21/91*	Bell 214ST	NA	Timor Sea	Unscheduled passenger	0	0	17	Substantial
Smoke was seen coming from the left engine after takeoff. The helicopter was landed 75 meters from an oil platform using the emergency floats. One float bag burst and the helicopter rolled over.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
11/22/91*	Bell 214ST	Lloyd Helicopters	Timor Sea, off Western Australia, Australia	Unscheduled passenger	0	0	17	Destroyed
The pilot ditched the helicopter after partial power failure during departure. The pilot and passengers were rescued without injury and the helicopter was recovered.								
1/11/92	Bell 206B-3	NA	Crockett, California, U.S.	Aerial observation	5	0	0	Destroyed
The helicopter collided with a power line, entered an uncontrolled descent and struck the water of a strait.								
2/4/92	Bell 206B	NA	Swan Reach, Victoria, Australia	NA	0	1	3	Destroyed
While flying north, following a river about 250 feet above the water, the helicopter struck a power line. The helicopter descended into the river, where it sank inverted.								
2/12/92*	Bell 206L-3	NA	Fort Collins, Colorado, U.S.	Ferry	2	1	0	Substantial
While in cruise flight over a reservoir, the engine failed. The pilot conducted an autorotation through dense fog to the water surface, which contained patches of ice. The helicopter sank. SAR personnel found the pilot about 45 minutes after the accident. The pilot was the only person on the surface at the time.								
2/15/92*	Robinson R22M	NA	Chandler, Arizona, U.S.	Business	0	0	2	Substantial
The pilot was conducting an autorotation to the water in a float-equipped helicopter as a part of a sales demonstration flight. The helicopter pitched forward during the touchdown phase of the water landing. The right float sank and the helicopter rolled over on its right side.								
3/2/92	Bell 206B-3	NA	Glenbrook, Nevada, U.S.	Aerial observation	0	0	5	Substantial
The helicopter began an uncommanded right turn while being flown out of ground effect. The pilot attempted to stop the right turn without success. The helicopter descended uncontrolled until it struck a lake.								
3/14/92	Aerospatiale AS332L Super Puma	Bristow Helicopters	East Shetland Basin, Great Britain	Unscheduled passenger	11	1	5	Destroyed
The helicopter was destroyed when it struck the sea during a 200-meter flight from an oil platform to a vessel that provided living quarters. After liftoff, the pilot began a climbing right-hand turn toward the vessel. About 15 seconds later, while in the right turn, the helicopter began to descend and struck the sea. The flight time was 47 seconds.								
3/20/92*	Bell 206B-3 JetRanger	Manchester Helicopter	Blackpool, England	Private	0	0	1	Destroyed
During cruise at 3,000 feet over the Irish Sea about two minutes after takeoff, the engine failed. The pilot transmitted a distress call and conducted an autorotation to the sea. After touchdown the helicopter turned over and later sank.								
4/9/92	Bell 206L-3	Petroleum Helicopters Inc.	Venice, Louisiana, U.S.	Unscheduled passenger	0	2	1	Destroyed
The helicopter was en route to an offshore oil platform when the pilot became ill. While descending to conduct a precautionary landing on the water, the pilot lost consciousness and lost control of the helicopter. Food poisoning was caused by ingestion of day-old fish that the pilot had prepared the previous night for dinner.								
4/22/92	Robinson R22	NA	Rottnest Island, Western Australia, Australia	Aerial photography	0	0	2	Destroyed
The pilot, who was conducting aerial photography, lost control of the helicopter. The helicopter spun right and descended into the water.								
6/4/92*	Bell 212	Aeroleo Taxi Aereo	Campos Basin, Brazil	Unscheduled passenger	3	3	1	Destroyed
According to press reports, a fire occurred the helicopter's no. 2 engine during a flight to an oil platform and the helicopter subsequently was ditched about 46 kilometers from the shore.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/10/92*	Hughes 369D	CRI Helicopters	Ketchikan, Alaska, U.S.	Personnel positioning to site	0	0	4	Destroyed
About three minutes after takeoff from a hilltop, the helicopter began to vibrate and tail rotor thrust was lost. The pilot could not control the helicopter and elected to land immediately. The helicopter was ditched and sank in 30 feet of water.								
6/16/92	Bell 47-G4A	NA	Shelburne Falls, Massachusetts, U.S.	Aerial observation	3	0	0	Destroyed
The helicopter struck power lines. Control was lost and the helicopter struck a river that was parallel to the flight path.								
7/4/92*	Robinson R22 Beta	NA	Cooktown, Queensland, Australia	Personal	0	0	2	Destroyed
The pilot was operating from a cleared area in a mangrove swamp. The helicopter lifted off and continued forward above the mangroves. The pilot believed that he had overpitched the rotor and took corrective action, then conducted a ditching in the Normanby River.								
7/26/92	Bell 206B-3	Industrial Helicopters	Gulf of Mexico	Unscheduled passenger	1	0	0	Destroyed
The helicopter was approaching a platform to pick up two passengers. A nose-high flare was observed by the waiting passengers and the tail-rotor blades struck the fence guard around the helideck. Control was lost as the tail-rotor assembly and gear box separated from the tail boom. The helicopter spun off the helideck, falling to the ocean.								
8/9/92	Eurocopter MBB BO-105	Rocky Mountain Helicopters	Madison, South Dakota, U.S.	Business	0	0	3	Substantial
The pilot said that he entered a shallow right turn 200 feet to 300 feet above Lake Madison. He then realized that the helicopter had descended considerably and was in a steep right bank. He said that he attempted to level the helicopter and climb but the helicopter struck the water.								
8/13/92*	Rotorway Exec	NA	Kirkland, Washington, U.S.	Personal	0	0	0	Substantial
The pilot said that just after liftoff from a dock, about 50 feet above the water and 200 yards from the departure point, the cyclic control became very stiff and almost impossible to move. The pilot attempted to return to the dock, but about 50 yards from the landing area, the helicopter began to spin. Because of the restricted landing area and people along the shore, the pilot ditched the helicopter in the lake.								
9/13/92	Robinson R22 Beta	NA	Colfax, California, U.S.	Personal	0	0	1	Substantial
The pilot and passenger were flying about 150 feet above the ground in a canyon. The pilot failed to see and avoid a steel cable crossing the helicopter's flight path. The helicopter struck the cable, descended and struck a river.								
9/25/92	Hughes 369D	Temsco Helicopters	George Inlet, Alaska, U.S.	Unscheduled passenger	0	0	4	Destroyed
While the helicopter was being flown along a shoreline at about 300 feet, a passenger asked the pilot to fly in the opposite direction. During the turn, the helicopter descended and struck the water.								
9/25/92	Bell 47G-5	NA	Cairns Harbour, Queensland, Australia	Aerial photography	1	2	0	Substantial
While the helicopter was being used in filming operations, about 150 meters from the shoreline of an inlet, it began rotating to the right and losing altitude, narrowly missing the mast of a yacht. As the rotation continued, the helicopter veered closer to the shoreline and lost more altitude while maintaining level flight. The helicopter struck the water right-skid-first about 70 meters from the shoreline and sank almost immediately.								
11/5/92*	Mil Mi-8MT	NA	Yuanyang, Henan Province, China	NA	0	0	5	Destroyed
The helicopter was ditched after tail-rotor problems were experienced during a practice rescue mission.								
12/7/92*	Hughes 269B	NA	Kahului, Hawaii, U.S.	Aerial observation	0	0	2	Destroyed
The helicopter was ditched in the ocean after an in-flight loss of control.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/8/93	Robinson R22 Beta	NA	Coolangatta, Queensland, Australia	Personal	0	2	0	Destroyed
The pilot conducted a takeoff and flew the helicopter at a low level down a creek. The helicopter struck power lines and then struck the water. The pilot and passenger swam to shore.								
1/11/93	Hughes 269C	NA	Tonawanda, New York, U.S.	Aerial observation	2	0	0	Destroyed
The pilot requested and received a special VFR clearance to depart on a radio-traffic-watch flight into adverse weather. The helicopter struck power-transmission lines 194 feet above a river and descended into the river.								
1/12/93	Bell 206B	Helinet Corp.	Hayward, California, U.S.	Cargo	2	0	0	Destroyed
The pilot flew the helicopter across a coastal bay in an area of low visibility near a bridge that spanned the bay. A witness observed the helicopter descending below the level of the bridge where visibility was about 0.25 mile in rain. The helicopter struck the water about 0.5 mile from the shore and about 400 yards south of the bridge and was destroyed.								
1/25/93*	Fairchild-Hiller FH-1100	NA	Volcano National Park, Hawaii, U.S.	Sightseeing	4	0	1	Destroyed
While the helicopter was hovering near a shoreline, a total failure of the left pedal occurred. The helicopter began to spin and the pilot lost control. The pilot performed an autorotative descent and touched down in the Pacific Ocean. A wave swamped the helicopter and it sank. The helicopter was not equipped with floats, and none of the passengers was wearing a life vest.								
2/8/93	Bell 206L-1	Petroleum Helicopters Inc.	Gulf of Mexico	Unscheduled passenger	0	0	3	Substantial
Witnesses said that they saw the helicopter depart from the helideck in a steep left bank and nose-down attitude, which were maintained until the helicopter struck the water.								
3/24/93*	Bell 47-G2A	NA	Pacific Ocean	Aerial observation	1	0	1	NA
On a fish-spotting mission with the ship's master as passenger, the pilot heard a loud bang and felt a vibration in the rudder pedals. All yaw control was lost. The pilot believed that the tail rotor had been struck by a large sea bird. He was able to maintain directional control with the throttle and collective, and the ship from which the flight had departed maneuvered to create a smooth water surface for ditching. The passenger unexpectedly jumped out of the helicopter and was killed; the pilot conducted a running landing on the water. The helicopter was hoisted onto the deck of the ship.								
3/25/93	Hiller UH12E	NA	Greeleyville, South Carolina, U.S.	Personal	0	0	1	Substantial
The pilot was flying over a lake while approaching to land at an empty field adjacent to his house. When the helicopter was flared for landing over the lake, the tail rotor struck the lake surface. Directional control was lost and the helicopter struck the lake.								
4/11/93*	Fairchild-Hiller FH-1100	Pelican Air Helicopter	Caribbean Sea between Curacao and Santo Domingo	Ferry	0	0	2	Destroyed
Flying at 4,500 feet, about two hours and 20 minutes after departure, the pilot noticed that the engine turbine-outlet temperature had begun to rise. The temperature continued to rise well past the maximum for continuous operation, and the pilot conducted a precautionary ditching before the engine failed. The helicopter touched down on the sea but rolled over almost immediately in a swell and began to sink, disappearing below the water after about 10 minutes. The crew was rescued three hours and 15 minutes later.								
5/8/93*	Bell 212	Lufttransport AS	Tomso, Norway	Test	0	0	3	Substantial
Shortly after takeoff for a routine test flight following maintenance, the helicopter apparently began to experience control difficulties and the crew was conducted a ditching.								
5/29/93	Robinson R22	NA	Reading, England	Aerial photography	0	0	2	Substantial
The helicopter struck water while a passenger was filming water sports. The helicopter came to rest inverted in the water.								
7/26/93*	Bell 206B-2 JetRanger	Motions Video Productions	Lake Powell, Utah, U.S.	Aerial observation	0	0	3	Substantial
The pilot was conducting a low-level pass over a jet ski for the purpose of filming when the helicopter entered a right-hand climbing turn. During the turn, the engine failed and the pilot conducted an autorotation to the lake.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
7/28/93*	Bell 206B-3	Lloyd Helicopters	Facing Island, Australia	Unscheduled passenger	3	1	0	Destroyed
While flying at 1,500 feet, the pilot reported that he had felt a sudden jolt and that he was returning. Shortly after this, he reported that he was ditching the helicopter and transmitted a mayday call. This was the last radio communication with the flight, which struck the sea off Facing Island.								
7/29/93	Bell 206A JetRanger	Osterman Helicopter	Musholmen, Sweden	Aerial observation	0	0	3	Substantial
The helicopter was being used to collect water samples. At one of the sampling points, the water surface was still and glassy and the pilot used some water lilies for visual reference. He also expected that rotor downwash would ripple the water surface and provide additional visual reference for the touchdown. The rate of descent was excessive; however, a normal landing flare could not be conducted to stop the descent. The tail boom or the rear of the left float struck the water, and the main rotor struck and severed the tail boom. The helicopter cartwheeled and came to rest inverted in the water.								
8/10/93	Robinson R22 Beta	Offshore Helicopters	Honolulu, Hawaii, U.S.	Personal	2	0	0	Destroyed
The helicopter's main rotor diverged from its normal plane of rotation, which caused the rotor to contact the airframe. The helicopter descended in uncontrolled flight and struck the Pacific Ocean.								
9/10/93	Aerospatiale SA365-N2	NA	Ogden, Utah, U.S.	Executive/ Corporate	1	2	3	Destroyed
The helicopter was flying over glassy water. The pilot had set the bug on the radio altimeter for 50 feet; while he was looking outside, however, the helicopter descended below 50 feet. The pilot said that seconds before impact with the water, the radio altimeter had indicated an altitude of 10 feet.								
9/22/93	Bell 206B	Supremas Bel Golso	Pacific Ocean	Aerial observation	2	0	0	Destroyed
The helicopter pilot was conducting a fish-spotting mission, 15 miles to 20 miles from the ship from which it had been launched. The pilot advised that he was returning to the vessel. Shortly thereafter, the pilot transmitted, 'We are going down … the engine has stopped." The vessel immediately went to the last known position of the helicopter and began a search, which was suspended at dusk. At 0900 local time the following morning, pieces of fiberglass and an unopened life raft were found, and a short time later, the body of the passenger was found.								
10/23/93*	Bell 47J-2A	NA	Whyalla, South Australia, Australia	Personal	1	1	0	Destroyed
Five minutes after departing Whyalla and 10 kilometers from the coast, the helicopter began experiencing engine problems. The pilot instructed the passenger to prepare for a ditching. After the helicopter forcefully struck the sea during the ditching, the passenger egressed and removed the injured pilot from the helicopter. During the long swim to shore, the pilot was lost.								
10/25/93	Bell 206B	Petroleum Helicopters Inc.	Gulf of Mexico	Nonscheduled passenger	0	0	2	Substantial
The pilot reported that, during takeoff from an offshore oil platform, the helicopter pitched nose-down and began to spin uncontrollably. The helicopter then struck the water. The operator reported that the left-front tiedown had not been removed prior to takeoff.								
10/29/93*	Bell 206L	New York Helicopter Corp.	New York, New York, U.S.	Sightseeing	0	0	6	None
The helicopter pilot was conducting a sightseeing flight over the East River in New York City when the engine failed. The pilot deployed the emergency floats, initiated an autorotation and ditched in the river.								
10/29/93	Bell 206B	SeaHawk Services	Gulf of Mexico	Business	1	0	2	Destroyed
The pilot set up an orbit to wait for thunderstorms and squalls to move out of the area. During one orbit, the helicopter was struck by a 15-foot swell and rolled into the water. The three occupants were able to exit the helicopter and inflate their life vests. According to passengers, the helicopter continued to float for five hours to six hours, during which one passenger attempted unsuccessfully three times to retrieve the life raft from inside the helicopter. The passenger did retrieve another life vest, which he gave to the pilot for additional flotation. The helicopter sank, and one of the passengers swam to the oil platform, which he estimated as being about two miles away. Shortly thereafter, the second passenger began swimming toward the platform, but the pilot said that we would await rescue. The first passenger reached the unmanned platform about three hours after he began swimming and was able to telephone his office. The passenger on the platform was rescued by a Coast Guard cutter and the second passenger was recovered by a work boat. The same boat found the unconscious pilot, who was face-down in the water, the following morning. During the recovery, the pilot's life vest came off and he sank below the surface.								

Table 2

Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
11/7/93	Hughes 369D	Big Eye Helicopters	Bismark Sea, Papua New Guinea	Aerial observation	2	0	0	Destroyed
The helicopter was destroyed when it struck the Bismark Sea during a fish-spotting flight from a motor fishing vessel. The helicopter was being tracked by radar from the ship, but about 1.5 hours into the flight, with the helicopter operating about 27.5 miles from the ship, the radar return disappeared. There was no distress call.								
11/17/93*	Agusta-Bell 204B	Meteor Constructionie Aeronautiche	Chania/Souda, Greece	NA	2	0	0	Destroyed
The helicopter was en route to retrieve a drone that was floating in the sea, and was being flown at 600 feet and 70 knots when the pilot reported that he was ditching. Almost immediately, the helicopter entered a steep dive that continued until impact with the sea.								
11/19/93*	Bell 206L-1	Echo	Portland, Maine, U.S.	Emergency medical services	3	1	0	Destroyed
During a flight to Portland, the pilot encountered IMC and a substantial headwind of 40 to 60 knots. The engine failed because of fuel exhaustion and the helicopter was ditched in the ocean in rough seas seven miles east of the airport.								
2/15/94	Bell 206B	NA	Dalywoi Bay, Northern Territory, Australia	Unscheduled passenger	0	0	6	Destroyed
The pilot initiated a descending right turn to land into the wind. But as he raised the collective at 150 feet, the helicopter continued to turn right. The tail-rotor pedals appeared to be ineffective, and the pilot was unable to regain control before the helicopter struck the sea. The pilot and passengers evacuated the helicopter and were found safe on a beach later.								
4/9/94	Bell 206L-3	NA	Point Nepean, Victoria, Australia	Personal	0	1	3	Destroyed
The helicopter was being used to drop marker buoys from 100 feet, with the pilot maintaining altitude by reference to the radio altimeter. The flight was being conducted at low speed over the sea at night for a SAR exercise with boats. As soon as the buoys were released, the pilot directed his attention to the global positioning system receiver. As the pilot increased throttle to climb, the helicopter skids contacted the water and the helicopter nosed over into the sea at about 15 knots. The four persons on board, none of whom was wearing a life vest, were rescued within 20 minutes.								
4/10/94	Bell 212	Hill Aviation (Hill Construction Corp.)	Mayaguez, Puerto Rico, U.S.	Aerial observation	0	1	2	Destroyed
The helicopter was destroyed when it struck the sea shortly after takeoff on a local observation flight.								
4/23/94*	Sikorsky S-76A Spirit II	Pelita Air Service	Alpha One Platform, Matak Island, Indonesia	Unscheduled passenger	NA	NA	NA	Destroyed
During approach to the helideck on an oil platform, the pilot allowed the helicopter's speed and rate of descent to increase excessively. Near the platform he attempted to reduce the rate of descent by flaring the helicopter and increasing power. The helicopter touched down hard on the helideck and bounced. The helicopter then pitched over the side of the platform, striking the edge of the deck with the rear fuselage and tail. The pilot regained control and restored level flight. Because of the damage, the pilot conducted a ditching in the sea beside the platform. He entered a hover just above the surface of the sea, inflated the emergency floats and settled onto the water. The passengers and crew were not injured. They evacuated and were rescued quickly. The helicopter remained afloat and later was recovered.								
6/22/94	Hughes 369HS	C&C Endeavors	Sarasota, Florida, U.S.	Aerial observation	0	1	2	Substantial
The helicopter struck water during an aerial photography flight.								
6/27/94	Bell 47G-3B-KH4	NA	Fraser Island, Queensland, Australia	Unscheduled passenger	0	0	4	Destroyed
The pilot reported that when the helicopter was on final approach to the beach, about 30 feet above the water, he felt a "stiffness" in the cyclic control as he attempted to move the control forward. Before he was able to assess the situation, the helicopter descended and struck the water. The helicopter remained upright and all the occupants were uninjured. They evacuated and made their way through the surf to the shore, 40 meters away. The helicopter subsequently rolled over because of wave action.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
6/30/94*	Sikorsky S-76B Spirit	United Technologies Corp.	Newport, Rhode Island, U.S.	Private	0	0	3	Substantial
About one minute after takeoff, while in level flight at 500 feet, the pilot heard an unusual hum or buzzing. Within a few seconds, this noise grew considerably louder and the helicopter began to vibrate severely. There was then a loud bang and the main transmission-chip caution light illuminated. The pilot flying called for the emergency floats to be deployed and conducted a ditching in the sea. The left engine, which was at flight idle, was shut down. The pilot began to water-taxi the helicopter toward safer waters but after about two minutes there was a loud rumble from the right engine and the crew shut down the right engine. Shortly after this, emergency services arrived, recovered the occupants and towed the helicopter. The helicopter was recovered.								
7/7/94*	Hughes 369HS	Hornet Corp.	Gilbert Islands	Aerial observation	0	0	2	Substantial
The helicopter was orbiting a fishing vessel when it pitched forward and began an uncommanded spin to the right. The pilot lowered the collective and initiated an autorotation to the water. He had difficulty maintaining control and the helicopter landed hard.								
7/9/94	Robinson R22	Palm Beach Helicopters	Sanford, Florida, U.S.	Aerial observation	0	0	2	Substantial
The helicopter was hovering at 15 feet when it began to spin to the right and descend. The pilot was unable to control the helicopter and it struck the water.								
7/13/94	Aerospatiale AS350B1	Sea Link	Galveston, Texas, U.S.	Unscheduled passenger	4	1	0	Destroyed
The pilot reported that the helicopter was being flown through 2,000 feet in a climb when several bumps were felt, and then control was lost. The helicopter struck the Gulf of Mexico about 11 miles offshore. The loss of control was caused by inadequate torquing by maintenance personnel of the left lateral servo, which allowed the servo to become disconnected from the controls.								
7/14/94*	Aerospatiale AS350D	Papillon Helicopters	Hanalei, Hawaii, U.S.	Sightseeing	3	0	4	Substantial
The helicopter was being flown parallel to the shoreline when engine failure occurred. The pilot conducted an autorotation to the water about 150 feet from a cliff shoreline. The helicopter was not equipped with emergency floats. All occupants were uninjured and exited the helicopter as it was sinking. Life vests were aboard the helicopter, but were not worn by the occupants. Three occupants climbed onto rocks and were rescued by helicopter. They said that they had not been briefed that life vests were aboard the helicopter. One of the other passengers was rescued by personnel of a boat, but the pilot and the two other passengers drowned.								
7/14/94*	Aerospatiale AS350B	Hawaii Helicopters	Kalaupapa, Hawaii, U.S.	Sightseeing	0	1	6	Substantial
While in a hover about 150 feet from shore, rotor rpm deteriorated and the pilot of the emergency-float-equipped helicopter conducted a ditching. The emergency floats were deployed. After the ditching, the seven occupants donned life vests and swam to the shore, where they spent the night before being located by airborne searchers.								
8/9/94	Bell 206B	Pilot	Chuit River, Alaska, U.S.	Business	0	0	5	Substantial
The pilot landed the helicopter on a gravel bar in a river that had high banks. He conducted a hover to reposition the helicopter on the gravel bar, and the helicopter began a right turn. The pilot applied left pedal and felt a response, but was unable to stop the turn. During the turn, the helicopter descended and struck the water. After everyone exited the helicopter, it rolled over and sank in the river.								
8/10/94	Eurocopter MBB BO-105C	United Arab Emirates Police	Arabian Gulf, off United Arab Emirates	NA	NA	NA	NA	Substantial
The helicopter was lost at sea. Details were not reported.								
9/1/94	Sikorsky S-64F	Erickson Air Crane	Libby, Montana, U.S.	NA	0	0	3	Destroyed
The helicopter was destroyed when it settled into Hanging Flower Lake while in a hover. Investigation determined that the flight crew had allowed the weight-and-balance limits to be exceeded.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants			Damage to Aircraft
					Fatal	Serious	Minor/None	
9/17/94	Bell 47G-5	Helguam	Pacific Ocean	Aerial observation	2	0	0	Substantial
The helicopter was on a fish-spotting mission when communications ceased with the ship base. Helicopters from other fishing vessels reported that the helicopter had struck the ocean 17 miles from the ship. When the ship arrived at the scene, the helicopter was found inverted in the water.								
9/23/94*	Hughes 369D	Caribbean Fishing Co.	Pacific Ocean	Aerial observation	0	2	0	Destroyed
While the pilot was conducting a fish-spotting flight at an altitude of about 480 feet above the Pacific Ocean, the cyclic control began to shake violently. The pilot regained control of the helicopter and conducted an autorotation. The helicopter was ditched on its emergency floats but later sank.								
10/11/94	Aerospatiale AS350B	NA	Whitianga, New Zealand	Passenger	2	1	3	Destroyed
The helicopter struck the sea near Needle Rock, 10 nautical miles northeast of Whitianga.								
11/8/94	Sikorsky S-76A	Mobil Business Resources	Cameron, Louisiana, U.S.	Executive/ Corporate	1	0	2	Destroyed
The only visual references available were several lights on land, about four miles ahead. The local altimeter setting was 30.02. The captain's altimeter was set at 30.05 and the copilot's altimeter was set at 30.12. These settings caused the captain's altimeter to indicate an altitude 30 feet higher, and the copilot's altimeter to indicate an altitude 100 feet higher, than the actual altitude. The copilot, the pilot flying, was transitioning to outside visual references while the captain, changed radio frequencies. Neither pilot was aware of a descent until impact with the water in a level attitude. The helicopter came to rest submerged and inverted, with all windows on the left side broken. The copilot exited through his broken window. The captain was not able to open his door and became disoriented. He exhausted the air in his emergency breathing system during the four minutes it took him to egress. The passenger drowned.								
1/3/95	Bell 47G	NA	Bunnell, Florida, U.S.	Personal	0	0	2	Substantial
The pilot failed to maintain altitude while descending over a lake and struck the water.								
1/10/95*	Aerospatiale AS332L Super Puma	Bristow Helicopters	North Sea, United Kingdom	Unscheduled passenger	0	0	18	Destroyed
Shortly after commencing the descent from 3,000 feet towards an oil-production platform in the North Sea, lightning struck the helicopter. The helicopter immediately began to vibrate severely and the first officer, who was the handling pilot, transmitted a distress call saying that he had a lightning strike and that was going to ditch. Although the severe vibration continued, the helicopter was controllable, so he leveled the helicopter at 1,300 feet. The captain reported that they were going to proceed to the platform that was the nearest available landing site. Then the helicopter yawed rapidly left, rolled and pitched down. The captain shut down both engines to control the yaw and the first officer conducted a gentle touchdown on the sea. The crew deployed the helicopter's emergency-float system and, despite a five-meter or six-meter swell and a wind gusting to 40 knots, the helicopter remained upright with its left side into the wind. The passengers and crew evacuated the helicopter into life rafts and were rescued.								
1/18/95	Hughes 369E	City of Tampa Police Dept.	Tampa, Florida, U.S.	Rescue	1	0	1	Destroyed
While searching for a drowning victim in the vicinity of a bridge, the helicopter was seen to enter a left descending turn that continued until impact with the water.								
1/19/95*	Aerospatiale AS332 Super Puma	Bristow Helicopters	North Sea	Unscheduled passenger	0	0	18	Substantial
The helicopter was struck by lightning as the pilot began a descent toward an oil platform. A severe vibration developed, followed by the separation of the tail-rotor gearbox from the helicopter. The pilot conducted a ditching in heavy seas. The helicopter remained upright, enabling the passengers and crew to board a heliraft, from which they were rescued.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
2/14/95	Bell 206L-4	Offshore Logistics	East Cameron, Louisiana, U.S.	Unscheduled passenger	5	0	0	Destroyed
The pilot transmitted a series of mayday calls indicating inadvertent flight into IMC. The helicopter, however, was not certificated for flight in IMC. When the helicopter did not arrive at the destination, a search was initiated, but SAR efforts were hampered for several days by weather conditions. Parts of the helicopter were found with indications that it had struck the water, and the bodies of four of the occupants were recovered.								
2/14/95	Hughes 269C	NA	Moorabbin Airport, Victoria, Australia	Personal	1	0	0	Destroyed
The helicopter pilot reported at Carrum, inbound to Moorabbin. Shortly afterward, the helicopter struck the sea south of Moorabbin. Investigators found that the main-rotor assembly and about half of the static mast had separated during flight.								
3/6/95*	Bell 206L LongRanger	Biscayne Helicopters	Biscayne Bay, Miami, Florida, U.S.	Survey/Patrol	0	0	3	Destroyed
About 45 minutes after takeoff, while maneuvering over Biscayne Bay, the pilot heard three loud thumps and felt a loss of engine power. The pilot subsequently conducted a ditching.								
3/20/95	Bell 206B	Western Pacific Fisheries	Pacific Ocean	Aerial observation	0	1	1	Destroyed
The pilot said that the helicopter had a tail-rotor problem during takeoff from a ship for a fish-spotting mission. The pilot reduced throttle and lowered the collective to control the yaw. The helicopter's main-rotor blade struck the ship. The helicopter landed hard on the water and sank.								
4/7/95*	Bell 214ST	NA	Ocean, 440 kilometers west-northwest of Darwin, Northern Territory, Australia	Unscheduled passenger	0	0	2	Substantial
The crew returned to the oil platform from which they had departed because of airframe vibration that had stopped. When the vibration began again, they lost tail-rotor control and were forced to ditch the helicopter short of their destination. The crew conducted an autorotational descent and ditching. The helicopter overturned on entry to the water and floated upside down. When the pilot surfaced, he observed that the tail boom was detached and was floating away from the main wreckage. The tail boom later sank.								
5/2/95	Bell 206L-3	Offshore Logistics	Venice, Louisiana, U.S.	Unscheduled passenger	1	2	0	Destroyed
During final approach to an offshore oil platform, the helicopter flew into exhaust gases from a flare boom. When the pilot attempted to add power to stop the descent and transition the helicopter to a hover for landing, there was no engine response. The helicopter settled, collided with the edge of the platform and descended in an inverted attitude into the water. The pilot and front-seat passenger exited the helicopter unaided and were picked up by a boat. The rear-seat passenger did not exit the helicopter and drowned.								
5/3/95	Eurocopter AS350D	NA	Sea Bright, New Jersey, U.S.	Unscheduled passenger	0	0	2	Substantial
The helicopter struck the water because of fuel starvation and engine failure.								
5/8/95	Robinson R22 Beta	NA	Toano, Virginia, U.S.	Personal	1	0	1	Substantial
The pilot misjudged altitude and distance, which resulted in an undershoot of the landing area and striking water.								
5/15/95	Bell 206L LongRanger	Government of Canada Coast Guard	East Margaree, Nova Scotia, Canada	Survey/Patrol	1	3	0	Destroyed
During a fisheries patrol, the helicopter collided with a power line that crossed a river. Control was lost and the helicopter struck the frozen surface of the river.								
6/18/95	Bell 206B	NA	Grafton (Township), New South Wales, Australia	Personal	2	0	0	Destroyed
Witnesses reported that the helicopter was seen flying low near the accident site and shortly afterward, the sound of impact was heard. The helicopter knocked down three power lines and struck a river.								

Table 2

Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
6/28/95	Bell 205A-1	Northern Mountain Helicopters	Leaf Rapids, Manitoba, Canada	Public use	3	1	4	Destroyed
The helicopter was transporting a fire fighting crew. The pilot encountered significantly reduced visibility en route and turned the helicopter to the right to return for landing. The helicopter descended while in the turn, the main-rotor blades struck the water and the helicopter struck the river. The pilot and four of the passengers exited the helicopter and were rescued. Three passengers were incapacitated by head injuries and drowned.								
6/29/95*	Agusta Bell 206	Castle ACH	Alderney, Channel Islands, U.K.	NA	0	0	2	Destroyed
In cruise flight, a sudden severe disturbance in yaw control occurred, accompanied by abnormal noises from the engine and transmission and an engine-chip warning. The pilot transmitted a mayday call, and following engine failure, initiated an autorotation to the sea. The helicopter rolled left, filled with water and inverted. Although the engineer escaped quickly, the pilot initially had difficulty in evacuating from the cockpit. He was wearing a life vest fitted with a short-term air-supply system (STASS), providing as much as three minutes of breathable air, which was "extremely beneficial" in aiding his escape. A SAR helicopter arrived and both survivors were lifted aboard by winch within 30 minutes of the accident.								
7/9/95	Enstrom F-28A	NA	Philadelphia, Pennsylvania, U.S.	NA	0	0	3	Minor
The pilot maneuvered the helicopter for takeoff to the east over the Delaware River. As the helicopter entered effective translational lift, it began to descend, and main-rotor rpm decreased. The pilot increased throttle, but the rotor rpm did not increase in time. The skids contacted the water, resulting in the helicopter striking the water and sinking.								
7/17/95*	Bell 206B	Air Logistics	Gulf of Mexico	NA	0	0	1	Substantial
The helicopter was in level flight at an altitude of 500 feet to 700 feet when the pilot felt a high-frequency vibration in the tail-rotor antitorque pedals. Subsequently, a low pitch "hum" and a "shuddering vibration" were felt "followed by a loud bang from the rear of the helicopter." The helicopter began to rotate to the right, and the application of full left pedal had no effect in stopping the rotation. After several 360-degree turns, the pilot attempted unsuccessfully to streamline the helicopter. An autorotation was initiated, and the helicopter's rotation was reduced to a "slow right-motion spiral or flat spin." Near the end of the autorotation, the rate of rotation increased, and when the left emergency float contacted the water, the helicopter rolled inverted.								
8/17/95*	McDonnell Douglas 500	Starkist Foods Co.	Pacific Ocean	Aerial observation	0	0	2	Substantial
The helicopter was in a hover 10 feet over a floating log that the observer was going to mark with a buoy using a spear gun. The observer accidentally fired the spear gun into the main-rotor system. The pilot was able to maintain helicopter control and conducted a ditching in a rough sea. The aft extensions to the utility fixed floats broke during the landing and the helicopter rolled over and sank.								
9/10/95	Bell 206B	U.S. Dept. of the Interior	Glennallen, Alaska, U.S.	Public use	0	0	2	Destroyed
The helicopter pilot was attempting to rescue another pilot whose Cessna 180A had become inverted on a lake. The Cessna pilot had been sitting on the inverted floats of the airplane for five hours and was showing signs of severe hypothermia and shock. As the helicopter was hovered next to the airplane, the helicopter passenger partially stepped into an external-load basket and began to assist the stranded pilot into the helicopter. The helicopter began to roll to the right, and the main-rotor blades struck the lake surface. The helicopter then struck the lake and sank. The pilot of a third helicopter observed the accident and landed on the lake to rescue the others.								
9/11/95	Agusta A109A II	Hospital Air Transport	Winslow, Washington, U.S.	Emergency medical service	3	0	0	Destroyed
The helicopter was flying at night to transport a woman on an island, who was in labor, to a hospital. Witnesses reported that the helicopter was flying at low altitude over the ground and then over water toward the island. The helicopter struck the water and sank. Water condition at the time of the accident was described as calm or glassy.								
9/23/95	Eurocopter AS350BA	Manufacturer	Crater Lake, Oregon, U.S.	Business	2	0	0	Destroyed
A helicopter manufacturer employed the pilot as a demonstration pilot. The pilot and a passenger were flying to a business-aviation conference. Along the route, numerous witnesses observed the pilot performing low-altitude maneuvers over a lake in a national park. Witnesses observed the helicopter descend gradually in a shallow glide path at cruising speed until it struck the lake. The helicopter was being flown toward the sun and over glassy water at the time of impact.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
11/2/95*	B47G-4A	Z Fishing Co.	Pacific Ocean	Aerial observation	0	0	2	Destroyed
Following a hydraulic failure, the pilot planned to ditch the utility fixed-float-equipped helicopter in the water next to the ship from which it had departed. He believed that the helicopter could not be landed safely on the pitching-and-rolling ship deck with no hydraulic assist on the controls. While the helicopter was hovered just above the water, the passenger (a fish spotter) unexpectedly jumped out of the helicopter. This resulted in a sudden imbalance, and the pilot lost control of the helicopter. The helicopter rolled over, struck the water and sank.								
12/17/95	Mil Mi-8	Petrozavodsk Flight Unit	Lake Ladoga, Helule, Russia	Miscellaneous	2	0	1	Destroyed
The helicopter pilot encountered poor weather with visibility down to 200 meters. The pilot turned back but while in the turn, at low level and with a crosswind, control was lost. The helicopter struck the ice-covered surface of Lake Ladoga about 100 meters from the shore and sank.								
12/28/95*	Bell 412	Forestry Aviation Office (Korea)	Korean Republic	Fire suppression	0	2	2	Substantial
The helicopter was ditched while returning to its base.								
1/18/96*	Aerospatiale AS332L Super Puma	Helikopter Service	North Sea, off Norway	Unscheduled passenger	0	0	18	Destroyed
In normal cruise flight at 2,000 feet, about 26 minutes after takeoff, the helicopter suddenly developed severe vibration. The crew immediately conducted a ditching on the sea and declared mayday. The helicopter was turned into the wind and, during the descent, the emergency floats were armed. The helicopter touched down on the sea and initially floated upright in a three-meter swell to four-meter swell. Despite attempts to evacuate into life rafts, the sea conditions made them unusable and the passengers and crew remained aboard the helicopter. All were rescued by helicopters about one hour after the ditching. After the rescue, the helicopter remained floating upright in gradually worsening conditions for some time. Fifteen hours after the ditching, with the swell now increased to seven meters to eight meters, the helicopter rolled over and continued to float inverted. Seventeen hours later, with the sea conditions even worse, the helicopter sank.								
1/29/96	Bell 47G-2A1	NA	Honiara, Solomon Islands	Aerial observation	1	0	0	Destroyed
The pilot lifted off the helicopter from a ship with the right-rear skid still attached with a tiedown rope. The helicopter rolled to the right and struck the water inverted, sinking immediately. The floats on the skids separated during the impact. The pilot and the helicopter were not recovered because of the depth of the water.								
2/10/96	Aerospatiale MBB BO-105	ERA Aviation	Gulf of Mexico	Unscheduled passenger	2	0	0	Destroyed
The helicopter did not arrive at its planned destination and was reported missing. A six-day search failed to locate the helicopter or its occupants. The aircraft was found 18 days after the accident when it became entangled in the net of a shrimp boat. Analysis of the deformation signatures and the dynamic components of the helicopter suggested that the helicopter had struck the water at a high rate of airspeed, near-level pitch attitude and slightly right-skid-down.								
3/6/96*	Robinson R22 Beta	NA	Georgina River, Queensland, Australia	Aerial observation	0	0	2	Destroyed
While inspecting flood fences, the pilot lost control and conducted a ditching in a river. The pilot later said that the main-rotor blades may have struck tree branches immediately prior to loss of control. Both the pilot and the passenger exited the helicopter while under water without injury.								
3/31/96	Robinson R44	NA	Muriwai Beach, New Zealand	NA	1	0	0	Destroyed
The helicopter pilot called ATC and reported low cloud, poor visibility and gale-force winds. When the helicopter failed to arrive at its destination, SAR efforts were initiated. The pilot's body and some helicopter wreckage were found the next morning. The helicopter had struck the sea, but no cause was established.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants Fatal	Serious	Minor/ None	Damage to Aircraft
4/21/96*	Enstrom F-28-A	NA	Lake Havasu City, Arizona, U.S.	Aerial observation	0	0	2	Substantial
During photography of boats, the helicopter began to descend from about 35 feet. Corrective action failed to increase main-rotor rpm or stop the descent. The pilot ditched the helicopter and both occupants emerged uninjured after the main rotor contacted the water.								
5/7/96*	Bell 206L-1	NA	Dauan Island, Queensland, Australia	Unscheduled passenger	2	0	3	Destroyed
During climbout, engine failure occurred. The pilot conducted an autorotation from about 300 feet. After forcefully striking the water, the helicopter sank and rolled inverted. The pilot and three of the four passengers escaped. The remaining passenger remained in the helicopter as it sank. One passenger did not remain afloat after exiting from the helicopter.								
6/3/96	Robinson R22 Mariner	Bering Sea Reindeer Products	Mekoryuk, Alaska, U.S.	Business	1	0	0	Destroyed
The pilot had departed to pick up a company worker about 35 miles south of the departure point on a remote island. The wreckage of the helicopter was found the following day, partially submerged and floating in a small lake.								
6/19/96*	Hughes 269C	NA	Eldon, Washington, U.S.	Personal	1	1	0	Destroyed
Fatigue failure of the connecting-rod cap resulted in engine failure and ditching of the helicopter at sea. The pilot and passenger exited the helicopter and the passenger was able to swim to shore with serious injuries. The pilot, who was observed swimming toward the shoreline by the passenger, was not recovered and was presumed to have drowned.								
6/21/96	Eurocopter MBB BO-105	Air Logistics	Sabine Pass, Texas, U.S.	Unscheduled passenger	4	0	0	Destroyed
The helicopter was destroyed after striking water in the Gulf of Mexico, while en route to an oil platform. The last known radio transmission from the pilot came when the helicopter was 38 miles from the destination.								
8/14/96*	Robinson R22	NA	Galway, Ireland	Personal	0	0	2	Substantial
Abrupt left yaw movements occurred at 1,500 feet after takeoff and again at 1,000 feet after carburetor heat was applied. The pilot conducted an autorotation and ditching in the sea.								
8/15/96	Mil Mi-8P	Hummingbird Helicopters	Male, Maldives	Unscheduled passenger	0	0	24	Destroyed
During takeoff and climb to about 160 feet, hydraulic pressure failed. Control was lost and the helicopter descended into the shallow waters of a lagoon next to the airport. The helicopter struck the water on its right side and was substantially damaged.								
8/17/96*	Aerospatiale SA330J Puma	Pelita Air Service	Indonesia	Unscheduled passenger	0	0	15	Minor
About 20 minutes after departure, the pilot reported technical problems and said that he was ditching. Three life rafts containing 15 passengers and crew were located about 17 nautical miles from land about an hour later. All occupants were rescued without injury. The helicopter continued to float upright and was recovered with only minor damage.								
9/13/96*	Bell 206L-1/C-30P	Mobil Business Resources	Gulf of Mexico	Unscheduled passenger	0	0	6	Substantial
En route to an oil platform shortly after takeoff, the helicopter began making continuous, chattering sounds and vibrated violently. As the pilot was preparing for ditching in a canal, the vibration ceased but the helicopter began turning to the right. The pilot initiated an autorotation and deployed the emergency floats. The helicopter touched down on the water in a level attitude and came to rest on its side.								
9/20/96*	Sikorsky S-61N	Aeroleo Taxi Aereo	Brazil	Unscheduled passenger	2	0	16	Destroyed
Near the end of a flight, as the helicopter descended through about 500 feet on approach to an offshore drilling ship, a loud bang was heard and a puff of white smoke was seen from the top of the helicopter. A severe vibration began and the helicopter pitched nose-up, yawed and rolled. The pilot attempted to ditch the helicopter but, without full control, the helicopter forcefully struck the water, rolled over and sank.								
11/6/96*	Bell 206B-3 JetRanger	Serbian Police	Belgrade, Yugoslavia	Survey/Patrol	3	0	1	Destroyed
While flying low over the River Danube with a film crew on board, the helicopter's engine failed. The helicopter was ditched in the water about 100 meters from the river bank and sank.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
3/11/97*	Hughes 369HS	Caribbean Fishing Company	Pago Pago, American Samoa	Survey/Patrol	0	0	2	Destroyed
The helicopter was being used for fish spotting from a ship. As the helicopter approached the ship, it lost engine power and was ditched.								
4/8/97*	Bell 206L-1 LongRanger	Air Logistics	Louisiana, U.S.	Unscheduled passenger	0	0	2	Destroyed
During takeoff from an offshore oil platform, the helicopter began to spin. The pilot ditched the helicopter.								
4/15/97	Eurocopter MBB-BK117-B2	Colgate-Palmolive Co.	New York, New York, U.S.	Executive/ Corporate	1	2	1	Destroyed
After takeoff, at an altitude of 30 feet, the helicopter rotated to the right several times, descended, struck the heliport pier and struck the East River, where it sank. The pilots exited the helicopter under water without assistance and were pulled from the water. Divers entered the water to search for the passengers. The fuselage had rolled upside down, and the passengers were found unconscious and released from their restraints inside the cabin, and were brought to the surface.								
6/1/97	Bell 206B	NA	Intracoastal City, Louisiana, U.S.	Positioning	0	0	1	Substantial
The Bell 206B collided with a Bell 206L-1 during flight. The Bell 206B pilot said that the helicopter descended and was "shaking violently." The helicopter touched down in the water, rolled over and sank. The pilot exited and swam to the surface, where he was rescued by a man in a boat. (The pilot of the other helicopter was killed, and the helicopter struck terrain.)								
6/20/97	Hughes 369HS	Hansen Helicopters	Pacific Ocean	Aerial observation	1	1	0	Destroyed
The pilot was spotting tuna and was about a 10-minute flight from the ship from which he was based. The cyclic moved to a full-left position, and the pilot tried to re-engage the cyclic trim motor but could not. He was unable to return the cyclic to neutral position. The pilot flew the helicopter back to the ship but lost control because he could not hold the cyclic with one hand. The helicopter struck an antenna, rolled to the left and struck the water in an inverted attitude.								
8/15/97	Bell UH-1H	Nevada Division of Forestry	Tahoe City, California, U.S.	Public use	0	0	7	Substantial
The helicopter was transporting firefighting personnel to the vicinity of a small lake. After arriving at the lake and lifting off again, the pilot had insufficient blade pitch and power to climb above trees and was forced to reverse direction. In the middle of the turn, the helicopter began descending toward the water, then settled into the lake with about 10 knots of forward speed. While the pilot was attempting to take off again, the helicopter rolled to the right and sank inverted. The investigation determined that the helicopter had been overloaded for the density altitude.								
9/17/97*	Hughes 269A	Pasco County	Tarpon Springs, Florida, U.S.	Public use	0	0	1	Substantial
The engine failed and the helicopter, which was engaged in mosquito-control work, was ditched.								
9/18/97*	Bell 407	Petroleum Helicopters Inc.	Gulf of Mexico	Unscheduled passenger	0	0	5	Substantial
The helicopter was in 130-knot cruise flight over open ocean at about 800 feet when a tail-rotor-blade strike severed the aft part of the tail boom. The pilot reduced throttle and began an autorotation. The helicopter struck the water in a level attitude with slight forward speed. The helicopter stayed afloat on its emergency floats. After about one hour, a rescue boat arrived and the pilot and passengers were transported to the nearest offshore oil platform. The helicopter was kept afloat by a recovery crew and transported by barge to Lafayette, Louisiana, U.S.								
12/20/97	Sikorsky S-76B	KLM ERA Helicopters	North Sea	Unscheduled passenger	1	0	7	Substantial
The helicopter was being used for shuttle flights among oil-drilling rigs and production platforms. One approach to a platform in dark-night conditions ended in a go-around, and a second approach was begun. After a large power reduction, the helicopter's forward speed decreased almost to zero knots and the helicopter entered a steep descent toward the sea. The crew recognized too late the high rate of descent and their corrective actions failed to stop the helicopter from striking the water. The crew and passengers evacuated the helicopter and after about one hour in the water, they were taken aboard a supply vessel. One passenger died after rescue.								

Table 2

Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/24/98	Hughes 369D	Big Eye Helicopters	Pacific Ocean	Aerial observation	1	0	1	Destroyed
The pilot and observer left the ship on an aerial observation flight to herd fish. During climb to about 400 feet to spot fish, the pilot turned the helicopter downwind and descended into the prevailing 15-knot tailwind. Neither the descent nor the turn were stopped before the helicopter struck the water.								
4/10/98	Bell 206B-3	NA	Dampier, Western Australia, Australia	Unscheduled passenger	0	0	1	Destroyed
After delivering a ship's pilot to a vessel, the pilot was returning to Dampier when he was distracted by a mechanical problem involving the pedals. He was unaware that the helicopter was descending until it struck the water. The helicopter sank and the pilot was rescued.								
7/10/98*	Agusta A109A II	Monacair	Villefranche sur Mer, France	Unscheduled passenger	0	0	6	Destroyed
About four minutes after takeoff from Nice, France, while flying at 120 knots, the low-fuel warning light for the helicopter's right fuel tank illuminated. The pilot had begun to respond to this warning when the engine-failure warning light for the right engine illuminated. Subsequent events were unclear but the pilot ditched the helicopter in the sea. The pilot and passengers escaped without injury, but the helicopter was damaged by saltwater immersion.								
10/5/98*	Bell 407 and Aerospatiale AS355-F1	Petroleum Helicopters Inc. and Tex-Air Helicopters	Gulf of Mexico	Positioning	1	0	1	Destroyed
The Bell 407 and the Aerospatiale AS355-F1 collided while both helicopters were in cruise flight at 1,000 feet over the Gulf of Mexico. The pilot of the Bell 407 initiated an autorotation to the water and was rescued. The pilot of the Aerospatiale AS355 was killed during the collision and water impact, and the helicopter sank.								
10/26/98	Bell 47G-3B1	NA	Swim Creek, Northern Territory, Australia	Aerial work	0	0	2	Substantial
The pilot reported that he maneuvered the helicopter to a high hover during a sling-load operation. As he initiated forward flight, the helicopter pitched rapidly nose down. The pilot was unable to regain control and the helicopter struck water in a swamp. The investigation revealed that the pilot had not lifted the sling load clear of the swamp before moving the helicopter forward.								
12/3/98*	Eurocopter EC-135-P1	Aerial Films	Newark, New Jersey, U.S.	Aerial observation	0	0	2	Destroyed
The pilot flew the helicopter below and behind the path of an airliner, and encountered wake turbulence. He inadvertently rolled the throttles to manual mode and could not restabilize the engines or main-rotor rpm. The pilot declared an emergency, reported a double power failure and ditched the helicopter in a river.								
3/12/99*	Bell 206L-3	NA	Cairns, Queensland, Australia	Unscheduled passenger	1	1	5	Substantial
The helicopter entered an area of rain on an overwater flight. The pilot attempted to maintain visual contact with the water by flying slowly at a lower altitude, but the weather deteriorated and he lost all outside visual references. The pilot activated the skid-mounted floats, lowered the collective control and allowed the helicopter to contact the water. The helicopter capsized immediately. Emergency services responded when ATC radio contact with the pilot ceased, and the helicopter was found with the survivors clinging to the wreckage.								
3/17/99	Eurocopter AS 350-B2	Petroleum Helicopters Inc.	Gulf of Mexico	Unscheduled passenger	2	2	0	Destroyed
When the pilot conducted the lift off from the oil platform, he believed that "something wasn't normal." The helicopter nose pitched up violently and the helicopter bounced from side to side on the platform. The pilot realized that he did not have enough space to land, and raised the collective in an attempt to move the helicopter away from the platform. The helicopter rolled inverted and descended into the water on the north side of the platform.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
4/5/99*	Bell 206B JetRanger	P & I Data Services	Lyme Bay, Dorset, England	Private	0	0	2	Destroyed
Flying at 500 feet, the helicopter encountered deteriorating weather. After the pilot lost control and regained control several times, the helicopter descended and struck the sea in a tail-low attitude. After impact, the helicopter pitched forward and rolled over. The pilot and passenger, who were wearing light clothing and did not have life vests, escaped from the cabin and climbed on top of the inverted helicopter. The helicopter continued to float, and a fishing boat rescued the pilot and passenger about one hour and 20 minutes after the ditching.								
5/28/99	Eurocopter MBB BO-105LS A-3	Southern California Edison	Huntington Beach, California, U.S.	Executive/Corporate	3	0	0	Destroyed
The helicopter was to transport two company employees to Santa Catalina Island, 22 miles offshore. The pilot was not instrument rated. Weather along the coast was overcast skies with cloud bases from 700 feet to 1,100 feet, tops between 1,900 feet and 2,200 feet, and visibilities generally in the four-statute-mile to five-statute-mile range. While flying over water en route to the island, the pilot radioed another company pilot and said that he would be feet wet in two minutes. There were no further communications, and the U.S. Coast Guard found debris identified as being from the helicopter about 3.5 miles from the mainland, along with a fuel slick.								
6/7/99	Hughes 369HS	Hoffman Helicopters	Pacific Ocean	Aerial observation	0	0	2	Destroyed
At 600 feet above the water, a violent vibration of the helicopter was felt. The pilot decreased throttle and airspeed to stabilize the helicopter, but control became increasingly difficult. About 250 feet above the water, an extreme forward CG (center of gravity) shift occurred and the pilot heard a whirring or spinning noise. The helicopter spiraled down toward the water, spinning to the right with an estimated 55-degree to 60-degree nose-down attitude. After the helicopter struck the water, it rolled inverted. The pilot released his seat belt and floated to the surface wearing his life vest. The passenger, also equipped with a life vest, also reached the surface. Both occupants waited in the helicopter's life raft until rescue about 40 minutes later.								
6/9/99*	Bell 412	Petroleum Helicopters Inc.	Gulf of Mexico	Positioning	0	0	2	Destroyed
A tail-rotor blade separated from the helicopter in flight as a result of fatigue cracking, and then the tail-rotor system separated. The pilot flying said that the helicopter "immediately and violently tucked down and left, then rolled over inverted and [was] spinning to the right." At about 1,000 feet, the pilot righted the helicopter. The pilot not flying inflated the emergency floats and the pilot flying conducted a ditching. The helicopter came to rest upright in the water, and the two pilots exited through the right-side cargo window and entered a life raft. Ocean waves caused the helicopter to roll to the left inverted and sink.								
7/16/99*	Hiller UH12-C	Commercial pilot	Venice, Florida, U.S.	Aerial observation	0	0	2	Substantial
The engine failed while the helicopter was being flown 100 feet above the ocean at 50 knots. The pilot conducted an autorotation to the water, and the pilot and passenger immediately were rescued by a nearby boat. The passenger, who was wearing a seat belt loosely while operating a video camera and carrying other equipment, inadvertently had shut off the fuel supply.								
9/1/99	Hughes 369HS	Hoffman Helicopters	Pohnpei, Federal States of Micronesia	Aerial observation	1	0	0	Destroyed
About 90 minutes after takeoff from a fishing vessel to conduct tuna-spotting operations, the helicopter struck the ocean under unknown circumstances. The ship's crewmembers located the helicopter's floats, pieces of the airframe and the engine. There were no distress calls from the pilot.								
10/15/99	Kawasaki KH-4	NA	Joondalup Lake, Western Australia, Australia	Aerial application	0	0	2	Destroyed
The helicopter was being flown at a low altitude, spraying for mosquitoes in a lake. During a turn, before beginning a spray run, the helicopter descended into the water.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
12/5/99*	Bell 206L-1	Evergreen Helicopters International	Gulf of Mexico	NA	0	1	0	Destroyed
The helicopter was about halfway to its intended destination in the Gulf of Mexico, about 150 feet above the water, when the engine failed. The pilot initiated an autorotation and deployed the emergency floats. The helicopter was landed hard during the ditching, but remained upright and afloat. The pilot retrieved the life raft from the cabin and inflated it. After the pilot got into the life raft, waves estimated at six feet to eight feet overturned the helicopter, and it sank in 160 feet of water.								
12/30/99	Hughes 369HS	Hansen Helicopters	Pacific Ocean	Aerial observation	0	0	1	Substantial
The pilot conducted a takeoff from a fishing vessel with a tail wind, and the helicopter settled into the water in a tail-low attitude. The helicopter was equipped with utility fixed floats and remained upright.								
2/14/00*	Hughes 369HS	O'Hara Helicopters	Pacific Ocean	Aerial application	0	0	2	Destroyed
The pilot conducted a precautionary landing in the ocean about 500 miles north of Papua New Guinea, after he felt a metal-on-metal grinding sensation from the cyclic control and heard a loud bang. Following the ditching, helicopter was struck by an ocean swell, rolled over and sank. The pilot and observer exited the helicopter and were rescued by the fishing vessel from which the flight had originated.								
2/18/00	Hughes 500C	Heli Guam	Pohnpei, Federal Republic of Micronesia	Aerial observation	0	0	2	Destroyed
The pilot and the observer were planning to conduct tuna-spotting operations. After takeoff, at about 100 feet to 150 feet, the helicopter began an uncommanded right turn, followed by an uncontrollable right spin. The helicopter spun several times, then struck the water. The two right-landing-gear legs collapsed and the helicopter rolled onto its right side and sank. The pilot and observer both exited without difficulty and were rescued by the ship's crewmembers.								
2/21/00	Hughes 369E	NA	Mackay, Queensland, Australia	Unscheduled passenger	0	0	1	Substantial
Because of high humidity, the helicopter's windscreen became fogged, impairing the pilot's forward vision. The pilot turned on the heater/demister, which immediately increased the fogging and further reduced his vision. The pilot turned back to the flight's point of origin, reduced speed and descended clear of the low clouds in the area. During transition to a hover, the pilot leaned forward and began wiping the windscreen with his hand. While he was wiping the windscreen, the helicopter struck the water. The pilot shut down the engine and activated the helicopter's emergency floats.								
3/20/00	Bell 206B-3	Horizon Helicopters	Gulf of Mexico	Unscheduled passenger	0	0	3	NA
While maneuvering to land on an offshore oil platform, the pilot's low-airspeed turn resulted in loss of tail-rotor effectiveness, a spin to the right and loss of control. The helicopter descended and struck the water. The main rotor, transmission, tail rotor, tail-rotor gearbox and vertical fin separated from the helicopter on impact, and the helicopter rolled inverted.								
4/29/00*	Bell 206L-3	Chevron USA	Gulf of Mexico	Unscheduled passenger	0	0	2	Substantial
Tail-rotor control effectiveness failed while the pilot was approaching an offshore oil platform. The pilot conducted an autorotative landing on the water. According to witnesses, the helicopter began the autorotation and proceeded to rotate to the left and pitch nose-down. The helicopter entered a steep descent, and the pilot could not control the helicopter. Prior to striking the water, the helicopter entered level flight and the emergency floats were deployed. Upon impact with the water, the helicopter rolled right and came to rest inverted in the water.								
8/6/00*	Bell 206B-2	NA	Norman Reef, Queensland, Australia	Unscheduled passenger	0	0	5	Substantial
Following takeoff from a floating pontoon, at about 500 feet and with a forward airspeed of about 20 knots, the pilot lost directional control of the helicopter. He immediately deployed the emergency floats and conducted a ditching. The helicopter rolled inverted in the water.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/None	Damage to Aircraft
9/7/00*	Bell 206L-1	Horizon Helicopters	Gulf of Mexico	Positioning	0	1	0	Destroyed
After about two hours and 54 minutes of flight, the engines failed during approach to an offshore oil platform. The pilot initiated an autorotation and subsequently landed hard on a rough and choppy ocean surface. Fuel-consumption calculations provided by the operator showed that the helicopter could have been at or near fuel exhaustion at the time of the accident.								
10/28/00	Aerospatiale AS350BA	Tex-Air Helicopters	Gulf of Mexico	Positioning	1	0	0	Destroyed
The helicopter departed from a helipad located on an offshore oil platform, and was three minutes from landing at a refueling helipad on another platform, when the pilot transmitted two distress calls saying that the helicopter was "going down." There were no witnesses to the accident. Nine minutes after the distress calls were heard, the helicopter was found floating inverted in three-foot to four-foot seas. The helicopter sank but was later recovered.								
12/1/00*	Bell 206B	American Helicopters	Rockport, Texas, U.S.	NA	0	0	1	NA
As the helicopter was returning to an airport from an offshore oil platform, engine failure occurred. The pilot initiated an autorotation, inflated the floats and declared mayday. During the descent, the pilot had "full [aircraft] control to include tail-rotor authority." During the ditching, the tail-rotor blades entered the water and the tail-rotor drive shaft was twisted apart. The helicopter remained upright in the water, and the pilot exited after the main-rotor blades stopped. After the pilot moved away from the helicopter, it rolled over. The pilot crawled onto the helicopter and awaited rescue.								
12/10/00	Robinson R22	Volar Helicopters	Marathon, Florida, U.S.	Instructional	0	0	2	Destroyed
Without receiving a weather briefing, the flight instructor conducted the flight under VFR. IMC were encountered and the pilot landed on an island. The instructor then called an FAA Automated Flight Service Station and received a standard weather briefing. The briefer told the pilot that VFR flight was not recommended. The instructor began a second flight under VFR after he believed that weather had moved past his location, but again encountered IMC. While reversing course the instructor became spatially disoriented, and the helicopter descended and struck the Atlantic Ocean.								
12/26/00	Bell 206B	Tarlton Helicopters	Gulf of Mexico	Cargo	1	0	0	Destroyed
The helicopter was reported missing and presumed destroyed. Search efforts were hampered by weather, including eight-foot to 10-foot seas, wind from 25 knots to 44 knots, thunderstorms, rain, fog and limited visibility. The helicopter was equipped with utility fixed floats; other than the pilot's life vest, there was no overwater survival equipment aboard the helicopter. The pilot was presumed to be a fatality.								
1/5/01	Bell 206B JetRanger	Helixair	Lake Windermere, Cumbria, England	Ferry	0	0	1	Destroyed
The helicopter was being positioned to take its owner from his private residence by the shore of Lake Windermere. On arrival, the pilot commenced a descending left turn to approach the landing site from the west. While in this turn, the pilot encountered reduced visibility and lost all depth perception over the dark, still waters of the lake. As the pilot completed the turn at a point about 700 meters from the shore, the helicopter struck the surface of the lake. The helicopter began to sink but the pilot exited and swam to shore.								
1/7/01*	Bell 206L-1 LongRanger	Island Helicopters International	Virgin Gorda, British Virgin Islands	Unscheduled Passenger	0	0	7	Destroyed
The helicopter was being used for a sightseeing flight along the coast and was flying at about 300 feet offshore when the left fuel-boost pump warning light illuminated. The engine failed, and the pilot ditched in the surf close to the beach. Emergency floats were deployed and the helicopter touched down in a level attitude, then rolled over onto its right side.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
1/8/01*	Bell 206L-3 LongRanger	Rotorcraft Leasing Co.	Gulf of Mexico	Unscheduled passenger	0	0	3	Substantial
The pilot was conducting a short flight over the Gulf of Mexico. During departure, the pilot reported his fuel as 9/10th hours remaining. Sometime later, he reported that he had missed a platform by a couple of miles and would be critical on fuel. The helicopter continued toward the platform but, as it turned for the approach, the engine failed. The pilot transmitted a mayday call and deployed the helicopter's emergency floats. He subsequently conducted an autorotation to the water. The pilot and passengers exited the helicopter into a life raft and were later rescued without injury. About five minutes after touchdown, the helicopter rolled over and floated inverted. It was later recovered.								
3/21/01*	Bell 47G-2	Versatile Helicopters	Ardmore, Oklahoma, U.S.	Instructional	0	0	2	Substantial
During a night flight, the helicopter was in level flight about 1,400 feet over a lake as the student pilot began a turn to the left with a forward airspeed of about 45 knots to 50 knots. The flight instructor then assisted the student pilot on the controls with the coordinated turn, and noticed that the turn indicator showed that the helicopter was slipping. The instructor applied left pedal to correct the slip, and the airframe shuddered and began to yaw to the right. The airspeed began to decrease and the helicopter began to "spin to the right rapidly." The instructor then applied full left pedal and the helicopter continued to spin to the right. After lowering the collective and reducing the throttle, the helicopter stopped spinning. The instructor then lowered the nose and maneuvered the helicopter toward shallow water near the heavily vegetated shoreline for the landing. The helicopter came to rest on its left side in the shallow water.								
3/30/01	Hughes 369HS	NA	Pohnpei, Micronesia	Personal	0	0	1	Substantial
During a flight test after maintenance, cables being used by the engineer became jammed in the flight controls. The engineer removed the shoulder part of his harness to enable him to release the cables. The pilot momentarily lost control and, as control was regained, the helicopter struck the water. The pilot escaped uninjured and made several attempts to rescue the engineer, who had sustained head injuries and was unconscious. The engineer was presumed to have drowned while the pilot was trying to release him.								
4/21/01	Robinson R44	NA	Airlie Beach, Queensland, Australia	Personal	0	0	2	Substantial
The pilot was conducting a local flight, intending to find friends aboard a yacht. The pilot reported that, after finding what he and his passenger believed was the yacht, he descended to about 500 feet and reduced airspeed to between 45 knots and 50 knots to allow the passenger to identify the crew of the yacht. While circling the yacht, the pilot noticed that airspeed had reduced to between 25 knots and 30 knots and the helicopter was descending. The pilot increased the throttle but there was no response and he believed that the engine had failed. The low-rotor-speed warning sounded and the helicopter yawed right. Despite applying full-left pedal, the pilot was unable to prevent the helicopter from rotating right, and the helicopter forcefully struck the water.								
4/27/01	Bell 407	NA	Swain Reefs, Queensland, Australia	Search and rescue	0	0	2	Substantial
The crew was assigned to drop a life raft to the occupants of a sinking yacht at the southern end of the Great Barrier Reef. On the drop run, the pilot intended to overfly the yacht at about 20 knots and 50 feet, using the radio altimeter. As the helicopter approached the yacht at 40 knots, and shortly after a crewmember called 50 feet, the helicopter struck the water.								
5/4/01*	Bell 407	Air Logistics	Gulf of Mexico	Unscheduled passenger	0	0	2	Substantial
While in cruise flight, the pilot reported a slight vibration. After a few minutes, the vibration became more pronounced, and was accompanied by a noise. During an attempted precautionary landing at an offshore oil platform, the vibration and noise level increased again, and the engine failed. The pilot then initiated an autorotation to the water, deployed the emergency floats and landed safely. While being towed in the water, the helicopter rolled inverted.								
8/5/01	Bell 206L-1	Offshore Logistics	Gulf of Mexico	Unscheduled passenger	0	3	0	Substantial
The pilot had initiated an approach to an offshore oil platform into the wind when the helicopter made an "uncontrolled, uninduced yaw to the right." He turned to the right to stop the yaw and to maneuver away from the platform. As he increased throttle, the helicopter "went into an uncontrollable and rapid spin to the right." The pilot then closed the throttle, which "slowed but did not stop the spin." As the pilot raised the collective, the helicopter struck the water, rolled over and sank.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/ None	Damage to Aircraft
8/24/01*	Bell 206L-3	Offshore Logistics	Gulf of Mexico	Unscheduled passenger	0	2	0	Destroyed
The helicopter was in cruise flight over the Gulf of Mexico when it began to vibrate and shudder. The pilot lowered the collective to initiate an autorotation and the engine failed. During the pilot's autorotation, the helicopter's emergency floats were deployed. The pilot attempted to reduce the rate of descent but the controls became stiff and the helicopter forcefully struck the water.								
9/5/01*	Hughes 369HS	NA	Pacific Ocean, 741 kilometers southeast of Tarawa	NA	0	0	2	Destroyed
The pilot reported that, while the helicopter was in cruise flight, he suddenly became aware of an unusual vibration in the airframe. He immediately began a descent and touched down on floats on the ocean surface. A swell overturned the helicopter before the two occupants could evacuate from the cabin. They egressed under water and held on to the inverted helicopter until the floats began to fill with water. The helicopter sank and the two occupants were rescued by personnel from their parent vessel soon afterward.								
9/26/01*	Bell 206L-1	Offshore Logistics	Gulf of Mexico	Unscheduled passenger	0	0	3	Substantial
The helicopter was on approach to an offshore oil platform, turning from base leg to final at 300 feet when the pilot heard the low-rotor-rpm audio warning, and then noticed that the "LOW-ROTOR-RPM" warning light was illuminated. He initiated an autorotation and observed that the main-rotor rpm needle had dropped to zero. The pilot said that as the helicopter was descending, he felt feedback in the flight controls and decided that a precautionary landing was necessary. The pilot landed the helicopter in the water and shut down the engine.								
9/27/01	Bell 206B-3 JetRanger	EAC Helicopters	Potato Lake, Minnesota, U.S.	Survey/Patrol	0	0	4	Destroyed
The helicopter was being used to take photographs in the vicinity of a lake. While the pilot was maneuvering, the helicopter struck the surface of the water.								
9/29/01*	Bell 206B-3 JetRanger	Divesa	Balfate, Honduras	Private	5	0	0	Destroyed
The helicopter was reported missing during a flight to an offshore island and was assumed to have been ditched.								
10/18/01	Bell 206L	Era Aviation	Anchorage, Alaska, U.S.	Unscheduled passenger	3	2	0	Substantial
Because of falling snow and low ceilings, the pilot, who did not hold an instrument rating, was intentionally flying very low over the surface of an open area of flat and glassy water in whiteout/grayout conditions. As he continued toward his destination, he continued descending to maintain visual reference with the water surface. The helicopter's skids contacted the water, and almost immediately, the tail rotor and then the fuselage struck the water.								
10/18/01*	Bell 206L-3	Air Logistics	Gulf of Mexico	Unscheduled passenger	0	3	2	NA
The helicopter was in cruise flight at 500 feet when the pilot heard a "thud," the helicopter yawed left. The engine failed, and the pilot initiated an autorotation to the water. The emergency floats were not deployed.								
1/8/02*	Bell 206L-3 LongRanger	Air Logistics	Houma, Louisiana, U.S.	Ferry	0	0	1	Major partial
In cruise flight at 1,200 feet, the helicopter suddenly yawed to the left and the audio warning for engine power and main-rotor rpm sounded. The pilot regained control and conducted an autorotation to the sea near an oil platform. The helicopter touched down hard, causing the right-front emergency float to detach, and rolled over. The pilot later reported that there was only a light swell and that he had had difficulty judging his height above the water.								
3/8/02	Aerospatiale AS355F1 TwinStar	SK Logistics	Savannah, Georgia, U.S.	Unscheduled passenger	1	0	0	Destroyed
The helicopter was destroyed when it struck the water and sank during approach to an offshore oil platform.								
3/21/02	Aerospatiale AS350B Ecureuil	Mountain Life Flight	Susanville, California, U.S.	Ferry	1	2	0	Destroyed
The helicopter was destroyed when it struck the surface of a lake while en route to its base. Just before the accident the pilot told the passengers, "Boy, it's disorienting when the lake is this smooth."								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Serious	Minor/None	Damage to Aircraft
3/23/02	Bell 206L-4 LongRanger	Petroleum Helicopters Inc.	Lafayette, Louisiana, U.S.	Ferry	1	0	0	Destroyed
The pilot lost control of the helicopter during liftoff and struck the sea about 100 feet below the platform.								
3/30/02*	Rotorway Exec 162F	NA	May River, 210 kilometers northeast of Broome, Western Australia, Australia	Personal	0	0	1	Substantial
During a short flight over the May River, the pilot overpitched the helicopter, causing engine failure. The pilot ditched in the river. The pilot exited the helicopter without injury and was rescued by the occupants of a nearby boat. The helicopter sank in about nine feet of water.								
4/14/02*	Hughes OH-6 (369)	City of Tampa Police Department	Tampa, Florida, U.S.	Private	0	1	0	Destroyed
During a routine police patrol, the tail-rotor effectiveness failed and the pilot conducted a ditching in Tampa Bay. The helicopter rolled over on touchdown.								
5/11/02	Aerospatiale SA316B Alouette III	Helicopter Services Organization	Kharq Island, Iran	Unscheduled passenger	4	1	0	Destroyed
Shortly after takeoff from an oil platform, while flying at about 300 feet, the pilot transmitted a mayday call and reported technical problems. According to press reports, he said that he was returning to the oil platform. Communication ceased and the helicopter was found to have struck the sea about four miles from the platform.								
5/24/02	Eurocopter MBB BO-105D	Bond Air Services	Orkney Islands, Great Britain	External load	1	0	0	Destroyed
The helicopter was being used to support construction at a lighthouse on a small tidal island and had made about seven trips to the mainland with sling loads of surplus building material and rubbish. The eighth load comprised scaffolding sections and stainless-steel cable. After the load was attached, the pilot climbed away. As the helicopter crossed the 45-meter cliffs at the edge of the island, the load appeared to become unstable and started to swing. The helicopter was seen to yaw to the left while banking to the right. Control was not regained and the helicopter struck the sea.								
6/25/02	Bell 206B JetRanger	Wisk-Air	Tilly Lake, Ontario, Canada	Personnel positioning	0	0	3	Major partial
The helicopter had been landed on a lake and was being air-taxied slowly toward shallower water so that the passengers could collect sediment samples. Waves began breaking over the left float. The pilot increased throttle to climb but as the helicopter lifted off, it began to spin rapidly to the right. Control was not regained. The helicopter's left float struck the water and it rolled inverted. The pilot and passengers escaped from the submerged cabin and were rescued about three hours later.								
6/26/02	Robinson R44	Quicksilver Air	Shageluk, Alaska, U.S.	Positioning	0	0	1	Substantial
The pilot was conducting a visual approach over water to a beach on the shore of a lake. About 200 feet above the water, the pilot shifted his attention inside the helicopter to check the carburetor heat. When he looked up, the helicopter was descending nose-down toward the water. During corrective actions, the tail rotor struck the water and then the fuselage struck the water. The helicopter sank in about nine feet of water.								
7/10/02	Sikorsky S-58ET	Midwest Truxton International	Brookville Lake, Indiana, U.S.	Ferry	1	2	0	Destroyed
While apparently maneuvering at a low altitude during a ferry flight from Indianapolis to a location in Ohio, the helicopter struck power lines and then struck a lake.								
7/16/02	Sikorsky S-76A Spirit	Bristow Helicopters	Cromer, Norfolk, England	Unscheduled passenger	11	0	0	Destroyed
As the helicopter was approaching a drilling rig in level flight at 320 feet and 100 knots, workers on the rig heard a loud bang and then saw the helicopter dive steeply into the sea. One witness saw what appeared to be the main rotor head with blades attached falling separately into the sea.								

Table 2
Helicopter Water-contact Accidents, 1980–Feb. 23, 2003 *(continued)*

Date: Month/Day/ Year	Aircraft	Operator	Location	Nature of Flight	Injury to Occupants: Fatal	Injury to Occupants: Serious	Injury to Occupants: Minor/ None	Damage to Aircraft
7/25/02*	Bell 206L-3 LongRanger	Air Logistics	In the Gulf of Mexico, off Franklin, Louisiana, U.S.	Unscheduled passenger	0	0	2	Destroyed
While in normal cruise flight, about 10 minutes after takeoff, the pilot heard a bang and the helicopter yawed. The pilot was unable to control the yaw and conducted a ditching. During the final stage of the autorotation, the pilot deployed the emergency floats. The helicopter rolled over and floated inverted.								
8/1/02*	Bell 206L-1 LongRanger	Go Helitrans (Go Helicopters)	Harlingen, Texas, U.S.	Unscheduled passenger	0	0	4	Major partial
While in cruise flight, the helicopter's engine failed. The pilot conducted an autorotation to the water but, on touchdown, the main rotor struck the tail boom. The crew of a boat rescued the pilot and passengers. The helicopter was recovered onto a barge and transported to shore.								
9/7/02	Robinson R22B	Quicksilver Air	Jamestown, Kentucky, U.S.	Aerial observation	0	0	2	Substantial
The helicopter was being used by a photographer to take pictures of boats during a race conducted on a lake. The helicopter was about 200 feet above the lake when the pilot spotted a boat that had not been photographed. The pilot entered a left turn and began a descent to keep pace with the boat. The pilot later said, "I noticed an abnormal sink rate and put in aft cyclic. The rate did not arrest, so I brought in more aft cyclic along with collective power. As I came into about 50 [feet] to 100 feet AGL, I heard a low-rpm warning horn. I continued to slow the [helicopter], while rolling on throttle. The descent rate brought the [helicopter] in contact with the water." The helicopter sank and came to rest at a depth of about 115 feet. It was not recovered.								
9/15/02*	Hughes OH-6A (369A)	Killian Cable Contracting Co.	Rocky Gorge Reservoir, Maryland, U.S.	Private	0	0	2	Destroyed
The pilot experienced a sudden shuddering of the helicopter followed by a loss of directional control. The helicopter began an uncommanded left turn and would not respond to the anti-torque pedals. The pilot was able to regain control by using collective but, as the helicopter neared its destination, warning indicators illuminated in the cockpit and the engine began to spool down. The pilot turned the helicopter through 180 degrees and began an autorotation toward the surface of a reservoir. As the helicopter descended to the water, the engine power was restored and the helicopter began to rotate to the left. The pilot was completed the ditching and the helicopter immediately rolled to the left. The pilot and passenger were able to escape before it sank.								
10/31/02	Agusta A109C	Lionel Poilane	Cancale, France	Private	1	0	0	Destroyed
The helicopter disappeared while en route to an island off the Brittany coast, and is believed to have crashed in the sea near Cancale.								
10/31/02	Hughes OH-6A (369A)	Lancaster Helicopters	Susquehanna River, Pennsylvania, U.S.	Crew training	0	2	1	Destroyed
During a crew training flight, practicing maneuvers in a confined area over a river, the flight instructor, who was handling the controls, misjudged its height above the water. One of the helicopter's skids struck the water and then the fuselage struck the water.								
11/8/02	Aerospatiale SA341G Gazelle	William Smitters	East Hampton, New York, U.S.	Private	1	0	0	Destroyed
The helicopter was destroyed when it struck the sea off East Hampton while en route from Long Island MacArthur Airport, Islip, to East Hampton.								
1/27/03*	Robinson R44	NA	Antarctica	Private	0	0	2	Destroyed
The helicopter was ditched in the sea off Antarctica following an engine failure. Both crewmembers evacuated into a life raft and were rescued.								
2/23/03	Aerospatiale SA350 Ecureuil	PLM Dollar Group	Auchtertyre, Scotland	Fire fighting	0	0	1	Substantial
The helicopter was being used in fighting a forest fire. The tail rotor struck the surface of a loch (lake) while collecting water.								

References

References

PUBLICATIONS
RECEIVED AT FSF JERRY LEDERER
AVIATION SAFETY LIBRARY

They're Slippery When Wet, Better Read Them Now

Here are many of the books, manuals, handbooks, reports, videotapes and standards we encountered in preparing this issue. Go ahead, immerse yourself in reading.

— FSF LIBRARY STAFF

A Further In-water Performance Assessment of Lifejacket and Immersion Suit Combinations. Light, I.M.; Slater, P. Health and Safety Executive (HSE), Offshore Technology Information (OTI). OTI report 91 550. 1991. 65 pp. Figures, tables, appendixes, references. Available on the Internet at <www.hse.gov.uk/research/offshore.htm> or from HSE.[6]

This report describes a series of tests to study self-righting ability and airway protection when immersion suits and life vests are used in combination, the goal being to evaluate performance of immersion suit and life vest combinations available to crewmembers. A mannikin was used to simulate a relaxed or unconscious person in the sea.

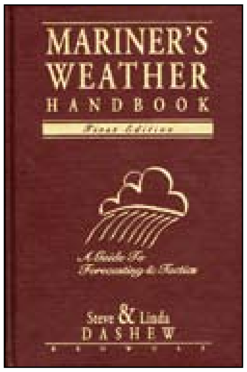
Comparative data, representing combinations tested in calm waters and disturbed waters in a wave tank, showed a decrease in airway protection as rough water was introduced into the tests. The project identified design features considered important to achieving effective protection for survivors and illustrated the need to define acceptable sea conditions for which equipment should be designed.

A Literature Survey of Airborne Vehicles Impacting With Water and Soil; Head Injury Criteria and Severity Index Development of Computer Program KRASH. Wittlin, G.; Gamon, M.A. U.S. Federal Aviation Administration (FAA), Technical Center. Report DOT/FAA/CT-90/24. July 1992. 72 pp. Figures, tables, appendixes. Available from NTIS.[11]

When this study was conducted, analyses of airplane accident impacts were based on the assumption that impact surfaces were rigid and unyielding. The report said, "The difficulty in modeling water and soil impacts relates to the ability to accurately depict the force distribution on the fuselage as the vehicle penetrates the terrain." Crashworthiness simulation software, such as KRASH, which was developed by FAA and the U.S. National Aeronautics and Space Administration, uses coded data to provide airframe response to dynamic accident impact. To determine possible code modifications for structure/terrain interaction and head/structure interaction, 28 water-impact-related reports and 40 soil-impact-related reports were identified and reviewed. Their abstracts and summaries are included in the report. Head injury criteria and severity of injury also are addressed.

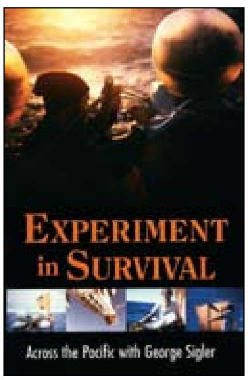
A Practical Guide to Lifeboat Survival. The Center for the Study and Practice of Survival. Jeffs, David S.; Keating, David, translators. Annapolis, Maryland, U.S.: Naval Institute Press, 1997. 160 pp. Figures, drawings, charts, plotting tool, index. Available in French and English.

This is an English translation of *Manuel Pratique de Survie en Mer* by Centre d'Etude et de Pratique de la Survie (CEPS), first published in 1990 by



Editions Charles-Lavauzelle in Panazol, France. The original guide was developed by survival instructors and other professionals, endorsed by the French Maritime Administration and required to be aboard all French lifeboats.

Widely divergent needs and contingencies are addressed, from 20 people in a lifeboat in the North Sea to a lone survivor in a life raft in tropical seas. Guidelines cover issues that survivors may face — leadership; morale; organization of activities; protection from environmental elements; first aid and hygiene; navigation; weather forecasting; fatigue, rest, relaxation and sleep; food and drink; marine life; equipment use, maintenance and repair; and prayer.



The book's format is especially useful. Each chapter begins by highlighting quick-reference information and continues with detailed explanations and illustrations. For example, the chapter about rescues emphasizes the point that the rescue itself can be the most dangerous part of abandonment at sea and lists favorable and unfavorable conditions for rescue before explaining the numerous aspects of rescue.

A Safety Study of Survivability in Seaplane Accidents. Transportation Safety Board of Canada (TSB). Report SA9401. 1994. 12 pp. Tables, appendixes, references. Available on the Internet at <www.tsb.gc.ca/en/reports/air/studies/index.asp> or from TSB.[17]

The TSB analyzed data from seaplane accidents that occurred in Canada from 1976 through 1990 to identify safety deficiencies in seaplane operations. Results showed there were 1,432 seaplane accidents and 452 deaths. A 1993 report used the data to identify deficiencies in pilot skills, abilities and knowledge. Based on the same data, this 1994 report identified factors affecting occupant survivability in seaplane accidents terminating in water.

The study examined use of personal restraint systems, use of flotation devices, causes of deaths and locations where deaths occurred. Findings showed that:

- Most pilot and passenger drownings occurred inside the aircraft;
- Those able to egress did so with difficulty;
- Twenty percent of deaths occurred outside the cabin, most from drowning; and,
- When shoulder harnesses were available, two-thirds of the accident pilots did not use them, and one-half of accident passengers did not use them.

One recommendation from the study was that all seaplane occupants wear personal flotation devices during standing, taxiing, takeoff and the approach-and-landing phase of flight.

A Study Into Onshore and Offshore Based Rescue and Recovery (OBRR) Helicopters. Bomel. Health and Safety Executive (HSE), Offshore Division. OTO report 2001/039. 2001. 136 pp. Appendixes, references, index. Available on the Internet at <www.hse.gov.uk/research/offshore.htm> or from HSE.[6]

The study was commissioned by the HSE to provide a detailed review of OBRR helicopters supporting oil and gas field operations on the U.K. Continental Shelf. The following government bodies were consulted on their roles in regulating and setting standards for offshore helicopter and search-and-rescue operations: HSE, Civil Aviation Authority, Maritime and Coastguard Agency, Royal Air Force Search and Rescue Training Unit, and British Helicopter Advisory Board.

The study reviewed routine factors and key factors that may arise in planning for helicopter use in OBRR operations. Principal areas reviewed relate to regulations and codes of practice; OBRR helicopter operations management; offshore facilities and equipment; OBRR helicopters, equipment and operations; and historical data on helicopter operations incidents.

A Wind-tunnel Assessment of the Contribution of the Wind Loads on a Liferaft to the Problem of Overturning. Ponsford, P.J. National Maritime Institute. Report NMI TM 26. November 1978. 32 pp. Figures, tables, illustrations, photographs. Availability.[4]

At the time of this study, little was known about the role of wind in overturning life rafts. The report describes a study of wind loads on a 25-person life raft with open and closed hatches (windows) in the raft's canopy. The life raft was tested in several positions, from full contact with water to overhanging waves. The tests showed that maximum lift and overturning (pitching) moment occurred with the canopy hatches closed and increased progressively as the leading edge of the life raft underside extended beyond the edge of a wave.

Adlard Coles's Heavy Weather Sailing. Bruce, Peter. Camden, Maine, U.S.: The McGraw-Hill Companies, International Marine Publishing Co., 30th anniversary edition, 1999. 308 pp. Figures, photographs, illustrations, bibliography, index.

This edition follows Adlard Cole's style of presenting actual accounts of heavy weather sailing as learning experiences for readers. It is a collection of articles about storm experiences and expert advice, with information about crew fitness, use of drag devices, meteorology, wave action, life raft use, and survival equipment for non-sailors wanting an understanding of storm winds and sea conditions as preparation for life raft use.

Adrift: Seventy-six Days Lost at Sea. Callahan, Steven. Boston, Massachusetts, U.S.: Houghton Mifflin Co., 1986. 260 pp. Map, illustrations, photographs.

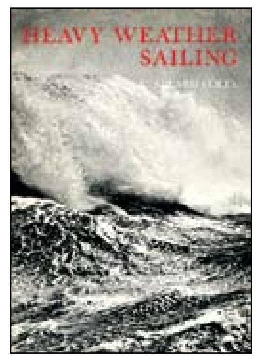
Callahan built a 21-foot (6.4 meter) sloop and outfitted it for single-handed ocean sailing. Callahan and his boat performed very well during successive voyages from the eastern coast of the United States, to Bermuda and across the Atlantic Ocean to England, then down the coasts of Portugal and Spain to the Canary Islands. A few days into the trip from the Canary Islands to the Caribbean Sea (an anticipated 14-day trip), a storm caused the sailboat to sink in approximately one minute. It would take 76 days and approximately 1,800 nautical miles (3,334 kilometers) for the sailor and his life raft to drift into the Caribbean Sea. Callahan had drifted within 60 nautical miles (111 kilometers) of his original destination when he was rescued by local fishermen.

Callahan was better prepared for living aboard his life raft than most, having read survival manuals and having included additional equipment in his life raft and emergency travel bag. The book details his use of a spear gun and other makeshift tools; his life raft and safety equipment; fishing techniques and food preparation; improvised water collection systems; life raft repairs and first aid. He also shares his experiences, thoughts, beliefs and lessons learned.

Airmen Against the Sea: An Analysis of Sea Survival Experiences. Llano, George Albert. Research Studies Institute, Arctic, Desert, Tropic Information Center (ADTIC). Maxwell Air Force Base, Alabama, U.S. ADTIC publication G-104. 1955. 119 pp. Figures, tables. Availability.[1]

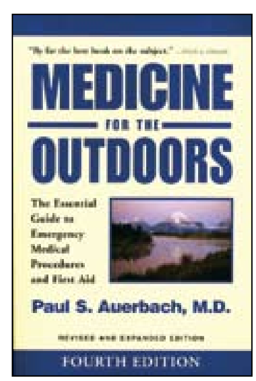
This retrospective study was fourth in a series of ADTIC studies undertaken to determine how military personnel survived under emergency conditions in different parts of the world (Southwest Pacific tropics, African deserts and the Arctic). Most of the incidents occurred in the 1940–1946 period. The oldest account is from 1913, and the most recent is from 1955.

The report contains factual accounts of men who survived aboard rubber life rafts, following aircraft ditchings or parachute bail-outs over water. Personal accounts describe successes and failures of survival equipment, rescue efforts, survival manuals and training used during respective time periods. Two opposing groups emerged from narrative accounts — those who lacked planning, foresight and imagination and experienced despair; and those who planned for eventualities by making personal survival kits, checking their equipment repeatedly and practicing survival drills.



The report includes a chapter on development of water survival concepts from 1913 to 1954.

American Practical Navigator: An Epitome of Navigation. Bowditch, Nathaniel. Washington, D.C., U.S.: Defense Mapping Agency, Hydrographic/Topographic Center (DMAHTC). 1984 edition with updates, volume I, pub. no. 9. 1430 pp. Figures, tables, illustrations, appendixes, references, index.



This technical book begins with the history of navigation and basic definitions. Timeless navigation topics are discussed thoroughly: instruments, such as compasses and sextants; celestial navigation; oceanography; and weather. Final chapters cover modern electronics for navigation.

The point is made that when emergencies arise, knowledge of basic principles leads to ingenuity and improvisation of equipment from available materials. "For the navigator prepared with such knowledge, and a determination to succeed, the situation is never hopeless. Some method of navigation is always available."

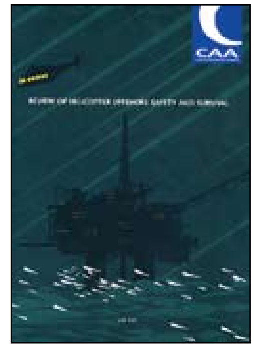
[Nathaniel Bowditch (1773–1838) contributed to the first American edition (1798) of John Hamilton Moore's book, *The Practical Navigator.* This British book was the leading navigational textbook at the time. Subsequent revisions to the American edition were made by Bowditch. The U.S. Navy purchased the copyright in 1868, and DMAHTC continues to make corrections and modifications to the text and to publish the book.]

An Investigation Into the Performance of Sea Anchors for Inflatable Liferafts. Foreman, E.J. National Maritime Institute (NMI). Report NMI R 127. January 1982. 40 pp. Figures, table, photographs, references. Availability.[4]

A sea anchor, towed behind a drifting life raft, provides drag to reduce the raft's drift rate and to orient the raft so that its canopy entrance faces away from the weather. In this study, British researchers at NMI examined the physical properties and design theories of sea anchors, drogues and parachutes, and they conducted in-water tests (some of which were conducted in Iceland) to identify problems that need to be addressed in future designs and with materials of the future.

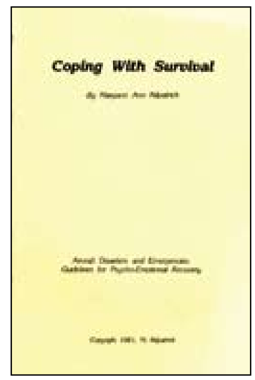
Analysis of Ditching and Water Survival Training Programs of Major Airframe Manufacturers and Airlines. Cosper, Donna K.; McLean, Garnet A. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report DOT/FAA/AM-98/19. July 1998. 33 pp. Figures, tables, appendixes, references. Available on the Internet at <www.cami.jccbi.gov> or from NTIS.[11]

The report was produced in response to concerns expressed by the aviation industry and regulators regarding short-term and long-term increases in aircraft operations near or over water. Tables in the report show the number of survivable worldwide water landings and the number of FAA-controlled airports and their proximities to large bodies of water. In 1996, 44 of the 50 busiest U.S. airports were located within five statute miles (eight kilometers) of a significant body of water. The report said that opportunities for emergency water landing events are significant and that aircrew training, survival equipment and survival procedures are "likely to become more important than ever before." Aircrew training programs related to ditching, water survival equipment and water survival procedures at nine major airlines and six major airframe manufacturers were reviewed. Deficiencies were identified, and recommendations for improvement were discussed.



Aviation Distress Signal. Society of Automotive Engineers (SAE), S-9a Safety Equipment and Survival Systems Committee. Aerospace Standard (AS): AS5134, revision A. December 2001. 11 pp. Figures, references. Availability.[14]

An aviation distress signal is defined by SAE as "a handheld, high-intensity, stroboscopic light source designed to facilitate location and rescue of aviation accident/ditching survivors by ground, sea or airborne search-and-rescue resources." This document defines a signaling device that can be used in lieu of pyrotechnic devices in aviation survival kits to aid in search and rescue and eliminate hazards of pyrotechnics if used by untrained personnel in inflatable life rafts.



Business Turbine Aircraft Accidents Involving Intentional In-water Ditching, 1964–2003. Robert E. Breiling Associates. Proprietary report for Flight Safety Foundation (FSF). February 2003. 17 pp. Available at the FSF office in Alexandria, Virginia, U.S.

A review and analysis of 787 business jet and 917 turboprop aircraft accident reports worldwide identified ditchings involving four jet-powered aircraft and five turboprop aircraft. Accidents involving inadvertent flight into water or impacting water during approach and departure were not included. The report includes summaries and data for each of the ditching accidents.

Capsized. Nalepka, James; Callahan, Steven. New York, New York, U.S.: HarperCollins Publishers, 1992. 244 pp. Map, illustrations, photographs.

In August 1989, four men left New Zealand on a leisurely sail aboard a trimaran (a three-hulled sailboat). Three days out of port, Antarctic gale-force winds and rough seas capsized the trimaran.

All of the men survived, but most of their gear, food and water were lost overboard. They lived inside a small compartment of one hull and outside, atop the capsized hulls.

Initially the men functioned independently. As they learned to trust each other, their collective will to live forged them into a cooperative team, performing survival tasks such as collecting water and finding food. Adrift in the wintry South Pacific for 119 days, the craft was finally carried by ocean currents toward shore, where it was crushed by nature's forces at the Great Barrier Island, and the team's will to live was tested again.

Chapman Piloting: Seamanship & Small Boat Handling. Chapman, Charles F. Revisions by Elbert S. Maloney, et al. New York, New York, U.S.: Hearst Marine Books, 62nd edition, 1996. 1430 pp. Figures, tables, photographs, illustrations, charts, appendixes, index.

Charles F. Chapman produced the first edition of his book in 1917 as a handbook for instructing boatmen who had volunteered to assist the U.S. Navy in World War I. The original handbook was a combination of educational articles previously published in *Motor Boating Magazine* and new material appropriate for military boatmen.

The 62nd edition contains chapters on various aspects of sail and power boating. Chapters of particular interest to aviators deal with water-related emergencies; first aid and medical emergencies; navigation and navigational aids; wind, waves and weather; tides and currents; communication; abandoning ship; survival floating; helicopter rescue and life rafts.

Chapman Piloting: Seamanship & Small Boat Handling is updated periodically by contributing writers and contributing consultants.

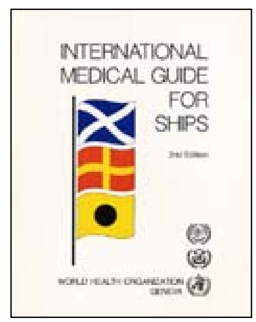
Coast Guard Approach to Develop Improved Personal Flotation Devices: Final Report for the Period May 1992–November 1992. Macesker, Bert; White, Richard P., Jr. U.S. Coast Guard (USCG) Research and Development Center. Report AL/CF-TP-1994-0019. November 1992. 15 pp. Figures, references. Available from NTIS.[11]

Since the early 1970s, the USCG has sponsored personal flotation device (PFD) related research studies conducted in static, calm water using safe, repeatable methods. However, calm water testing practices cannot measure the effects of wave action on life vests to determine optimum angle of repose, optimum head angle relative to a wave, the number of mouth immersions or buoyancy requirements in waves.

This report provides an overview of the Coast Guard's research program on the performance of PFDs in rough water and describes an instrumented mannikin under construction that would serve as a full-scale validation tool for Coast Guard survival system studies. [This report was published in the 1992 SAFE Symposium Proceedings.]

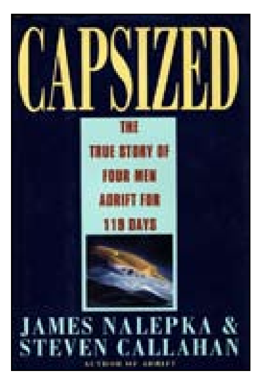
Commuter/Air Taxi Ditchings and Water-related Impacts That Occurred From 1979 to 1989. Chen, Charles C.T.; Muller, Mark. U.S. Federal Aviation Administration, Technical Center. Report DOT/FAA/CT-92/04. July 1994. Figures, tables, appendixes, references, glossary. 105 pp. Available from NTIS.[11]

The study's purpose was identification of trends in occupant survivability in commuter and air taxi aircraft ditchings and water-contact accidents from 1979–1989. Of the accidents examined, 40 met the criteria for inclusion in the study. The study reviewed impact conditions, post-impact conditions, aircraft behavior, impact velocities and attitudes, injury causes and severity, flotation availability and flotation performance.



There were numerous findings on impact conditions, occupant survivability hazards, effect of restraint use on occupant injury and aircraft impact damage, most notably:

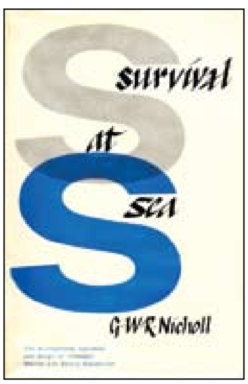
- The most prevalent impact hazard was injury attributed to flailing;
- Frequency and severity of injuries increased as weight and size of the aircraft decreased;
- The most significant post-impact hazard was drowning; and,
- There was a direct correlation between the lack of personal flotation equipment and the number of drowning fatalities.



Compatibility Test Protocol for Lifejackets and Immersion Suits on Offshore Installations. Mensafe. Health and Safety Executive (HSE). OTO report 2002/021. April 2002. 22 pp. Tables, appendixes, glossary, references. Available on the Internet at <www.hse.gov.uk/research/offshore.htm> or from HSE.[6]

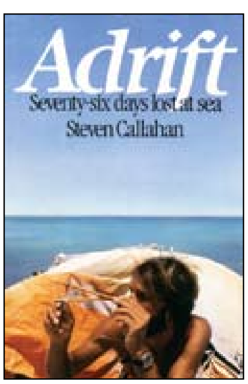
The International Maritime Organization, U.K. Civil Aviation Authority and the Comité Européen De Normalisation specify performance standards for life vests and performance standards for immersion suits used by helicopter and marine crewmembers while working in offshore environments, and the offshore industry has accepted these standards for type testing. Nevertheless, the report says a significant shortfall in performance standards for compatibility and suitability exists when life vests and immersion suits are used in combination.

Previous HSE and industry reports on tests of life vest-immersion suit combinations found that several combinations are unsuitable for use offshore. This report provides protocol for compatibility testing in situations common to all installations (e.g., immersion suit and life vest compatibility with helicopter seats and restraint systems).



Coping With Survival. Aircraft Disasters and Emergencies: Guidelines for Psycho-Emotional Recovery. Kilpatrick, Margaret Ann. Glendale, California, U.S.: Self-published, 1981. 36 pp. Addenda, photographs.

This monograph was published in booklet format by its author, Margaret Kilpatrick. It is about people helping people recover from traumatic events, such as aircraft accidents. The author, a licensed clinical social worker, provides information to increase awareness of what to expect and ways to assist. The text identifies factors influencing the nature and severity of an event's impact upon survivors; characteristics of typical mental and physical reactions; strategies to assist and support survivors with their psycho-emotional recovery; and guidelines for self-care.



Ditching Investigations of Dynamic Models and Effects of Design Parameters on Ditching Characteristics. Fisher, Lloyd J.; Hoffman, Edward L. National Advisory Committee for Aeronautics (NACA), Langley Aeronautical Laboratory. NACA Technical Note 1347. 1956. 28 pp. Tables, references. Availability.[9]

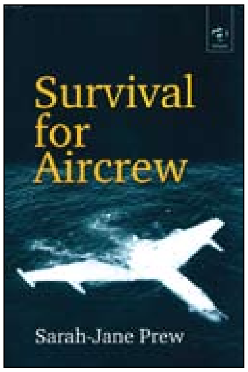
Data from actual, full-scale aircraft ditchings and data from dynamic, scale-model investigations were collected and analyzed to gain an understanding of the effects of design parameters on the ditching characteristics of airplanes. The goal was to determine design parameters that could improve ditching safety without sacrificing aerodynamic properties. Performance data from scale models of bomber, fighter and transport aircraft are summarized.

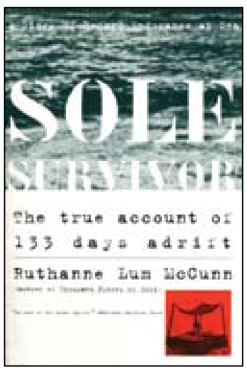
Drift of Common Search and Rescue Objects — Phase II. Fitzgerald, R.B.; Finlayson, D.F.; Cross, J.F.; Allen, A. Transport Canada, Transportation Development Centre; Canadian Coast Guard. Report TP 11673E. March 1993. 200 pp. Figures, tables, appendixes. Available from NTIS.[11]

According to the report, "leeway is defined as the movement of a craft through the water caused by the wind acting on the exposed surface of the craft." This report, the second in a series of multi-year projects, describes in-water experiments conducted in 20-knot and 50-knot winds to determine leeway rates and angles for several objects commonly found in search-and-rescue operations — an asymmetrical life raft, a symmetrical life raft, and an 18-foot (six meter) plank boat used in the Atlantic coastal waters of Canada. The rafts and boat were tested with various configurations of people aboard and with and without drogues. The leeway rates were determined to be less than those shown in the *National Search and Rescue Manual* (National Defence and Canadian Coast Guard, 1985).

Emergency Locator Transmitter (ELT) Installation and Performance. RTCA, Special Committee 136. Report DO-182. Nov. 17, 1982. Figures, tables, appendixes. Availability.[13]

This document provides consensus-based guidelines for ELT placement and installation; reports on false alarms, activations in crash environments and analyses of ELT systems performance in various aircraft installations; and makes specific recommendations on each of the topics.





Essentials of Sea Survival. Golden, Frank; Tipton, Michael. Champaign, Illinois, U.S.: Human Kinetics, 2002. 320 pp. Figures, tables, photographs, appendix, glossary, bibliography, index.

According to the book, analyses of maritime tragedies suggest two underlying causes: a general lack of understanding about the nature of various threats and the human body's reactions or physiological responses to those threats; and "in a survival situation, costly safety equipment is often not readily at hand, is difficult to operate in adverse conditions, or is impossible to use correctly without specific training." Referencing historical anecdotes and published scientific research, the authors examine threats to survivors at sea and methods to prevent or minimize these dangers.

The first half of the book discusses physiological and behavioral responses to cold temperatures, immersion and drowning. The second half covers techniques for survival and rescue in a lifeboat or in water. The intent of the book is to provide a comprehensive and practical guide to open-water survival.

Estimating Extreme Wave Heights in the NE Atlantic From GeoSat Data. Carter, D.J.T. Health and Safety Executive (HSE), Offshore Safety Division. Offshore Technology Report OTH 93 396. 1993. 35 pp. Figures, tables, appendix, references. Available on the Internet at <www.hse.gov.uk/research/offshore.htm> or from HSE.[6]

An Earth-orbiting satellite, using downward-looking radar, measures altitude to estimate significant ocean wave heights. Significant wave height is a measure of the general sea state. This technical report explains how radar altimeters measure wave height and describes some of their limitations.

Experiment in Survival. Sigler, George. Vero Beach, Florida, U.S.: Vero Technical Support, 2001. 208 pp. Photographs.

Sigler said that his "entire philosophy about ocean survival revolved around the castaway saving himself, totally independent of outside help." He believed that he could make a survival kit with appropriate supplies to sustain a person's life for 60 days, yet small enough to fit into a life raft compartment.

After extensive research of survivor accounts, survival kits and life rafts, Sigler prepared to test his theory. With no open-ocean experience in a floating vessel, he and another former U.S. Navy pilot modified a small rubber inflatable (Zodiac) raft to carry a sail and two solar stills for water collection. They started the voyage with Sigler's self-designed survival kit, six pounds (three kilograms) of food and no fresh water. The men sailed from San Francisco, California, U.S., across the Pacific Ocean to Hawaii, U.S., in 56 days and successfully provided adequate food and water en route.

"Fastnet, Force 10." Rousmaniere, John. New York, New York, U.S.: W. W. Norton & Co., 1980. 288 pp. Charts, maps, drawings, appendixes, references, photographs, index.

A vicious "Force 10" summer gale, lasting about 20 hours, battered 303 yachts sailing in the 1979 Fastnet yacht race off the English coast. Force 10 velocity on the Beaufort scale of wind and sea conditions equals a wind speed of 48 knots to 55 knots, very high waves with long overhanging crests and a tumbling sea.

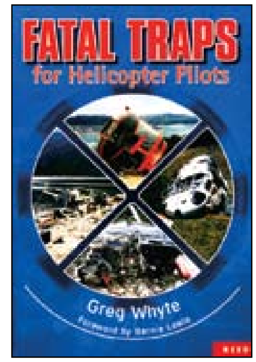
Many yachts were overturned, capsized or badly damaged. Some crewmembers were seriously injured, lost overboard, swept away, drowned, or died of hypothermia. Of the 2,700 male and female crewmembers, nine died and 136 were rescued from sinking sailboats, from life rafts and from the rough waters.

Yacht and crew accounts and descriptions of search-and-rescue efforts are described with enough detail to encourage experienced seamen and novices to think carefully about the suitability of their own life rafts and life vests in rough seas and stormy weather.

Fatal Storm: The Inside Story of the Tragic Sydney-Hobart Race. Mundle, Rob. New York, New York, U.S.: The McGraw-Hill Companies, International Marine, 1999. 275 pp. Map, photographs.

Each Dec. 26, sailboats of all sizes begin the Sydney-to-Hobart Yacht Race (from Sydney to Hobart, Australia), a distance of 630 nautical miles (1,167 kilometers). In 1998, a freakish, unseasonal storm with hurricane-strength winds and rough seas with waves 60 feet (18 meters) high or higher struck the 115-boat racing fleet. During the storm, some boats were so badly damaged that racing crews were forced to abandon them.

The book recounts the experiences of those requiring assistance and search-and-rescue efforts. Readers unfamiliar with "riding out a storm" in a life raft with repeated capsizings or with jumping into rough seas and swimming to meet a rescue helicopter sling will have a new appreciation for the term, "safety and survival at sea."



Fatal Traps for Helicopter Pilots. Whyte, Greg. Auckland, New Zealand: Reed Publishing, 2003. 396 pp. Figures, bibliography, index.

The book's main purpose "is to promote safety in rotary-wing aviation by identifying and addressing the main causes of helicopter accidents." A broad range of situations and conditions that may lead to an accident are discussed. Each situation is described in general terms and followed by examples or an actual accident report with findings and recommendations.

In the chapter on ditching, a personal account by a pilot who ditched a Hughes 500D helicopter in Cook Strait, New Zealand, is used as an example. The pilot said that he "went from flying straight and level to swimming in two to 2½ minutes!" The account describes ditching, inversion and difficulties of evacuation.

The book suggests ways to prepare, in advance of flight, for ditching, cold water survival and life vests.

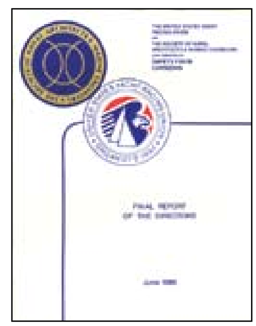
Field Manual: Survival. U.S. Department of the Army. Washington, D.C., U.S.: Headquarters, Department of the Army. Series FM 21-76. October 1970. 288 pp. Figures, appendix, references, map, index.

This 1970 version follows the Oct. 25, 1957, field manual and was written to prepare soldiers, alone and in groups, for survival in a variety of environmental and hostile settings. The "will to survive," valuing life, basic skills and adaptation are emphasized. Full text of the Army's June 1992 updated version can be found on the Internet.

Full-scale Trials of Inflatable Liferafts in the Waters Off Iceland. Foreman, E.J. National Maritime Institute (NMI). Technical Memoranda NMI TM 53. September 1980. 22 pp. Figures, references. Availability.[4]

Test trials of six 10-person inflatable life rafts (from four manufacturers) were conducted during February 1980 in the open waters off the northwest coast of Iceland. Production-model life rafts, with and without ballast modifications, were tested for life raft stability, effectiveness of sea anchor systems, canopy strength and door closing methods. Photographs and schematic drawings of trial equipment are included in the report.

Results showed that a life raft must have maximum stability immediately upon launch to prevent tipping or capsizing before passenger boarding and that an intact sea anchor can substantially improve inflatable life raft stability and drift rate. Effectiveness of modified ballast arrangements was not clearly demonstrated. Manufacturers were already aware of door closing problems and were making improvements.



Full-scale Trials of Inflatable Liferafts in the Waters Off Iceland — Second Series. Foreman, E.J. National Maritime Institute (NMI). Technical Memoranda NMI TM 63. June 1981. 22 pp. Figures, references. Availability.[4]

During March 1981, trials were conducted in open waters off the southeast coast of Iceland to determine the effectiveness of modifications made to life rafts as a result of sea trials conducted in February 1980. Four modified, inflatable life rafts with 10-person capacity, two new sea anchor designs and a newly designed canopy entrance were tested.

Results showed the new sea anchor designs were effective in maintaining life raft stability, and the NMI design was recommended for adoption on future British-manufactured International Convention for the Safety of Life at Sea (SOLAS) life rafts. It was recommended that research continue until optimum size and shape of ballast pockets on life rafts are determined.

General Aviation Safety Sense Series: Ditching. U.K. Civil Aviation Authority (CAA), SRG Safety Promotion Section. Leaflet 21A. 2000. 16 pp. Tables, illustrations, photographs, supplements. Available on the Internet at <www.caa.co.uk> or from Documedia.[5]

This leaflet addresses the main points of ditching — knowledge of your own aircraft (distance your aircraft can glide); criteria for selecting and maintaining life vests, life rafts and other safety equipment; crew and passenger preparation; ditching instructions, such as "above all, throughout, fly the aircraft"; and rescue instructions, "let the rescuer take control of the actual rescue."

The leaflet includes lists of companies offering survival training and lists of CAA-approved life raft and life vest manufacturers and service companies.

Global Survival Skills. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine. Videotape. Availability.[12]

The videotape covers eight topics about surviving in adverse conditions: the will to survive; survival signaling; survival medicine; surviving on open water; life rafts, survival kits and accessories; hotland survival; coldland survival; and tropical survival.

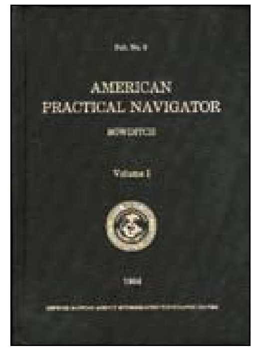
Guidelines for Management of Offshore Helicopter Operations. Australian Petroleum Production & Exploration Association (APPEA). February 2000. 82 pp. Available on the Internet at <www.appea.com.au> or from APPEA.[3]

The guidelines are intended as a reference of good industry practices for the safe conduct of operations within the offshore petroleum industry. Information regarding flotation devices, life rafts, life vests, immersion suits, emergency locators, emergency exit illumination systems, survival packs and first aid kits is included.

Handbook of Survival in the Water. U.S. Department of the Navy, Bureau of Naval Personnel. Navy Training Courses, NavPers 16046. Washington, D.C.: U.S. Government Printing Office, 1951. 224 pp. Figures, tables, appendix, index.

The handbook, first produced in 1947, was intended to serve primarily as a textbook for courses in survival that were administered to first lieutenants and other naval officers. It contains background material and training suggestions for first lieutenants to use in conducting similar programs for all shipboard personnel operating on naval surface ships.

Important topics addressed in the handbook are: types of survival equipment available; correct use of equipment; accepted medical and physiological procedures to prolong survival; contributions of psychology and neuropsychiatry; best methods for retrieving survivors from water; and best training methods for maximum results.



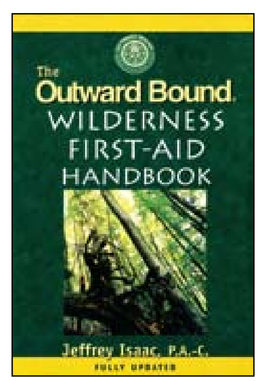
Heavy Weather Life Raft Test: June 22 and July 4, 1991. West Marine Products. 16 pp. Index. Available on the Internet at <www.ussailing.org> or from USSA.[18]

Four marine life rafts, one portable rescue platform and related safety equipment were tested in open waters off the California, U.S., coast to evaluate specific aspects of each item.

In repeated abandon-ship enactments on open waters, participants evaluated various aspects of each of the following: raft deployment, launch and canopy unfurling; boarding techniques and limitations; drogue deployment and resulting effects; canopy design, visibility and ventilation; life raft floor design, floor space and personal volume; air-holding ability and repairability; equipment ease of use, instructions or lack of information; leaking water, pumping and bailing; survival kits and water makers; life vests; seasickness; very-high-frequency (VHF) radios, and emergency position-indicating radio beacons (EPIRBs); and flares and smoke canisters.

Heavy Weather Sailing. Coles, K. Adlard. Tuckahoe, New York, U.S.: John de Graff, 1968. 310 pp. Tables, photographs, appendixes, bibliography, maps, diagrams, index.

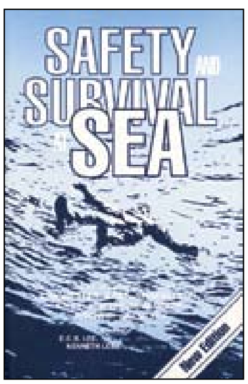
Heavy weather sailing as referenced in this book means sailing in fresh winds of 17–21 knots (Force 5), strong winds of 22–23 knots (Force 6 and Force 7) and gales of 34–40 knots (Force 8). Winds at these speeds permit the captain and crew to retain control of the boat.



In survival storms and hurricane-strength storms (Force 10), wind and sea become masters of the vessel, and captain and crew must battle to steer the boat to its best angle of defense against high waves and to keep the boat from sinking.

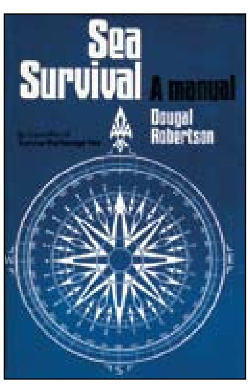
Most day-sailors and leisure-cruisers avoid heavy weather sailing, while sailors aboard racing boats generally commit to operating under any conditions. This book provides accounts and brief reports of boats that experienced heavy wind and sea conditions, followed by recommendations, observations and conclusions. The intent is to share learned experiences without readers having to endure such events.

Heavy Weather Tactics Using Sea Anchors & Drogues. Hinz, Earl R. Arcata, California, U.S.: Paradise Cay Publications, 2000. 182 pp. Figures, tables, appendixes, bibliography, glossary, index, photographs.



According to the book, over the past 30 years, there has been a growth in the number of people traveling over open water in small vessels and in airplanes who subsequently experience unanticipated storms and extreme weather conditions. There has been a corresponding growth in the need for drag devices as standard safety equipment on boats and life rafts.

There are two types of drag devices — a drogue attached to the stern of a vessel to slow it and a sea anchor attached to the bow of a vessel to "anchor" it to the surface of the water. Both types help to prevent vessels lacking power or control from being knocked about, rolled or capsized by high wind and large waves. The book is written for neophytes and experienced seamen who need an understanding of drag devices, their potential benefits, how they work and when to deploy and retrieve them. Design specifications and technical data illustrate optimum design and use of drag devices for sailboats, powered yachts and life rafts.



Helicopter Safety Offshore. Morrison, Graham. Health and Safety Executive (HSE), Offshore Division. OTO report 2000/089. 2001. 114 pp. Figures, tables, appendixes, bibliography, references. Available on the Internet at <www.hse.gov.uk/research/offshore.htm> or from HSE.[6]

According to the report, "Helicopter travel to and from offshore installations generates one of the main sources of risk for offshore workers. Particularly on more modern installations where other risks are low, helicopter transport may be the dominant risk." The study focused on accidents occurring in Western Europe and especially the U.K. Analysis of accident data and relevant literature led to conclusions and recommendations about causes of accidents; risk factors; aviation culture; current regulations; helicopter operating limitations; responsibilities of installation operators and owners; helicopter and helideck designs and related risk assessments; effects of platform physical environment; communication; and adverse weather policy.

The report is based on a dissertation submitted as partial fulfillment of the author's master of science degree program and was later revised and updated to include more recent information for this OTO report.

How to Fly Floats. Frey, J.J. Kenmore, Washington, U.S.: Kenmore Air Edo Floats, 20th edition, 2003. 65 pp. Photographs, diagrams.

First published in the early 1970s, this book discusses the basics of seaplane flight for new pilots and pilots transitioning from landplanes, telling readers that float flying is "the easiest type of flying to learn for the beginner" and that it "comes quickly and naturally for the seasoned landplane pilot."

The book includes chapters on preflight operations, taxiing, takeoffs, landings, sailing (controlling the aircraft by positioning it into the wind and using the force of the wind to move the aircraft to the desired position on the water), operating regulations, docking, and service and maintenance. An appendix describes methods of estimating wind speeds and provides advice for different types of wind conditions and water conditions.

How to Survive on Land and Sea. Craighead, Frank C., Jr.; Craighead, John J. Annapolis, Maryland, U.S.: Naval Institute Press, fourth edition, 1984. 444 pp. Figures, map, bibliography, index.

The first edition of this book was published in 1943 and contained materials developed by the U.S. Navy "to provide the best possible standardized instruction in survival techniques for combat naval pilots, both on land and at sea." After World War II, the book became widely used in the civilian sector. Through periodic updates, it continues to be a timely survival resource. Part 1 covers land survival, and Part 2 covers water survival. There are extensive lists of items for consideration in assembling well-stocked life raft survival kits and first aid kits for land or water.

"Survival is a state of mind, and your life may very well depend on it. The state of mind most likely to sustain you is achieved through a combination of will and behavior," says the book.

The book emphasizes "preparedness and priorities." Preparedness covers a broad range of tasks, from mental and physical readiness to practice with survival equipment. Survival priorities for an episode at sea are very specific and should follow in this order — flotation, first aid, water procurement, shelter construction, food procurement and travel.

Human Factors Relating to Escape and Survival From Helicopters Ditching in Water. Brooks, C.J. Advisory Group for Aerospace Research and Development (France); U.S. National Aeronautics and Space Administration. Report AGARD-AG-305. February 1991. 125 pp. Figures, tables, annex, references, photographs. Available in French and English. Available from NTIS.[11]

The report, *Evacuation et Survie en cas d'Amérrissage Forcé d'un Hélicoptère Le Facteur Humain*, was prepared by C. J. Brooks, Defence & Civil Institute of Environmental Medicine in Ontario, Canada, for the sponsoring organizations. The author reports on worldwide accidents and incidents involving military and civilian overwater helicopter operations. Accident scenarios review pilots' actions from the moment they step aboard and begin the pre-flight briefings, continuing through impact, underwater escape and search and rescue. Training, advance preparation, safety equipment, immersion suits, life vests and problems affecting survival are described. Recommendations for improvements in helicopter crashworthiness, life support equipment and a syllabus for underwater-escape training are included.

In Harm's Way: The Sinking of the USS Indianapolis and the Extraordinary Story of Its Survivors. Stanton, Doug. New York, New York, U.S.: Henry Holt and Co., 2001. 345 pp. Photographs, bibliography, notes.

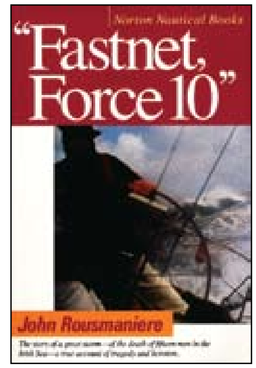
On July 30, 1945, while the battle cruiser *USS Indianapolis* was returning from a top secret mission — delivering components for the atomic bomb that would later be dropped over Hiroshima, Japan — it was struck by torpedoes launched from a Japanese submarine in the Pacific Ocean. Before sinking, the cruiser cast approximately 900 of its sailors (many others died aboard ship) into the ocean, where they struggled to survive for nearly five days.

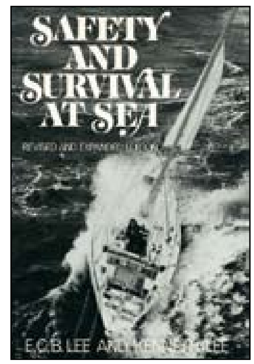
When the ship did not arrive as scheduled for practice maneuvers in the Philippines, there was no immediate concern by the U.S. Navy. Survivors adrift in the ocean were spotted accidentally by a U.S. Navy pilot on anti-submarine patrol and were subsequently rescued by Navy aircraft and Navy vessels. Several of the 317 survivors describe their own incredible experiences and those of their companions as they fought sharks, dehydration, sunburn, injuries, physical and mental exhaustion, fear, despair, and hallucinatory dementia before being rescued.

Individual Inflatable Life Preservers. Society of Automotive Engineers (SAE), S-9a Safety Equipment and Survival Systems Committee. Aerospace Recommended Practice (ARP): ARP1354, revision A. Oct. 28, 1991. 7 pp. Tables. Availability.[14]

SAE standards documents are technical information resources that provide guidance for the design, testing, construction, maintenance, and operation of self-propelled vehicles for use on land, at sea, in the air and in space. This ARP provides criteria for operational characteristics in designing individual inflatable life vests for four classifications of users — adults, combination adult/child, children and combination infants/small child.

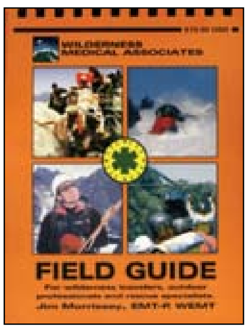
Inflatable Liferaft Research 1978–82: Summary Report. Morrall, A.; Foreman, E.J. National Maritime Institute. Report NMI TM 96. January 1983. 41 pp. Figures, tables, photographs, references. Availability.[4]





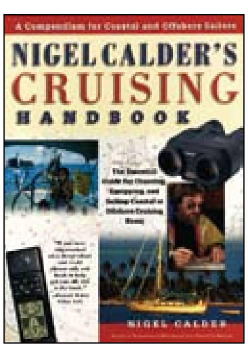
Inflatable life rafts were introduced for use aboard ships in 1959. While generally effective, some life rafts failed to save the occupants for reasons that were not understood. Incidents where life rafts were launched from ships in emergency situations were reviewed, and casualty information of eight launchings, occurring from 1964 to 1976, was examined. These life rafts had capacities for two to 12 occupants. It was concluded that inflatable life rafts were effective in saving lives, and the majority of capsize events occurred upon inflation or immediately after launching, when life rafts were lightly loaded.

International Aeronautical and Maritime Search and Rescue Manual (IAMSAR Manual). International Maritime Organization (IMO); International Civil Aviation Organization (ICAO). Montreal, Canada: ICAO, first edition, 1998–99. ICAO Doc 9731-AN/958. Figures, glossary, appendixes. Available in Arabic, English, French, Russian and Spanish.



The *IAMSAR Manual* provides search and rescue (SAR) guidelines to nation-states for organizing aviation and maritime resources to provide SAR services. Volume I, *Organization and Management*, gives an overview of the SAR concept at global, regional and national levels. Volume II, *Mission Co-ordination*, focuses on key components of the SAR system, like communications, planning, techniques and operations. Volume III, *Mobile Facilities*, is an on-board handbook to assist aircraft, rescue unit and vessel personnel with their own specific emergencies. Each volume is written as a stand-alone document and as a companion to the other volumes.

International Medical Guide for Ships, Including the Ship's Medicine Chest. World Health Organization (WHO). Geneva, Switzerland: WHO, second edition, 1988. 376 pp. Figures, tables, illustrations, index.



The guide was developed for people with little or no medical training who are responsible for health care aboard ships and diagnose and treat injured and sick seafarers. It also serves as a textbook resource for those studying for certification in medical training and gives ships' crewmembers basic training on first aid and disease prevention. Topics that may be of particular interest to those involved in aircraft overwater operations are examination of patients; care of the injured; medical care of castaways and rescued persons; external assistance by radio or helicopter; and death at sea.

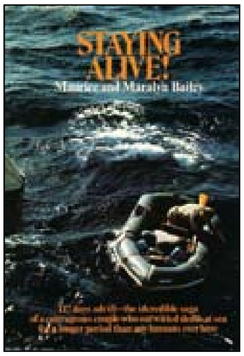
Changes in the second edition reflect marine, scientific and technological advances.

International Sailing Federation Special Regulations Governing Offshore and Oceanic Racing 2002–2003, Including US Sailing Prescriptions. International Sailing Federation (ISAF), Offshore Racing Council. March 2002. 52 pp. Tables, appendixes, index, notes. Available from ISAF[8] or USSA.[18]

The booklet outlines regulations for maintaining optimum safety at sea (inshore, offshore, and transoceanic) based upon the degree of exposure a sailing vessel likely will encounter while racing or cruising. These regulations can serve as benchmarks for anyone wanting to improve the safety of a vessel, its equipment and its crew. The regulations address structural features, stability, fixed and portable equipment, supplies, personal equipment and training. Benchmarks for life rafts, life vests, training, survival kits and signaling devices can be applied to aviation survival equipment. [This particular booklet was reprinted by US Sailing Association (USAA) and includes prescriptive information to meet USAA requirements.]

Lake Michigan Crew Over Board Study, 1998. Lake Michigan Sail Racing Federation. 1998. 43 pp. Appendix. Available on the Internet at <www.ussailing.org> or from USSA.[18]

The study is a collection of stories about sailing yachts and their crew who participated in offshore racing events, in all kinds of weather conditions on Lake Michigan, U.S. Stories, referred to as cases, were recounted by sailors who experienced crew-overboard events or boat sinkings and those who participated in rescue efforts. Each case gives essential facts, describing actions surrounding crew-overboard or boat-abandoning events, use of survival equipment (including life rafts and personal flotation devices), immersion time, effects of immersion at various temperatures, reactions of crew remaining aboard, and reactions of crew aboard rescue boats.

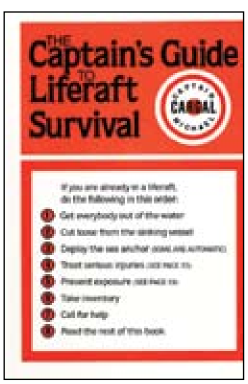


Life Raft Test. West Marine Products; Sea Star Yachting Products. June 25, 1994. 14 pp. Available on the Internet at <www.ussailing.org> or from USSA.[18]

This report documents tests of two different types of craft used in survival and rescue after vessel abandonment in rough seas — a conventional six-person life raft by Switlik that is stored in a packaged state and inflated on demand; and a combination (dual-purpose) inflatable dinghy and survival craft from Tinker that can be inflated on demand or carried on a boat's deck in its inflated state.

Comparisons were made for technical specifications, deployment, inflation, air-holding ability, survivor boarding and crew recovery from water, canopy design, drogue deployment, floor design, personal volume and floor space, survival kit inventory, ease of repair, intuitive assembly and operations, instructions, capsize resistance and righting after capsize, water intrusion and bailing, rate of drift, maneuverability, and special features. Summaries of advantages and disadvantages of both types of survival craft are included.

Life Rafts. Society of Automotive Engineers (SAE), S-9a Safety Equipment and Survival Systems Committee. Aerospace Recommended Practice (ARP): ARP1356, revision A. December 1989. 8 pp. Availability.[14]



SAE standards documents are technical information resources that provide guidance in product design, testing, construction, maintenance, and operation of self-propelled vehicles for use on land, at sea, in the air and in space. This ARP provides criteria for design and performance of aircraft life raft devices to ensure rapid and effective use as a flotation device in a water landing. The document does not specify design methods or equipment to be used in meeting the criteria.

Life-saving Appliances. International Maritime Organization (IMO), 2003 edition. 194 pp. Appendixes. Availability.[7]

This 2003 edition contains the text of the International Life-Saving Appliance (LSA) code regarding international standards for life-saving appliances required by chapter III of the International Convention for the Safety of Life at Sea (SOLAS). Included are requirements for personal lifesaving appliances (life vests, immersion suits, anti-exposure suits and thermal protective aids); visual signals (hand flares, rocket parachute flares and buoyant smoke signals); survival craft (inflatable and rigid life rafts and various types of life boats); rescue boats and other marine appliances and systems.

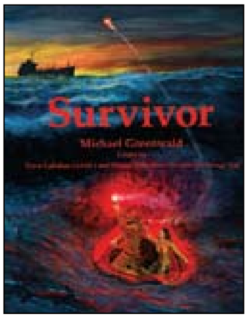
In addition to standards, there are revised recommendations for prototype, production and installation testing of lifesaving appliances and the code of practice for evaluation, testing and acceptance of prototype novel lifesaving appliances and arrangements.

Marine Offshore Rescue Advisory Group: Good Practice in Offshore Rescue. MaTSU. Health and Safety Executive (HSE), Offshore Safety Division. OTO report 2001/040. 2001. 78 pp. Tables, glossary, bibliography. Available on the Internet at <www.hse.gov.uk/research/offshore.htm> or from HSE.[6]

The report acknowledges that in recent years many research studies, codes of practice and company-based operations manuals have been created and dispersed. The concern is that best practices and relevant information may not be reaching all who are involved in offshore rescue. This report is an attempt to disseminate information about marine rescue to and from rescue craft so that rescue crews may benefit from the experiences of others. Good practices in ship and boat operations; location, care and transfer of the casualty; and human factors aspects of rescuers are provided.

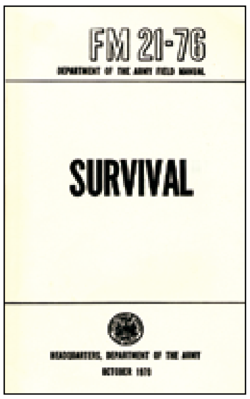
Mariner's Weather Handbook: A Guide to Forecasting & Tactics. Dashew, Steve; Dashew, Linda. Tucson, Arizona, U.S.: Beowulf, 1998. 604 pp. Photographs, illustrations, charts, bibliography, index.

The handbook is written with two goals — to present "the basics of what makes weather work the way it does" and to show mariners how to tactically take advantage of weather conditions (and resulting sea conditions). The book can serve as a textbook for beginners and as a reference handbook for those with experience. Some of the topics discussed are principles that cause weather to be created; types of weather systems; cloud recognition and interpretation; forecasting



based on current conditions; tropical meteorology; ways to obtain weather data; and weather forecasting tools.

Medicine for the Outdoors: the Essential Guide to Emergency Medical Procedures and First Aid. Auerbach, Paul S. Guilford, Connecticut, U.S.: The Lyons Press, fourth edition, 2003. 544 pp. Figures, appendixes, glossary, index.



The book, written by a physician who specializes in wilderness and emergency medicine, provides brief explanations of a wide range of medical problems that could be encountered outdoors (land or water) and offers practical solutions and treatments for laypersons to apply. Part 1 outlines general first aid principles, and parts 2 and 3 describe major and minor medical events, such as fractures and dislocations. Part 4 covers problems related to specific environments, such as underwater diving accidents, near-drownings, hazardous aquatic life, and injuries and illnesses due to cold. Instructions on compiling first aid kits, avoiding motion sickness and other practical information appear in part 5.

Minimum Operational Performance Standards for 406 MHz Emergency Locator Transmitters (ELTs). RTCA, Special Committee 160. Report RTCA/DO-204. Sept. 29, 1989. 92 pp. Figures, tables, appendixes. Availability.[13]

This document recommends consensus-based standards and test procedures for ELTs that utilize the 406.0 megahertz (MHz) to 406.1 MHz band and operate in the Cospas-Sarsat International Satellite system. It includes test conditions and procedures for installed equipment performance.

Minimum Operational Performance Standards for 406 MHz Emergency Locator Transmitters (ELTs), Change 1 to RTCA/ DO-204. RTCA, Special Committee 160. Paper 299-94/TMC-139. July 13, 1994. 6 pp. Availability.[13]

Change 1 to RTCA document, DO-204, deals with two requirements. ELTs are required to radiate a visual signal indicating the unit is operating. If an optional aural monitor is installed, it should have manual override capability that does not compromise the visual indicator.

Minimum Operational Performance Standards for Emergency Locator Transmitters (ELTs). RTCA, Special Committee 136. Report RTCA/DO-183. May 13, 1983. 82 pp. Figures, tables. Availability.[13]

This document contains minimum operational performance standards for ELTs installed primarily in fixed-wing aircraft. Four types of emergency locator transmitters operating on 121.5 megahertz (MHz) and 243.0 MHz are discussed — automatic fixed-ELTs, automatic portable-ELTs, automatic deployable-ELTs and survival-type ELTs.

Minimum Operational Performance Standards for Emergency Locator Transmitters (ELTs), Change 1 to RTCA/DO-183. RTCA, Special Committee 136. Paper RTCA/DO-183. Jan. 17, 1986. 1 pp. Availability.[13]

Change 1 to report RTCA/DO-183 changes values in modulation characteristics from those previously stated.

Nigel Calder's Cruising Handbook: A Compendium for Coastal and Offshore Sailors. Calder, Nigel. Camden, Maine, U.S.: The McGraw-Hill Companies, International Marine, 2001. 582 pp. Tables, photographs, illustrations, bibliographies, index.

Calder said that he designed this book to provide experienced and aspiring sailors with an understanding of sailboats and boat systems suitable for cruising under sail. Part of the book concentrates on practical and technical matters, and other sections focus on necessary skills.

Portions of the book may interest those involved in overwater operations. The chapter on health and safety issues provides a checklist of medical supplies to have aboard and a health-related bibliography of international resources. The chapter on weather discusses basic theory, predictions and weather systems. There are explanations of ways to deal with extreme wind, weather and sea conditions; how and when to use sea anchors and drogues; when and how to launch a life raft; and how to compile a ditch bag. Desirable features of life rafts, communication devices and signaling equipment, life vests and other safety features are enumerated. Explanations of basic compass use and rope/knot tying are accompanied by illustrations.

Notes of a Seaplane Instructor: An Instructional Guide to Seaplane Flying. Mees, Burke. Newcastle, Washington, U.S.: Aviation Supplies and Academics, 2002. 160 pp. Diagrams, glossary.

Mees, a commercial seaplane pilot in the Aleutian Islands, Alaska, U.S., and a flight instructor, wrote this book as an instruction manual for pilots seeking a seaplane rating and as a reference book for pilots who already have the rating.

The book, which discusses single-engine floatplanes, is intended to ease the transition to seaplanes for pilots with landplane experience.

The book describes the unique aspects of seaplane takeoffs and landings, as well as seaplane flight characteristics, water handling, preflight inspections, postflight procedures and cold-weather operations. A separate chapter is devoted to amphibious floatplanes.

Our Last Chance: Sixty-six Deadly Days Adrift. Butler, William; Butler, Simonne. Miami, Florida, U.S.: Exmart Press, first edition, 1991. 328 pp. Maps.

While crossing the Pacific Ocean, en route to circumnavigate the world, the authors found themselves traveling in the same ocean current and at the same speed as a pod of whales. After circling the boat for several hours, the whales began to push the 38-foot (12-meter) sailboat about, damaging it and causing it to sink. From this point, the book describes the experiences of life aboard a six-foot (two-meter) plastic life raft — a raft designed for 7–10 days of coastal use, not ocean use, and certainly not as a home for 66 days.

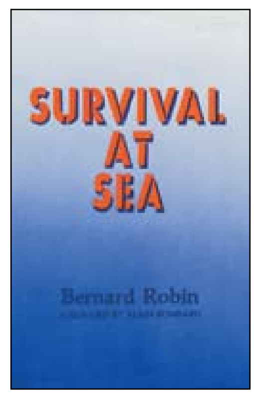
Overboard Light Study. The Sailing Foundation, Safety at Sea Committee. 1996. 4 pp. Tables. Available on the Internet at <www.ussailing.org> or from USSA.[18]

The committee conducted in-water tests on strobe lights used as floating man-overboard lights and strobe lights and incandescent lights used on personal life vests. Battery endurance tests for the same lights were conducted onshore. Some of the data collected on each light in the three-year study included: manufacturer, model, type, visibility range, ease of use, battery replacement, battery endurance, battery cell type, and product construction.

Among other findings, the report said:

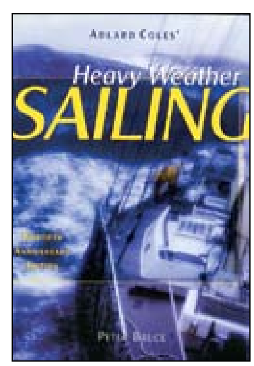
- "Strobe lights are the best type of light for attention-getting and extremely poor for distance-ranging";
- "Rescue helicopter pilots have indicated that strobes get them to the scene but spoil depth perception"; and,
- "They [rescue helicopter pilots] would like to have a steady light on the victim for exact location and height judgment for actual pickup."

Radar Reflector Test. Corenman, Jim; Hawley, Chuck; Honey, Dick; Honey, Stan. West Marine, 1995. 14 pp. Figures, tables. Available on the Internet at <www.ussailing.org> or from USSA.[18]



The report describes marine radar reflectors, in general and by specific reflector configurations (octahedral, quadrahedral, trihedral, spherical and variations of each). Test data for minimum reflectance were collected on 23 reflectors of various configurations. Data characteristics included strength of the reflected signal, range of visibility, probability of being seen by a ship at an unknown horizontal angle, angular width of blind spots and product durability.

Tests yielded sufficient data to influence product preference. For example, the larger the sailboat's reflector, the better.



The report makes the point that "a ship's radar may only see a sailboat three or four nautical miles [six kilometers or seven kilometers] away, but that same sailboat can typically see the ship 12 nautical miles [22 kilometers] away by radar and visually at least eight nautical miles [15 kilometers] away in clear weather."

Report of the NSW State Coroner Into the 1998 Sydney to Hobart Yacht Race. New South Wales (NSW) State Coroner's Court. 331 pp. Available on the Internet at <www.lawlink.nsw.gov.au/lc.nsf/> or from NSW.[15]

In December 1998, during Australia's Sydney-to-Hobart Yacht Race (from Sydney, New South Wales, to Hobart, Tasmania), a storm with hurricane-strength winds and rough seas with waves 60 feet (18 meters) or higher caused such havoc on the racing fleet that five sailboats sank, six sailors died at sea, 55 sailors were rescued, and 66 of 115 sailboats were forced to retire from the race.

Of particular interest to overwater operators are testimonies that describe performance of life rafts, life vests, locator beacons and flares, and testimonies that describe difficulties encountered during search-and-rescue efforts in rough seas.

[An executive summary of the coroner's report and the actual report are available on the Internet as noted above. The entire record of the coroner's investigations, containing thousands of pages of testimonies and evidence, is available on the Internet at <www.equipped.org> or from NSW.]

Rescue Pilot. McKinnon, Dan. New York, New York, U.S.: McGraw-Hill, 2002. 302 pp. Photographs.

The author, a former U.S. Navy aviator, writes about his experiences from the mid-1950s to late-1950s when U.S. naval aviation was undergoing continuous changes in aircraft and air carrier designs. He said, "It was a unique time to observe this transition in naval aviation as a helicopter rescue pilot." He said that his primary job and that of his squadron mates was to "pluck from danger" pilots and other individuals in trouble. To accomplish such tasks, rescue pilots faced the same difficulties as those in peril.

The book discusses the changing, maturing aviation environment and the pilot's accounts of dramatic at-sea rescues, vertical-lift rescues and evacuations from the pilot's seat.

Report of the Review of Helicopter Offshore Safety and Survival. U.K. Civil Aviation Authority, Safety Regulation Group. CAP 641. February 1995. 85 pp. Annexes, appendixes, glossary. Available on the Internet at <www.caa.co.uk> or from Documedia.[5]

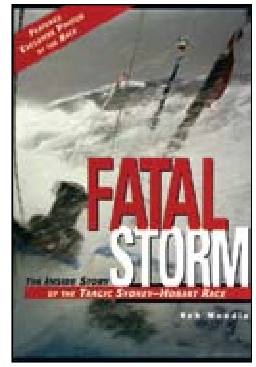
This report addresses elements of offshore helicopter safety and survival within the context of an integrated system, but it does not address causes or prevention of helicopter accidents. The review is presented as an event tree, representing all phases of offshore helicopter flight and illustrating significant points where something could go wrong. Scenarios include safe flight, ditching, impact (with or without warning), subsequent aircraft flotation or sinking, availability of life rafts, functionality of personal safety equipment, and the rescue process.

The report said, in its overall assessment of the safety and survival system in use at the time, that the success record of survival after ditchings was 100 percent successful, but the record of accident survival was less favorable, suggesting a need for greater emphasis on safety measures related to heavy impacts as opposed to ditchings.

Rotary Wing Aircraft Water Impact Test and Analyses Correlation. Wittlin, Gil; Schultz, Mike; Smith, Michael. Naval Air Warfare Center, Aircraft Division (NAWCAD). 2000. 14 pp. Figures, tables. Available from NTIS.[11]

NAWCAD and the U.S. Federal Aviation Administration jointly sponsored a program to investigate water impact dynamics and to develop analytical tools that could be used in demonstrating compliance with current civil and military ditching requirements. This technical paper reports initial findings from Phase II of the project, regarding the use of crash modeling and simulations, in lieu of scale model ditching tests. [This monograph was presented at the American Helicopter Society 56th Annual Forum in May 2000.]

Rotorcraft Ditchings and Water-related Impacts That Occurred From 1982 to 1989 — Phase I. Chen, Charles C.T.; Muller, M.; Fogarty, K.M. U. S. Federal Aviation Administration (FAA). Report DOT/FAA/CT-92/13. October 1993. 116 pp. Figures, tables, appendixes, glossary, references. Available from NTIS.[11]



Previous rotorcraft studies by the U.S. Army and FAA focused on impact terrains of all types. This document reports on phase I of a two-phase program that focused specifically on water as an impact environment to determine factors affecting occupant survivability during water impact and post-impact. The Army and FAA examined 89 rotorcraft accidents occurring in 1982–1989 and identified 77 accidents (67 from the private sector and 10 military) that met the study criteria. Three survivable water impact scenarios (vertical impact, longitudinal impact and flight path angle) were defined.

Researchers found four significant issues that contributed to survivability. Occupant survivability hazards were identified as:

- Flailing;
- Excessive decelerative loads;
- Drowning; and,
- Exposure.

Performance of aircraft flotation equipment generally was found to be inadequate, and performance of personal flotation equipment generally was found to be adequate.

Rotorcraft Ditchings and Water-related Impacts That Occurred From 1982 to 1989 — Phase II. Muller, Mark; Bark, Lindley W. U. S. Federal Aviation Administration (FAA), Technical Center. Report DOT/FAA/CT-92/14. October 1993. 39 pp. Figures, tables, appendixes, glossary, references. Available from NTIS.[11]

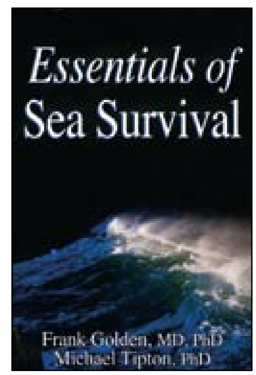
Data on rotorcraft structure and occupant hazards from 77 water-related accidents were collected in phase I of a two-phase program and analyzed in phase II. Phase I focused specifically on water as an impact environment to identify factors affecting occupant survivability during water impact and post-impact. Phase II analyzed specific aspects of the data against three impact scenarios — vertical impact, longitudinal impact and flight path angle.

Analyses showed that occupant injuries resulted primarily from flailing and excessive deceleration at impact with water, not from structural failures. Occupants used life rafts on a limited basis because rotorcraft flotation equipment was inadequate in keeping the occupied portion of the aircraft upright and afloat. To avoid entrapment, occupants rushed to evacuate without retrieving life rafts when aircraft overturned rapidly. Occupants also hurried to evacuate when water rushing into the aircraft caused life rafts to drift away from occupant reach.

To protect occupants from injury, the study identified areas needing improvements — occupant restraints and seats; cockpit and cabin hazards; life raft locations; personal flotation equipment; and rotorcraft flotation.

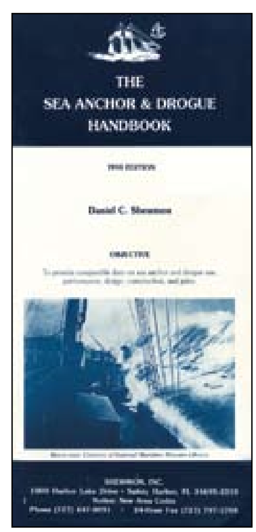
Rough Weather Rescue. W.S. Atkins Consultants. Health and Safety Executive (HSE), Offshore Division. OTO report 2001/089. 2002. 78 pp. Figures, tables, appendixes, references. Available on the Internet at <www.hse.gov.uk/research/offshore.htm> or from HSE.[6]

The report was generated from a study of types of equipment used in offshore rescues, limitations of equipment in extreme environmental conditions and effects of adverse weather conditions on equipment. The report reviews regulations and literature; training programs and practice activities; performance standards for crew and equipment; incidents of water rescues; types of equipment in use; methods and procedures for using rescue equipment and systems; and results from a survey of various industry sectors.



Recommendations address design and suitability of emergency response and rescue vessels; suitability and effectiveness of equipment; speed and safety of helicopter rescue; and the quantity and quality of training programs and practice sessions.

Rough-water Ditching Investigation of a Model of a Jet Transport With the Landing Gear Extended and With Various Ditching Aids. Thompson, William C. National Aeronautics and Space Administration (NASA), Langley Research Center. NASA Technical Note TN D-101. October 1959. 34 pp. Figures, tables, references. Availability.[9]



Researchers tested a dynamic, jet transport model (portions of the aircraft were constructed approximately to scale) in rough-water tanks to determine probable ditching behavior and resulting damage. Tests were conducted with and without the use of landing aids and with landing gear extended and retracted.

Data showed that ditching with landing gear retracted would likely tear away most of the fuselage bottom, and ditching with the landing gear extended would likely result in a dive or a "deep run," depending upon performance of the main gear. Either action would likely damage the fuselage bottom. Using landing aids, hydro-skis or hydro-foils may improve ditching performance and protect the fuselage bottom.

Safety and Survival at Sea. Lee, E.C.B.; Lee, Kenneth; editors. London, England: Greenhill Books, new edition, 1989. 358 pp. Appendixes, photographs.

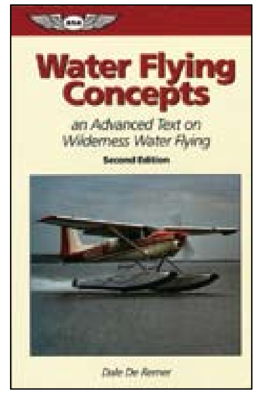
History has shown that those who have experienced trouble at sea could have improved their chances for survival significantly if they had been better prepared, better trained, better equipped and psychologically stronger. A review of numerous personal accounts that were collected following rescues reveals personal characteristics and actions that enabled individuals to survive at sea following collisions, fires, aircraft accidents, boat sinkings, acts of war and acts of nature. A section on human fallibility also is included.

Safety and Survival at Sea. Lee, E.C.B.; Lee, Kenneth. New York, New York, U.S.: W.W. Norton & Company, revised and expanded edition, 1980. 332 pp. Appendixes, illustrations, index.

One of the authors states, "The sea is capricious and the action to be taken in an emergency must depend on the prevailing circumstances, which can only be assessed on the spot. Nevertheless, there is much to be learnt from the past. We have attempted to draw conclusions from reports of disaster at sea and offer them for guidance when danger threatens."

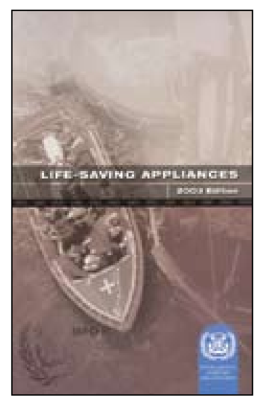
Material in this edition revises, augments and updates the first edition published in 1971. Text has been amended to reflect pronouncements by various national and international entities concerned with maritime matters. Information about medical emergencies, safety aspects, ocean engineering and hovercraft has been added.

Safety From Capsizing: Final Report of the Directors. The United States Yacht Racing Union (USYRU); The Society of Naval Architects & Marine Engineers (SNAME); Joint Committee on Safety From Capsizing. June 1985. 68 pp. Figures, appendixes, references. Available from USSA.[18]



USYRU/SNAME issued interim progress reports in 1983 and 1984 on the work of the Joint Project on Safety From Capsizing. The focus of the project was to attain an adequate understanding of the violent processes of wind and waves that cause sailing yachts to be rolled 360 degrees, to be inverted 180 degrees or to be knocked down 90 degrees. One benefit resulting from the project was a better understanding of capsize behavior and a formula that boat designers can employ.

Safety Recommendations for Offshore Sailing, Including ORC Special Regulations Governing Offshore Racing for Monohulls and Multihulls 2000–2001. International Sailing Federation (ISAF), Offshore Racing Council (ORC). 52 pp. Figures, tables, appendixes, index, Available from ISAF[8] or USSA.[18]



The ORC regulations and recommendations establish uniform minimum standards for yacht equipment (accommodations, structural features and safety gear), personal equipment and training. The regulations and recommendations apply to offshore sailing and racing environments and can serve as additional guidance for pilots and overwater operators regarding life raft and life vest specifications; radar reflectors, pyrotechnics and navigational position-fixing devices; emergency food and water; grab (ditch) bags; first aid manuals and kits; and training.

Existing regulations and submissions for changes from national authorities are reviewed annually. This particular booklet was reprinted by the US Sailing Association and includes prescriptive information to meet USSA requirements.

Safety Study — Air Carrier Overwater Emergency Equipment and Procedures. U.S. National Transportation Safety Board (NTSB), Bureau of Safety Programs. Report NTSB/SS-85/02. Jun. 12, 1985. 25 pp. Available from NTIS.[11]

The NTSB examined U.S. Federal Aviation Administration (FAA) standards and regulations for passenger-transport overwater operations in effect at that time. NTSB determined that standards and regulations reflected an FAA assumption that ditching accidents were planned events, occurring in favorable water and wind conditions. According to the study, accident history showed that inadvertent water-impact accidents were more typical than planned ditchings, and FAA requirements should be revised.

The study showed that chances of survival could be increased if improvements were made in the following areas: FAA overwater emergency regulations; basic water survival equipment; additional equipment for extended overwater flights; emergency equipment, including slides and life vests; training of flight crew and cabin crew to manage planned ditchings and inadvertent water impacts; and water rescue planning at airports located near water.

Safety Study — Emergency Evacuation of Commercial Airplanes. U.S. National Transportation Safety Board (NTSB). Safety study NTSB/SS-00/01. Jun. 27, 2000. Figures, tables, appendixes. 166 pp. Available from NTIS.[11]

The NTSB investigated 46 emergency evacuations of commercial airplanes involving 2,651 passengers that occurred between September 1997 and June 1999. Eighteen different aircraft types were represented. Summaries of evacuations in the study are included in the report, as are diagrams of aircraft configurations.

Information was collected by the NTSB from passengers, cabin crews, flight crews, air carriers and aircraft rescue and firefighting (ARFF) units. The study focused on the following safety issues:

- Certification issues related to airplane evacuation;
- Effectiveness of evacuation equipment;
- Adequacy of air carrier and ARFF guidance and procedures related to evacuations; and,
- Communication issues related to evacuation.

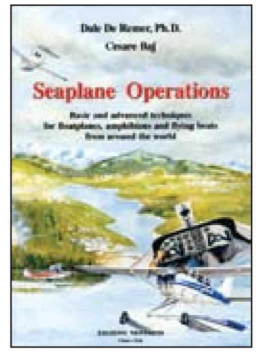
The study also compiled general statistics on evacuation, such as events leading to evacuations and numbers and types of passenger injuries incurred during evacuations.

Based on the findings, the NTSB made 20 recommendations and reiterated three safety recommendations to the U.S. Federal Aviation Administration.

[The complete safety study was reprinted by Flight Safety Foundation in *Flight Safety Digest*, December 2000.]

Sea Survival: A Manual. Robertson, Dougal. New York, New York, U.S.: Praeger Publishers, 1975. 164 pp. Tables, maps, appendixes, photographs, drawings.

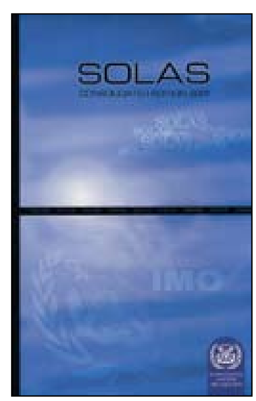
The purpose of this manual "is to provide survivors with enough information to enable them to cope with the life-and-death circumstances in which they find themselves immediately after their parent craft has sunk, and during the subsequent period of time which has to elapse before they reach safety either by rescue or by their own efforts, or, as is more usual, by a combination of both," said the author.



Information for the manual was gathered primarily from three sources: nautical knowledge and wisdom of seamen and scientists; research at practical survival institutes; and personal experiences. One example of personal survival given in the book is that of the author and five other castaways who survived a 37-day ordeal in the Pacific Ocean after their schooner was attacked and sunk by killer whales.

Seaplane Operations: Basic and Advanced Techniques for Floatplanes, Amphibians and Flying Boats From Around the World. De Remer, Dale; Baj, Cesare. Como, Italy: Edizioni Newpress, 1998. 450 pp. Figures, photographs, tables, diagrams, bibliography.

Originally written in Italian by Baj, this book subsequently was translated into English and expanded by De Remer, with the intention of transmitting knowledge of water flying to "water-flying enthusiasts, as well as people who have never seen or flown a seaplane or have never been to a seaplane base."



The book's chapters are organized according to the order of a typical flight, from takeoff to landing, with other chapters devoted to the effects of wind and water on the aircraft, water aerodromes, amphibious aircraft, multi-engine seaplanes, flight planning, aircraft choices and "seaplane art and collectibles." The authors also discuss aspects of water flying that are unique to Europe, North America and Australia — where most of the world's water flight operations are conducted.

The book includes a cutout seaplane pilot's computer, developed by Baj, along with instructions for its use. The computer can be used in determining the length of a water-landing area, the headwind component speed at the height of overflight, the aircraft's groundspeed and the length, speed and period of a wave.

SOLAS, Consolidated Edition, 2001 ***International Maritime Organization (IMO).*** London, England: IMO, third edition, 2001. 528 pp. Tables, appendixes. Availability.[7]

The IMO convened the International Convention for the Safety of Life at Sea (SOLAS), which produced SOLAS requirements to improve the safety of shipping, ship construction and ship equipment. This consolidated edition contains the text of the International Convention for the Safety of Life at Sea, 1974; its Protocol of 1988 and subsequent articles, appendixes and certificates; and amendments in effect from Jan. 1, 2001.

Of particular note to overwater operators are SOLAS requirements for personal lifesaving appliances — life rafts, immersion suits, distress flares, life vests, emergency training and practice drills, inspection and servicing of inflatable appliances, and communication signaling devices to aid in search and rescue.

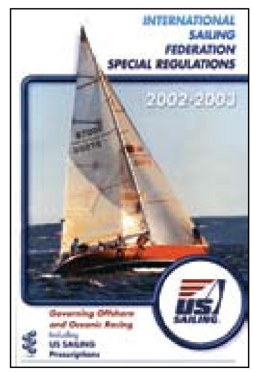
Sole Survivor. McCunn, Ruthanne Lum. Boston, Massachusetts, U.S.: Beacon Press, 1999. 239 pp. Photographs, maps.

In 1942, during World War II, German submarine torpedoes struck and sank the British merchant vessel *Benlomond* approximately 750 miles (1,389 kilometers) east of the mouth of Brazil's Amazon River while the merchant ship was en route from Cape Town, South Africa, to Dutch Guiana [Suriname]. The lone survivor, a Chinese steward named Poon Lim, floated for 133 days in one of the ship's wooden rafts to within 10 nautical miles (19 kilometers) of the Amazon, where he was rescued by a local fishing family. This is an account of his experiences as a lone survivor, intermingled with memories of his family and customs on Hainan Island, China. He applied many of the life skills he learned in Hainan to help him adapt to his immediate circumstances, capture fresh water, catch birds and fish, maximize his resources and ultimately persevere.

Staying Alive! 117 Days Adrift — the Incredible Saga of a Courageous Couple Who Outwitted Death at Sea for a Longer Period Than Any Humans Before. Bailey, Maurice; Bailey, Maralyn. New York, New York, U.S. David McKay Co., 1974. 196 pp. Photographs, illustrations, appendixes, maps.

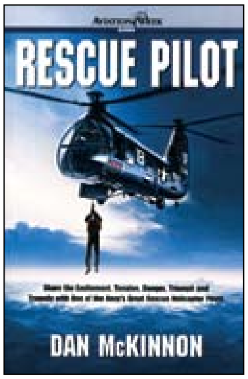
In the vicinity of the Galápagos Islands of Ecuador, during a trans-Pacific crossing, the Baileys experienced a sudden jolt and shaking of their sailboat. Moments later they observed a whale threshing its tail wildly, leaving the ocean surface reddened by blood and their sailboat with a large gash in its hull.

Fifty minutes later, the Baileys abandoned their vessel. One boarded a life raft and the other climbed into a small inflatable rubber dinghy. They drifted about 1,500 nautical miles (2,778 kilometers). Fortunately, most of the distance was across an area of the Pacific Ocean known as the tropical convergence, where the ocean current produces frequent (potable) rain and a variety of edible marine life. The Baileys were keen observers of details. They kept a journal of local marine species, their own adaptation to a very different lifestyle and their close association with and dependence upon an open ocean.



Stowage of Cabin Emergency Flotation Equipment. Society of Automotive Engineers, (SAE), S-9b Cabin Interiors and Furnishings Subcommittee. Aerospace Recommended Practice (ARP) ARP496C, revision C. March 2000. 4 pp. References. Availability.[14]

SAE standards are technical information resources that provide guidance in product design, testing, construction, maintenance, and operation of self-propelled vehicles for use on land, at sea, in the air and in space. This ARP establishes criteria for aircraft installations to ensure rapid and effective use of emergency flotation equipment in the event of ditching.



Study on Transport Airplane Unplanned Water Contact. Johnson, Richard A. U.S. Federal Aviation Administration, Technical Center. Report DOT/FAA/CT-84/3. January 1984. 36 pp. Figures, tables, references. Available from NTIS.[11]

Worldwide accident data from transport category aircraft that made inadvertent or unplanned contact with water were examined for occupant risks and survival equipment needs. Some of the findings regarding occupant risks were:

- "Unplanned water contact occurs less frequently than unplanned ground contact but more frequently than planned water landing (ditching);
- "[Such landings] lead to higher impact loads and greater fuselage damage than corresponding ground contact;
- "Flooding conditions adversely affect the ability of occupants to retrieve and make use of on-board flotation equipment; [and,]
- "Emergency flotation equipment that is intended for use during a planned ditching may not be useable during an unplanned water contact occurrence."

Survey and Analysis of Rotorcraft Flotation Systems. Muller, Mark; Greenwood, Richard; Richards, Marvin; Bark, Lindley; Simula. U.S. Federal Aviation Administration (FAA), Office of Aviation Research. Report DOT/FAA/AR-95/53. May 1996. 76 pp. Figures, tables, appendixes, references. Available from NTIS.[11]

Rotorcraft flotation system performance in water-contact accidents and ditchings was evaluated to identify areas for potential improvement. System performance data were gathered from the FAA, U.S. National Transportation Safety Board (NTSB) and the U.S. Navy.

The report said, "NTSB data showed that occupants generally survived impact conditions more severe than those defined in the FAA ditching regulations. Drowning was found to be the leading cause of death, even in rotorcraft equipped with floats."

Data also showed that rotorcraft (with and without deployed floats) in ditching and water-impact scenarios overturned immediately upon impact. These and other findings on flotation system performance resulted in recommendations for regulatory and design improvements to increase survivability.

Survival at Sea: A Practical Manual of Survival and Advice to the Shipwrecked, Assembled from an Analysis of Thirty-one Survival Stories. Robin, Bernard. Simpkin, Richard; editor and translator. Camden, Maine, U.S.: International Marine Publishing Co., 1981. 258 pp. Illustrations, appendix, index.

Bernard Robin, a French physician, said that he wanted to "give sailors the experience of all those who have actually known shipwreck and survived." He said that he was most interested in "accurate comments on how their [life] raft[s] behaved or the resources they drew from the sea." He studied shipwrecks, dating back to the year 1431, extracting relevant information.

In part 1 of the book, he summarizes 31 stories, showing "how the survivors managed and how this knowledge can be utilized." Part 2 contains information to help those who may face similar perils, battling against thirst, hunger, fatigue, climate, panic, drowning, illness, despair of not being spotted, and dangers of going ashore. He also provides practical advice for advanced preparation while still on shore.

Survival at Sea: The Development, Operation and Design of Inflatable Marine Lifesaving Equipment. Nicholl, G.W.R. London, England: Adlard Coles, 1960. 180 pp. Figures, appendixes, bibliography, photographs.

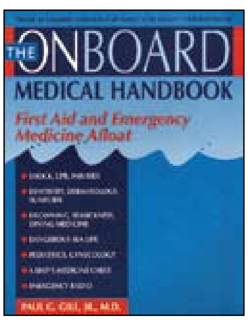
As a result of naval experiences — specifically, loss of life caused by exposure and drowning — during World War II, the British Admiralty created a committee to study lifesaving equipment and survival at sea. The committee's research led to the creation of inflatable life rafts and life vests. The book recounts the evolution of the life raft and life vest; operational, technical and design developments of life rafts, life vests and accompanying survival equipment; and regulatory and production controls.

Survival for Aircrew. Prew, Sarah-Jane. Aldershot, Hants, U.K.: Ashgate Publishing, 1999. 160 pp. Illustrations, photographs, bibliography, index.

The book is an instructional resource that focuses specifically on the role of aircrew in aviation survival situations occurring in water and wilderness regions, the major role being leadership. The book groups people into three categories: leaders (most being natural leaders), followers and obstructionists with negative attitudes. Leaders generally form about 25 percent of a given group, followers 50 percent and obstructionists 25 percent.

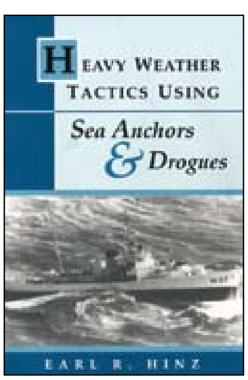
Leadership and management roles, required skills and training, and development of relationships between crew and passengers are discussed. There are brief chapters on the various aspects of advanced preparations, initial actions, equipment and rescue. Also included is a list of sources for survival equipment and training programs.

Survival Kit — Life Rafts and Slide/Rafts. Society of Automotive Engineers (SAE), S-9a Safety Equipment and Survival Systems Committee. Aerospace Recommended Practice (ARP), ARP1282, revision A. August 2000. 5 pp. References. Available from SAE.[14]



SAE standards are technical information resources that provide guidance in product design, testing, construction, maintenance and operation of self-propelled vehicles used on land, at sea, in the air and in space. This document establishes criteria for minimum survival equipment in survival kits carried with life rafts or slide/rafts on transport category airplanes — when approved radio frequency signaling devices are available for deployment.

Survival in Cold Waters: Staying Alive. Brooks, C.J.; Survival Systems. Transport Canada (TC), Marine Safety Directorate. Report TP13822E. January 2003. Figures, photographs, references, index. 92 pp. Available on the Internet <http://www.tc.gc.ca/MarineSafety/tp/Tp13822/TP13822E.pdf> or from TC.[16]



The report provides information on personal survival protection in cold water environments associated with work and leisure activities. The report is directed toward a broad audience — coroners, pathologists and physiologists; safety inspectors and investigators; manufacturers and operators; and fishing, cruise ship and petroleum industries.

The following topics are addressed:

- How and why drowning in cold water occurs; the four stages at which death may occur — initial immersion or cold shock, short-term immersion or swimming failure, long-term immersion or hypothermia, and post-rescue collapse — and protection from the four stages;
- Protection requirements based on need — constant-wear suits (i.e., workers aboard fishing boats); quick donning, ship-abandonment suits (for workers and passengers aboard cruise ships, ferries and tour boats who are currently unprotected);
- Key physical issues in the design and testing of cold-water immersion suits — water ingress (leakage), dryness, warmth, insulation and buoyancy;
- Key construction issues of cold-water immersion suits — water-integrity, fabrics, quality and technology;
- Inter-relationships between cold-water immersion suits and life vests; progress in the last 40 years regarding standards and regulations; and,
- Historical (1939–2002) reporting of cold-water immersion-suit studies and trials; accounts of cold-water accidents and incidents.

The report incorporates new information into the first edition, which was published in August 2001. Each chapter may be read as a stand-alone document. At the close of each chapter, there is a brief summary emphasizing salient points.

Survival Psychology. Leach, John. Washington Square, New York, New York, U.S.: New York University Press, 1994. 232 pp. Tables, bibliography, index.

Survival is a very personal and lonely event whether experienced alone or with others. "How [one] copes psychologically with this situation will determine whether [one] becomes a survivor or remains a victim," says the author. At the time this book was written, psychological concerns were primarily directed toward understanding and medically treating the aftermath of survival. One example of this was recognition of the medical condition called post-traumatic stress disorder.

Conversely, there was comparatively little effort being made to understand the psychological functioning of would-be survivors during actual periods of threat. This is the focus of the book — psychological functioning during survival. The book was written for seamen and aircrew, offshore and field workers, rescue workers, military personnel and all who may be called upon to plan for or deal with survival situations.

Survive the Savage Sea. Robertson, Dougal. New York, New York, U.S.: Praeger Publishers, 1973. 276 pp. Maps, photographs, drawings, glossary.

The Robertson family decided to leave the family farm in England and circumnavigate the world aboard a 43-foot (13-meter) schooner to enrich the children's education. By the time they reached the Canary Islands, they were seasoned seafarers.

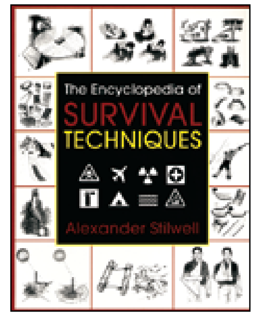
While sailing from the Galápagos Islands, Chile, to New Zealand, the schooner was suddenly struck by killer whales, and it sank in 60 seconds. Six castaways, in an inflatable rubber raft and a dinghy (a small boat), changed course and headed for Costa Rica, an estimated 50 days away. Their 37-day ordeal and subsequent rescue are recounted, day by day. Their fears and hopes, their determination to live, the techniques that enabled them to survive and lessons they learned are included.

Surviving the Storm: Coastal & Offshore Tactics. Dashew, Steve; Dashew, Linda. Tucson, Arizona, U.S.: Beowulf, 1999. 684 pp. Charts, photographs, index.

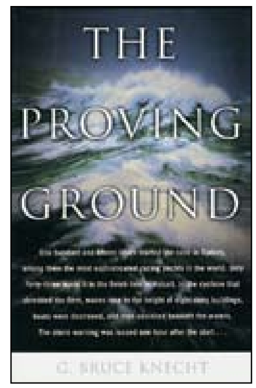
Storms at sea (heavy weather) fall into three categories based upon wind and sea conditions. The least serious are normal gales that make the crew uncomfortable and tax the vessel. The second category requires caution, good decision making and good seamanship to handle more challenging (not necessarily dangerous) conditions. "Survival storms," the most serious of all, are rare and can result in catastrophe for crew or vessel or both.

According to the authors, "mariners strive to avoid direct experience with heavy weather," and consequently limit their skills and limit advance preparation. The book is filled with descriptive accounts of people and vessels in survival storm conditions so that readers may learn from experiences of others. Human factors issues and preparing and using life rafts in heavy weather are included.

Survivor. Greenwald, Michael. San Diego, California, U.S.: Blue Horizons Press, 1989. 628 pp. Bibliography, index, illustrations, photographs.



"The most difficult aspect of survival preparation is the unique character of each situation and the limit of that for which one can prepare," said the author. This book was written as an instructive manual to improve chances for surviving a boating disaster. Examples of actual boating disasters are followed by accounts of lengthy survivals at sea. Detailed explanations, such as the physiology of water loss, and descriptions of events, such as "good reasons to abandon ship," could help anyone in a water-operations environment prepare for contingencies, whether from aircraft ditchings or sailboat sinkings.

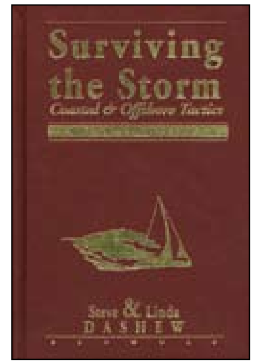


Test of Etafoam Buoyancy Material for Life Jackets Regarding Water Absorption. Påsche, Arvid. Sintef-Unimed, Section for Extreme Work Environment. Report STF23 A94030. Sept. 12, 1994. 6 pp. Table. Available from NTIS.[11]

In 1987, the buoyancy material, Etafoam, used in life vest construction, was evaluated for water absorption, using International Maritime Organization (IMO) test protocol. The water absorption test was repeated in 1994, against revised IMO requirements. After seven days of immersion in fresh water, the buoyancy material showed no sign of damage or change in mechanical properties and met the revised IMO acceptance requirements. Both tests were conducted in Trondheim, Norway, by Sintef-Unimed.

The Captain's Guide to Liferaft Survival. Cargal, Michael. Dobbs Ferry, New York, U.S.: Sheridan House, 1990. 198 pp. Appendixes, charts, illustrations, index.

The author, a U.S.-licensed master mariner with 20 years of experience as captain of merchant vessels around the world, says, "Life rafts certified for ocean service typically carry enough water and food for three to seven days. The raft itself might be guaranteed only for 30 days." His book discusses elements needed for short-term and



long-term survival in a life raft or lifeboat — leadership, teamwork, navigation aides, signaling, medical care and obtaining food and water. The book is concise and written in an easy-to-read style.

The Development of an Easily Recovered Liferaft. Paterson, R.B.; Sullivan, C.A. Transport Canada, Transportation Development Centre (TDC). Publication TP 13041E. March 1997. 130 pp. Figures, tables, illustrations, appendixes, glossary, references. Available from NTIS.[11]

The search-and-rescue (SAR) community was concerned that life rafts and associated recovery procedures in use at that time were inadequate for rescues in Canada's east coast waters where sea conditions can be too severe to permit rescue operations using standard procedures. The Canadian Coast Guard and TDC's Safety and Security project initiated a research program to investigate methods that could improve survivability during occupied life raft recovery by large vessels such as passenger ferries and smaller vessels such as fishing boats.

The study focused on two areas for improvement: seakeeping performance of life rafts to reduce capsize and performance of recovery systems. The report describes recovery systems, raft modifications and results of sea trials, concluding that test results proved promising and that further evaluation, development and discussions with the SAR community were warranted.

The Encyclopedia of Survival Techniques. Stilwell, Alexander. Guilford, Connecticut, U.S.: The Lyons Press, 2000. 192 pp. Appendix, illustrations, index.

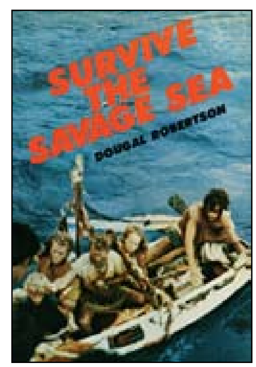
"The mental and physical quality that is most required of you as a survivor is endurance," said the author. He informs readers that they already possess the innate qualities necessary to survive — determination, perseverance, ingenuity and humor. All that is needed is to adapt these qualities, as quickly as possible, to the new circumstances.

The first part of the book gives an overview of survival techniques within the context of global regions. For example, one chapter is devoted to survival at sea: life rafts; survival and first aid kits; acquiring potable water and food; dangerous sea life; navigation, weather and ocean currents; and signaling and rescue. More detailed information is provided in the second half of the book.

The Evaluation of Surface Evacuation Procedures for a Ditched Helicopter. The CORD Group; National Energy Board, Program of Energy Research and Development. PERD report 200-9. July 1995. 99 pp. Tables, annexes, references. Available from NTIS.[11]

Preceding this Canadian study, there had been disagreement among offshore helicopter operators and training organizations, in Canada and internationally, regarding the best procedures to follow for evacuation from a ditched helicopter into life rafts. In the traditional or "dry shod" method, life rafts are inflated alongside the floating helicopter and held against the aircraft as passengers and crew step aboard. The other accepted method, called "wet" or "swim away" procedure, requires passengers and crew (wearing immersion suits) to swim clear of the helicopter before inflating and boarding life rafts.

As there had been no practical, scientific data differentiating between the two methods, the study team reviewed helicopter water-related accident reports and conducted a series of simulated helicopter evacuation trials in calm water, using both methods. The report recommends that further studies should include field trials of both methods for windward and leeward evacuations and that passengers and crew should be taught both methods and understand the advantages and disadvantages of each method.



The Evaluation of Surface Evacuation Procedures for a Ditched Helicopter — Phase II. Cord Group; National Energy Board, Program of Energy Research and Development. PERD report 200-17. December 1996. 105 pp. Tables, annexes, references. Available from NTIS.[11]

Phase II of this Canadian study was conducted as recommended in PERD report 200-9, the phase I study that compared simulated helicopter evacuation trials in calm waters, using wet and dry evacuations. [The dry method for evacuating an upright, ditched helicopter is to inflate a life raft alongside the floating helicopter and subsequently hold the raft against the aircraft as passengers and crew step aboard. The wet evacuation requires passengers and crew, wearing immersion suits, to swim clear of the helicopter before inflating and boarding life rafts.]

Phase II describes experiments conducted in wet and dry evacuations in severe sea state conditions. Using a helicopter simulator, Norwegian Underwater Technology Centre (NUTEC) conducted wet and dry evacuations from the windward and leeward sides of the helicopter into aviation life rafts with canopies and aviation life rafts without canopies. "The results indicate that the preferred method of evacuation is the dry method, on the windward side, using a non-canopy life raft," said the report. Included with the report is the text of the "Instructor's Guidance Course in Helicopter Surface Evacuation for Persons Taking Part in Evacuation Tests at NUTEC."

The Leeway of Persons-In-Water and Three Small Craft. Allen, A.A.; Robe, R.Q.; Morton, E.T. U.S. Coast Guard Research and Development Center. Report CG-D-09-00. July 1999. 151 pp. Available from NTIS.[11]

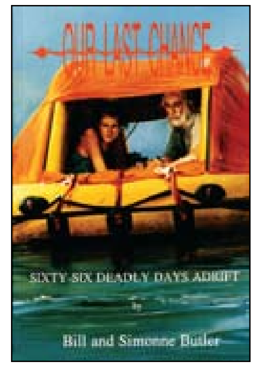
In preparation for a search operation, planners determine the area over which the search will be conducted, defining the smallest, most reasonable area where survivors or their craft may be located. The size of the search area is directly related to the last known position (LKP) of a search object, time of LKP, wind, ocean currents and type of search object. "While current-induced search object motion generally follows the surface water movement, the action of wind on a survivor or survivor craft leads to a drift direction that is usually different from the downwind direction," the report said.

Movement of survivors or objects through the water, caused by wind acting on their exposed surfaces is termed "leeway." This report describes experiments to determine leeway values for various persons and objects in open water to provide verifiable leeway planning guidance.

The Onboard Medical Handbook: First Aid and Emergency Medicine Afloat. Gill, Paul G., Jr. Camden, Maine, U.S.: International Marine/ Ragged Mountain Press, 1997. 240 pp. Figures, tables, appendix, glossary, index.

This is the revised edition of a previously published book, *The Waterlover's Guide to Marine Medicine*. The author's observation of boating enthusiasts, as a group, is that they want to know how things work and that they enjoy using their analytical skills to solve problems. He took this into account while writing this book, going beyond the usual "signs, symptoms and treatments" to explain how various illnesses and injuries disrupt normal anatomy and physiology.

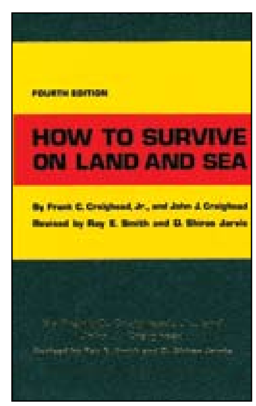
The book is organized in a general-to-specific format, beginning with cardiac arrest, shock and airway emergencies. The next five chapters address injuries to organ systems. Thirteen chapters cover specific marine medical problems, such as survival-at-sea. Chapters 20–26 are new to this edition and describe treatments for a variety of common medical problems affecting cruisers, including children. The book recommends an extensive inventory for the boat's medical kit and contains quick-reference sheets with step-by-step instructions for rapid handling of the nine most critical medical emergencies.



The Outward Bound Wilderness First-aid Handbook. Isaac, Jeffrey. New York, New York, U.S.: The Lyons Press, revised and updated edition, 1998. 272 pp. Appendix, illustrations, glossary, index.

The modern medical system permits the general population to maintain an acceptable level of comfort with the risks of daily living while knowing very little about emergency care. As a matter of routine, most people delegate responsibilities for medical emergencies and subsequent treatments to trained medical professionals. Responsibilities shift, however, when emergencies occur in locations where medical professionals are not immediately available.

To help in such situations, this handbook explains the principles of body functions, in health and in injury, and teaches readers how to apply basic knowledge and common sense to a wide variety of medical problems. Several sections in the book can be applied in aviation environments — major body systems and their functions; organized thinking; patient or situation assessment; problems with body core temperature; cold injuries; near drownings; first aid kits and medical kits; and symptoms and treatments of common medical problems.



The Proving Ground: The Inside Story of the 1998 Sydney to Hobart Race. Knecht, G. Bruce. New York, New York, U.S.: Little, Brown and Co., 2001. 308 pp. Photographs, illustrations, map.

The book reconstructs events which occurred in the 1998 Sidney-to-Hobart Yacht Race. Sailboats of many sizes raced from Sidney, to Hobart, Australia, a distance of 630 nautical miles (1,167 kilometers). According to the book, "many yachtsmen believe that every seventh Hobart [race] is subject to a special curse," with particularly severe storms causing serious harm to sailors and yachts. This 1998 race was one of those years.

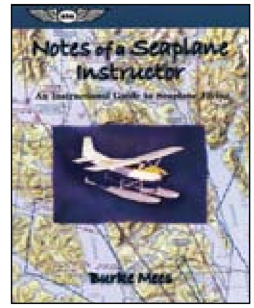
The book focuses on three yachts, profiling crewmembers and describing moment-to-moment events — while aboard their yachts, in their life rafts and during search-and-rescue operations.

The Sea Anchor and Drogue Handbook. Shewmon, Daniel C. Safety Harbor, Florida, U.S.: Self-published, 1998. 176 pp. Figures, tables, photographs, illustrations.

The handbook explains the differences between sea anchors and drogues and describes appropriate use of each. A sea anchor is deployed over the bow (front) of a boat where the water is too deep for ground anchoring. A drogue is launched over the stern (back) of a boat and exhibits a braking effect to slow the vessel. In discussions about sea anchors and drogues, the following topics are covered: historical background; how they function; sea and wind conditions; deployment and recovery; care and maintenance; construction and materials; design considerations and design types; and accessories.

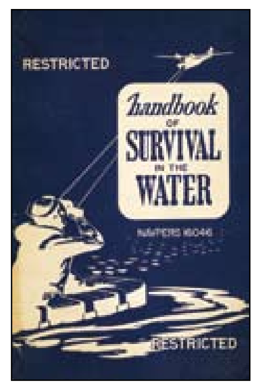
The Wilderness Medical Associates Field Guide. Morrissey, Jim. Bryant Pond, Maine, U.S.: Wilderness Medical Associates (WMA), third edition, 2000. 99 pp. Figures, tables, glossary, illustrations, index.

The field guide was written for wilderness travelers, outdoor professionals and rescue specialists who have completed the WMA training course or its equivalent. Its intended use is as a quick-reference tool for persons who are trained or experienced in emergency medicine and wilderness rescue. It contains guidelines for patient assessment to identify urgent problems, assignment of treatment priorities, patient management and patient transport. It also addresses common medical problems, rescue kits, survival kits and rescue operations.



Transport Water Impact and Ditching Performance. Patel, Amit A.; Greenwood, Richard P., Jr. U.S. Federal Aviation Administration (FAA), Office of Aviation Research. Report DOT/FAA/AR-95/54. March 1996. 68 pp. Figures, tables, appendixes, references. Available from NTIS.[11]

The study identified water-contact accidents occurring from 1959 to 1991 and examined structural features, fuselage breakup patterns, subsystem failures, cabin interiors as they related to injuries and fatalities, and interactions between passengers and their surroundings. These elements were examined within the context of relevant U.S. Federal Aviation Regulations (FARs) and aircraft ditching certification requirements.



Two findings of particular note are that the majority of water-related mishaps occur during flight phases with close proximity to an airport; and approximately three-fourths of all worldwide transport airports having international flights require approaches over significant bodies of water. Other findings address airport runways, seat cushion flotation, life vests, training, emergency procedures and emergency equipment.

Analysis of a survey of transport category airports located near significant bodies of water is included in the report.

Transport Water Impact, Part II. Tahliani, Jagdeep M.; Muller, Mark. U.S. Federal Aviation Administration, Office of Aviation Research. Report DOT/FAA/AR-95/112. May 1996. 114 pp. Figures, tables, appendixes, references. Available from NTIS.[11]

This report covers the second part of a program to study overwater operating environments of jet transport aircraft. In the first section of this report, a mathematical model was used to predict the outcome of actual land accidents had they occurred in water. Findings showed that post-impact fatalities were almost 2-1/2 times higher in water accidents than in land accidents.

The second section focuses on airport water rescue. Key findings are related to water rescue capabilities, proximity to water, new techniques, new equipment and regulations. For example, 38 percent of airports located immediately adjacent to water have no water-rescue capability.

Emergency flotation devices (life vests, seat cushions and life rafts) are reviewed in the third section and recommendations for their improvement are made.

United States National Search and Rescue Supplement to the International Aeronautical and Maritime Search and Rescue Manual. National Search and Rescue Committee (NSARC). Washington, D.C., U.S., May 2000. 234 pp. Figures, tables, appendixes, charts, glossary, index. Available on the Internet at <www.uscg.mil/hq/g-o/g-opr/sar.htm> or from the NSARC.[10]

The NSARC is a U.S. government committee that coordinates search-and-rescue (SAR) matters of interagency interest within the U.S. and provides guidance to these agencies regarding National Search and Rescue Plan (NSP) implementation. The NSP is based upon the principle that "no single U.S. organization has sufficient SAR resources to provide adequate SAR services," and "SAR authorities should use 'all available' resources, including federal, state, local, private and volunteer resources, to respond to persons and property in distress."

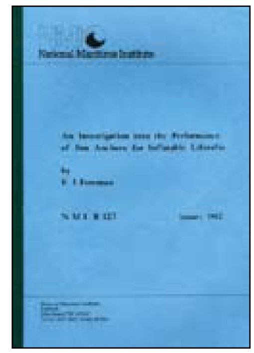
This supplementary manual provides specific national standards and guidelines to all federal forces (military and civilian) that support civil SAR operations. It is based upon provisions, standards, and recommendations of the International Civil Aviation Organization, the International Maritime Organization and other international organizations, and serves as a training tool and an operational tool.

Water Flying Concepts: An Advanced Text on Wilderness Water Flying. De Remer, Dale. Newcastle, Washington, U.S.: Aviation Supplies and Academics, second edition, 2002. 263 pp. Photographs, figures, glossary, bibliography.

De Remer, a professor at the Center for Aerospace Sciences at the University of North Dakota in Grand Forks, North Dakota, U.S., teaches advanced wilderness seaplane pilot courses and has written this book for pilots who already understand the basics of water flying.

The book discusses seaplane takeoff performance and takeoff techniques, center-of-gravity effects on seaplanes, external loads, reducing water drag, stability on the water, and flight planning and decision making in wilderness flying.

A separate chapter — written by Paul Johnson, a pilot and search-and-rescue volunteer — discusses survival issues for seaplane pilots who find themselves "down in the bush, perhaps hundreds of miles from civilization." Johnson's discussion of land-survival techniques includes how to cope with thirst, pain, cold temperatures, fatigue and boredom. He emphasizes the importance of immediately assessing the situation and establishing priorities for being rescued.

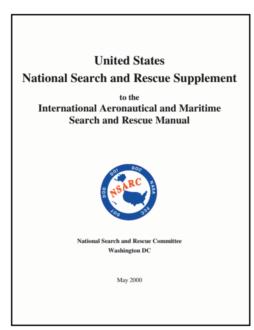


When Seconds Count: Care and Use of Immersion Suits. University of Alaska Marine Advisory Program; Alaska Marine Safety Education Association (AMSEA). 1998. Videotape, 15 minutes. Available from AMSEA.[2]

The videotape is a comprehensive and practical guide, explaining how to keep cold-water immersion suits in top condition and how to don them quickly and correctly. Additional topics covered are: sizing to one's body, personal product selection, features common among branded products, stowage and maintenance.

Wilderness Medicine: Beyond First Aid. Forgey, William. Old Saybrook, Connecticut, U.S.: The Globe Pequot Press, fourth edition, 1994. 252 pp. Figures, tables, appendixes, illustrations, glossary, index.

Leadership and behavior issues, not medical problems, are the most significant challenges to safety. Breakdowns in either area can "lead to the most significant of wilderness accidents — accidents which can easily magnify into serious medical disasters," the book says. Pre-trip preparation, (i.e., physical and mental conditioning), medical assessment and management of injuries and illnesses, and first aid/medical kits are emphasized.



An ideal medical kit is modular and contains multi-functional components. Instructions for compiling modules and lists of medical resources are included.■

Sources

1. Air University Library/
   LDRRX Interlibrary Loans
   600 Chennault Circle
   Maxwell Air Force Base, AL 36112 U.S.

2 Alaska Marine Safety Education Association
   P.O. Box 2592
   2924 Halibut Point Road
   Sitka, AK 99835 U.S.

3. Australian Petroleum Production &
   Exploration Association
   GPO Box 2201
   Canberra ACT 2601 Australia

4. British Maritime Technology
   Orlando House, 1 Waldegrave Road
   Teddington, Middlesex TW11 8LZ U.K.

5. Documedia Solutions
   37 Windsor St.
   Cheltenham, Gloucestershire GL52 2DG U.K.
   Internet: <www.documedia.co.uk>

6. HSE Books
   P. O. Box 1999
   Sudbury, Suffolk CO10 2WA U.K.
   Internet: <www.hsebooks.co.uk>

7. International Maritime Organization
   4 Albert Embankment
   London, England SE1 7SR U.K.
   Internet: <www.imo.org>

8 International Sailing Federation
   Ariadne House
   Town Quay, Southampton SO14 2AQ U. K.

9. NASA Center for Aerospace Information
   7121 Standards Drive
   Hanover, MD 21076 U.S.

10. National Search and Rescue Committee
    2100 Second St. SW, Suite 3106
    Washington, DC 20593 U.S.

11. National Technical Information Service
    5285 Port Royal Road
    Springfield, VA 22161 U.S.
    Internet: <www.ntis.gov>

12. Opportunity Productions
    2506 North Jefferson
    Enid, OK 73701 U.S.

13. RTCA
    1828 L St. NW, Suite 805
    Washington, DC 20036 U.S.

14. SAE World Headquarters
    400 Commonwealth Drive
    Warrendale, PA 15096 U.S.

15. The Clerk of the Court
    NSW State Coroner's Court
    44-46 Parramatta Road
    Glebe, New South Wales 2037Australia

16. Transport Canada
    Marine (AMSRE)
    Place de Ville, Tower C
    330 Sparks Street
    Ottawa, Ontario K1A 0N8 Canada

17. Transportation Safety Board of Canada
    Head Office
    200 Promenade du Portage
    Place du Centre, 4th Floor
    Hull, Quebec K1A 1K8 Canada

18. US Sailing Association
    P.O. Box 1260
    15 Maritime Drive
    Portsmouth, RI 02871 U.S.
    Internet: <www.ussailing.org>

Photo Credits

Front cover–© copyright 2004 Corbis

Inside front cover, page iv, 2, 110, 148, 232, 386, 468, 630–© copyright 2004 Corbis

Ditching

Page 1–U.S. Coast Guard

The Unthinkable Happens

Page 3–U.K. Air Accidents Investigation Branch

Page 5–© copyright 2004 Getty Images Inc.

Page 6–© copyright 2004 Getty Images Inc.

Page 8–© copyright 2004 Getty Images Inc.

Page 9–U.S. National Aeronautics and Space Administration (NASA) Langley Research Center

Page 10–Library of Congress, Prints & Photographs Division FSA/OWI Collection, Reproduction No. LC-USW3-033064-C

Page 11–Library of Congress, Prints & Photographs Division FSA/OWI Collection, Reproduction No. LC-USW3-032635-C

Page 15–© copyright 2004 Getty Images Inc.

Prepare to Ditch

Page 20–U.S. National Oceanic and Atmospheric Administration (NOAA)

Page 22–© copyright 2004 Getty Images Inc.

Page 32–© copyright 2000 PhotoDisc Inc.

Page 33–ARINC

Page 35–U.S. Coast Guard

Page 36–© copyright 2003 Corbis

Page 42–Flight Safety Foundation

Page 44–Cessna Aircraft Co.

Page 47–U.S. Coast Guard

Page 48–U.S. Coast Guard

Page 62–Flight Safety Foundation

Ditching Certification: What Does It Mean?

Page 66–Dassault Falcon

Page 68–Embraer

Page 69–Bombardier Aerospace

Page 70–Raytheon Aircraft Co.

Page 71–U.S. National Aeronautics and Space Administration

Page 72–U.S. National Aeronautics and Space Administration

Page 75–U.S. National Aeronautics and Space Administration

Page 76–U.S. National Aeronautics and Space Administration

Accident Experience Influences Helicopter Overwater Operations

Page 78–U.S. Coast Guard

Page 82–© copyright 2004 Corbis

Imagine the Worst Helicopter Ditching — Now Get Ready for It

Page 85–Civil Aviation Safety Authority–Australia

Offshore Helicopter Operators' Emergency Systems Incorporate Rescue Planning

Page 95–© copyright 2004 Corbis

Helicopter Hull-flotation Systems Reduce the Risk of Rapid Sinking

Page 103–Apical Industries

Page 105–Atlantic Airways

Search and Rescue

Page 109–U.S. Coast Guard

The Search-and-rescue System Will Find You — If You Help

Page 111–U.S. Coast Guard

Page 113–U.S. Coast Guard

Page 117–U.S. Coast Guard

Page 118–U.S. Coast Guard

Page 120–Gloria Heath

Page 121–Gloria Heath

A Signal for Help Is Heard, Help Arrives Too Late

Stay Tuned: A Guide to Emergency Radio Beacons

Page 139–Flight Safety Foundation

Survival

Page 147–A life raft at sea near Bermuda, before the crew of the hospital ship *USNS Comfort* rescued a survivor of a capsized fishing vessel. U.S. Navy photo by Journalist 2nd class J. Maurer.

Keeping Your Head Above Water When Your Aircraft Isn't

Page 149–Flight Safety Foundation

Page 150–Flight Safety Foundation

Page 151(upper right)–Flight Safety Foundation

Page 151(lower right)–Flight Safety Foundation

Page 152–Flight Safety Foundation

Page 155–Flight Safety Foundation

Page 156–Flight Safety Foundation

Page 157–Flight Safety Foundation

Page 160–Flight Safety Foundation

Page 162–Flight Safety Foundation

Page 165–Flight Safety Foundation

Page 166–Flight Safety Foundation

Page 167–Flight Safety Foundation

Page 168–Flight Safety Foundation

Page 171–Flight Safety Foundation

Page 172–Flight Safety Foundation

Page 173–Rescue Technologies Corp.

Page 174–U.S. Navy

'Water, Water, Everywhere, Nor Any Drop to Drink … '

Page 177–© copyright 2004 Getty Images Inc.

Page 178–Flight Safety Foundation

Page 179 (photos 1 and 2)–Flight Safety Foundation

Page 180–Katadyn North America

Page 182 (photos 1–4)– Flight Safety Foundation

Is There a Doctor Aboard the Life Raft?

Page 187–© copyright 2004 Getty Images Inc.

Page 198–© copyright 2004 Getty Images Inc.

Page 200–© copyright 2004 Getty Images Inc.

What's Eating You? It's Probably Not a Shark

Page 211–© copyright 2004 Getty Images Inc.

Page 212–© copyright 2004 Getty Images Inc.

Page 218–© copyright 2004 Corbis

Page 220–Florida Keys National Marine Sanctuary

Page 221–© copyright 2004 Getty Images Inc.

Page 222–U.S. National Oceanic and Atmospheric Administration Oceanic and Atmospheric Research/National Undersea Research Program

Aviators and Sailors in the Water Depend on the Same Rescue Resources

Page 225–U.S. Navy

Page 227–U.S. Navy

Page 228–U.S. Navy

Equipment and Training

Page 231–Aviation Egress Systems

A Life Raft Primer: Guidelines for Evaluation

Page 233–Flight Safety Foundation

Page 234–Flight Safety Foundation

Page 235 (upper right)–Flight Safety Foundation

Page 235 (lower left)–Flight Safety Foundation

Page 236 (upper left)–Flight Safety Foundation

Page 236 (lower right)–Winslow LifeRaft Co.

Page 238 (top)–Air Cruisers Co.
(bottom) Eastern Aero Marine

Page 239 (top)–Goodrich Corp.
(bottom) Hoover Industries

Page 240 (top)–RFD/Revere
(bottom) Survival Products

Page 241–Winslow LifeRaft Co.

Page 242–Flight Safety Foundation

Page 243–Flight Safety Foundation

Page 244–Flight Safety Foundation

Page 245–Flight Safety Foundation

Page 249–Flight Safety Foundation

Page 250–Flight Safety Foundation

Page 251–Flight Safety Foundation

Page 252–Flight Safety Foundation

Page 254–Flight Safety Foundation

Page 255–Flight Safety Foundation

Life Raft Evaluation: Pooling the Resources

Pages 258–335–Flight Safety Foundation

Primary photography for "Life Raft Evaluation: Pooling the Resources" by:

Michael J. Bailey (underwater video)

Nyle Leatham

Rick Lindstrom (video)

Chris Nelson (underwater still photography)

Douglas S. Ritter

Kim Rosenlof

Steve White

Physical Fitness for Life Rafts and Life Vests

Page 337–Flight Safety Foundation

Your Life Vest Can Save Your Life … If It Doesn't Kill You First

Page 346–Flight Safety Foundation

Page 347–Switlik Parachute Co.

Page 350–Flight Safety Foundation

Page 352–Switlik Parachute Co.

Cold Outside, Warm Inside

Page 357–Flight Safety Foundation

Page 358–Mustang Survival Corp.

Page 360–Mustang Survival Corp.

HEED This

Page 365–Flight Safety Foundation

Page 366–MSI-Defence Systems (Weymouth)

Page 369–MSI-Defence Systems (Weymouth)

Train to Survive the Unthinkable

Page 372–Flight Safety Foundation

Page 374–Flight Safety Foundation

Page 375–Aviation Egress Systems

Page 376–Flight Safety Foundation

Regulations

Page 385–Flight Safety Foundation

Regulations, Judgment Affect Overwater Equipment Decisions

Page 387— Duncan Aviation

Stats

Page 467–© copyright 2004 Getty Images Inc.

References

Page 629–Flight Safety Foundation

Photo Credits

Page 659–Flight Safety Foundation

We Encourage Reprints

Articles in this publication/compact disc, in the interest of aviation safety, may be reprinted in whole or in part, but may not be offered for sale directly or indirectly, used commercially or distributed electronically on the Internet or on any other electronic media without the express written permission of Flight Safety Foundation's director of publications. All uses must credit Flight Safety Foundation, *Flight Safety Digest*, the specific article(s) and the author(s). Please send two copies of the reprinted material to the director of publications. These restrictions apply to all Flight Safety Foundation publications. Reprints/duplicate CDs must be ordered from the Foundation. For more information, contact the director of publications by telephone: +1 (703) 739-6700, ext. 116; or by e-mail: <rozelle@flightsafety.org>.

What's Your Input?

In keeping with the Foundation's independent and nonpartisan mission to disseminate objective safety information, FSF publications solicit credible contributions that foster thought-provoking discussion of aviation safety issues. If you have an article proposal, a completed manuscript or a technical paper that may be appropriate for *Flight Safety Digest*, please contact the director of publications. Reasonable care will be taken in handling a manuscript, but Flight Safety Foundation assumes no responsibility for material submitted. The publications staff reserves the right to edit all published submissions. The Foundation buys all rights to manuscripts and payment is made to authors upon publication. Contact the Publications Department for more information.

Flight Safety Digest

Staff: Roger Rozelle, director of publications; Mark Lacagnina, senior editor; Wayne Rosenkrans, senior editor; Linda Werfelman, senior editor; Rick Darby, associate editor; Karen K. Ehrlich, web and print production coordinator; Ann L. Mullikin, production designer; Susan D. Reed, production specialist; and Patricia Setze, librarian, Jerry Lederer Aviation Safety Library

Subscriptions: One year subscription for 12 issues includes postage and handling: US$480. Include old and new addresses when requesting address change. • Attention: Ahlam Wahdan, membership services coordinator, Flight Safety Foundation, Suite 300, 601 Madison Street, Alexandria, VA 22314 U.S. • Telephone: +1 (703) 739-6700 • Fax: +1 (703) 739-6708 • E-mail: <wahdan@flightsafety.org>