Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report – 200502137

Final

Evacuation
Hobart Airport
17 May 2005
VH-VQI
Boeing 717-200

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Figure 6 : Hobart Airport Rescue and Fire Fighting Service.

Abstract

On 17 May 2005, a Boeing 717-200, registered VH-VQI, was scheduled to operate a regular public transport flight from Hobart to Sydney, departing at 0600 Eastern Standard Time. During the starting of the right engine, the aircraft dispatcher informed the flight crew that there was smoke and sparks shooting from the right engine and advised 'we'll have to get everyone off'. The pilot in command called for an emergency evacuation without initiating the Passenger Evacuation Checklist. As a result, the wing flaps were not set to the extended position and the tail section of the aircraft was dark without emergency lighting while passengers were exiting the aircraft. All three of the floor level exits were opened by cabin crew. The forward Door Right 1 escape slide fell to the ground uninflated when the door was opened. A number of ground personnel ran to the front of the aircraft and helped 22 passengers off the forward Door Left 1 slide and directed them towards the terminal. Four passengers exited by the Door 2 slide at the rear of the aircraft and ran into the middle of the apron. The overwing exits were not opened. The aircraft's dispatcher had not received any education in emergency communications with flight crew nor aircraft evacuations at the terminal. The flight crew were engaged in conversations not confined to the engine start process or other operational matters during both engine start sequences until the problem with the right engine was first mentioned by the dispatcher. The reported smoke and sparks was a result of the right engine air turbine starter failing during the engine start sequence.

ABBREVIATIONS

ARFFS	Aviation Rescue and Fire Fighting Service
CM	Cabin Manager
D2	Door 2 (rear exit)
FAA	Federal Aviation Administration of the United States
FAR	Federal Aviation Regulation of the United States
L1	Door Left 1 (main entry door)
LAME	Licensed Aircraft Maintenance Engineer
PIC	Pilot in Command
R1	Door Right 1 (service door)

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

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It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

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The ATSB does not have the resources to carry out a full cost-benefit analysis of each safety recommendation. The cost of a recommendation must be balanced against its benefits to safety, and transport safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed (for example, the relevant regulatory authority in aviation, marine or rail in consultation with the industry).

EXECUTIVE SUMMARY

On 17 May 2005, a Boeing 717-200 aircraft, registered VH-VQI, was scheduled to operate a regular public transport flight from Hobart, Tas, to Sydney, NSW, departing at 0600 Eastern Standard Time, with 6 crew and 26 passengers. During the starting of the right engine at 0606, the aircraft dispatcher noticed sparks on the outer right side of the engine cowl and informed the pilot in command (PIC) to shut down the right engine as there was a fire. The sparks were due to a failure of the right engine air turbine starter during the engine start sequence. As the right engine was spooling down, the dispatcher noticed that the amount of sparks and smoke was still increasing and he told the PIC 'we'll have to get everyone off'. The PIC replied 'Do you want me to do an evacuation?' which the dispatcher confirmed. The PIC then immediately made a public address system (PA) announcement 'This is your captain. Evacuate, evacuate, evacuate'. The investigation found that the flight crew were engaged in conversations not confined to the engine start process or other operational matters during both engine start sequences. The operator's sterile flight deck policy for flight crew did not commence until after the engines were started. There was some misinterpretation of information between the aircraft dispatcher and PIC due to a lack of standard phraseology and no evacuation awareness education for aircraft dispatchers.

Twenty three seconds after the PIC made the evacuation PA announcement, he called for flaps 25. Eight seconds later, at the PIC's direction, the copilot started to read the 'Passenger Evacuation Checklist' from the checklist card they had been using for earlier checks. The evacuation occurred while the morning was still in darkness. As a result of the PIC calling for the passengers to evacuate the aircraft before the Passenger Evacuation Checklist was initiated: the wing flaps were not set to the extended position while passengers were exiting the aircraft (as is necessary when using overwing exits); the emergency lights in the dark tail section of the aircraft were not illuminated during the evacuation; and the copilot was still completing the checklist with the PIC in the cockpit up to the time all passengers had evacuated and so could not direct the evacuation from the ground. As a further result, the cabin crew evacuated themselves from the aircraft without making any contact with the flight crew and the flight deck door remained closed and locked.

All three of the floor level exits were opened by the cabin crew. When the cabin manager (CM) opened forward Door Left 1 (L1) outwards, a queue of passengers was waiting behind her and the first passenger started to run out the door until the CM yelled 'wait' and grabbed the back of his clothing and pulled him back. Then she pushed the door open fully and the evacuation slide inflated. The investigation found that the operator's door opening procedures called for flight attendants to guard the door while they were being opened for an emergency evacuation, but did not provide instructions for flight attendants to explain to passengers to wait as the slide was still inflating.

When the forward Door Right 1 (R1) flight attendant opened that door, the escape slide was pulled out of the door and fell to the ground still contained in its clear bag. The flight attendant then grabbed hold of the handle and repeated 'blocked exit, move forward'. The investigation found that the door may have been incorrectly armed before the evacuation. The R1 flight attendant was unaware that this door's girt bar had a fixed floor bracket rather than two spring latches. The operator's

procedures called for visual cross-checking of the door arming from the opposite side of the aircraft and did not include touch confirmation.

A number of ground personnel ran to the front of the aircraft and assisted the 21 adult passengers and one infant who exited through the L1 door and slide. These passengers were helped off the slide and were directed towards the terminal by the ground staff. After about three passengers were down the L1 slide, the aircraft's tail cone was ejected. Four passengers exited by the Door 2 slide at the rear of the aircraft and ran into the middle of the apron. The overwing exits were not opened. The investigation found that none of the operator's ground personnel present had been given any education about policy or procedures during an aircraft evacuation on the apron near the terminal.

As a result of the occurrence, a number of safety actions were taken by the aircraft operator and the Australian Transport Safety Bureau.

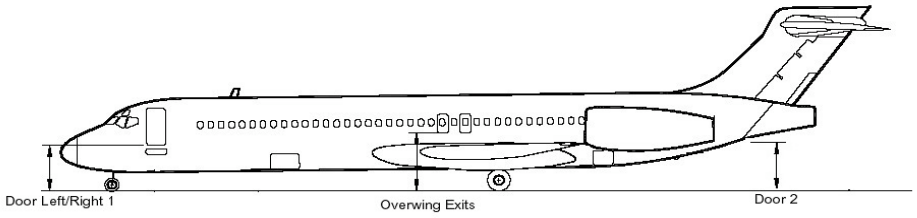
1 FACTUAL INFORMATION

1.1 History of the flight

On 17 May 2005, a Boeing 717-200 aircraft, registered VH-VQI, was scheduled to operate a regular public transport flight from Hobart, Tas, to Sydney, NSW, departing at 0600 Eastern Standard Time[1] with 6 crew and 26 passengers. The aircraft had been parked overnight at Bay 1, a stand-off bay[2], at Hobart Airport. The crew consisted of two flight crew and four cabin crew. During the engine start-up sequence, the pilot in command (PIC) called for an emergency evacuation after being advised of a fire in the right engine. The evacuation occurred before sunrise with a dark sky, with some airport apron lighting.

The flight crew reported that they signed on for duty at 0500 and arrived at the aircraft at about 0530 to conduct pre-flight checks and the pre-flight inspection. At the same time, the cabin crew conducted a briefing and assigned crew positioning. The cabin manager (CM) was assigned the main entry Door Left 1 (L1) as per company procedures, and the other three crew were assigned to the Door Right 1 (R1), Door 2 (D2), and to the overwing assist positions.

Figure 1: Aircraft door positions



At about 0555, 25 passengers and an accompanying infant boarded the aircraft via portable stairs to the main entry door. Passengers were able to select any seat from row 1 to 13. Rows 14 to 25 were taped off for aircraft trim reasons.

The engine start sequence involved an aircraft dispatcher situated on the ground in front of the aircraft who was able to communicate with the flight deck via a headset plugged into a jack near the nose landing gear of the aircraft. After the cabin crew finished loading the passengers, the dispatcher checked with the flight crew that the aircraft's brakes were on and then removed the wheel chocks. After the turn-around coordinator left the aircraft, the cabin crew closed the main entry door. Ground personnel then pushed away the portable stairs.

When the portable stairs were pushed away, the two forward doors and D2 were each armed and cross-checked by the cabin crew, and passengers were given the standard safety briefing.

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1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time, as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) +10 hours.

2 A stand-off bay is an aircraft parking area away from the terminal building and without aerobridge facilities.

The left engine was started normally, however, during the starting of the right engine, at 0606, the dispatcher noticed sparks on the outer right side of the engine cowl. The dispatcher told the PIC to 'shut down right engine, you've got a few sparks there'. The PIC, who could see no unusual cockpit indications, asked 'what's happened?', while switching off the fuel to the right engine, thereby terminating the start. By this time, the dispatcher reported to the Australian Transport Safety Bureau (ATSB) investigation team that he could see sparks streaming from the gaps in the engine cowl. The sparks were streaming into the air and hitting the ground and there was a lot of smoke. The dispatcher replied to the PIC 'Fire right engine. Fire right hand engine'. The PIC immediately made an announcement on the public address system (PA) to the cabin crew 'This is the captain. Cabin crew to your stations'.

The cabin crew quickly proceeded to their assigned doors. The overwing assist flight attendant proceeded from the crew seat at the rear of the cabin to the overwing area. Two of the cabin crew reported looking outside at this time but could only see darkness.

As the right engine was spooling down, the dispatcher noticed that the amount of sparks and smoke was increasing. He told the PIC to 'Shut left engine down. We'll have to get everyone off'. The PIC switched off the fuel to the left engine and replied almost immediately 'Do you want me to do an evacuation?' and the dispatcher confirmed 'yeah, we will do'. The PIC then immediately made a second PA announcement 'This is your captain. Evacuate, evacuate, evacuate'. This occurred twelve seconds after the first PA announcement. At this stage, the dispatcher was waving for assistance from the baggage handlers, who then started to run for the portable stairs.

The copilot called the air traffic control tower seven seconds after the evacuation PA announcement to inform them about the engine fire and requested the Aerodrome Rescue and Fire Fighting Service (ARFFS) to attend.[3] Twenty three seconds after the evacuation PA announcement, the PIC called for flaps 25. Eight seconds later, at the PIC's direction, the copilot started to read the 'Passenger Evacuation Checklist' from the checklist card they had been using for earlier checks.

When the PIC's evacuation call was given, most passengers immediately moved into the aisle and most headed toward the front exits. The CM recalled that she started opening L1 while yelling 'evacuate, evacuate, unfasten seatbelts'. As the door opened outwards a queue of passengers was waiting behind her and the first passenger started to run out the door until the CM yelled 'wait' and grabbed the back of his clothing and pulled him back. Then she pushed the door open fully and the evacuation slide inflated.

The R1 flight attendant stated that as R1 opened, the escape slide was pulled out of the door and fell to the ground still contained in its clear bag. The flight attendant then grabbed hold of the handle and repeated 'blocked exit, move forward'.

When the L1 slide inflated, the sparks from the right engine had reduced, but the dispatcher reported that he could still see a lot of smoke. The baggage handlers

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3 Although the copilot identified the aircraft's flight number, he did not inform the tower which stand-off bay the aircraft was in.

abandoned retrieving the portable stairs and ran to the L1 slide. The dispatcher removed his headset and also ran to the L1 slide and helped passengers at the bottom of the slide. He also waved to a second dispatcher who was attending another aircraft at Bay 2 to come over, who then also assisted with the passengers. The turn-around coordinator also came from the terminal to the front of the aircraft. Twenty-one adult passengers and an accompanying infant exited through L1 onto the slide. These passengers were helped off the slide and were directed towards the terminal by the ground staff. After about three passengers were down the L1 slide, the aircraft's tail cone was ejected. Four passengers exited by the D2 tail slide and ran from the aircraft towards the edge of the apron. The overwing exits were not opened.

The overwing assist, who was at the rear of the aircraft when the four passengers had exited by D2, ran to the front of the aircraft cabin checking for passengers in each row and reported 'cabin clear' to the CM. As all of the front exiting passengers had departed the aircraft by then, the overwing assist flight attendant exited by the L1 slide, followed by the CM, and then the R1 flight attendant. When the passengers had finished exiting via D2, that flight attendant re-entered the cabin to check her area of responsibility and noticed that there was no one else in the cabin and that the flight deck door was closed. She then exited through D2 and gathered together the passengers that had run onto the apron.

The flight crew finished the passenger evacuation checklist 64 seconds after the evacuation PA, after which the copilot entered the cabin to find that the aircraft had already been evacuated and he exited via the L1 slide. Fire crew, who had arrived at Bay 1 after all the passengers were evacuated, motioned him to the terminal. The PIC left the cockpit soon after the copilot and, after he had satisfied himself that no-one else was on-board, also exited using the L1 slide.

Once all of the cabin crew and passengers were inside the terminal, the CM conducted a head count of passengers and another flight attendant retrieved a first aid kit from the turn-around coordinator's office. The cabin crew attended the injuries of passengers until the fire fighting personnel took over administering first aid. The PIC entered the terminal at about this time and explained to the passengers what had happened.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	11	-	11
None	6	15	-	21

Eleven passengers reported they sustained minor injuries, 9 from using the slide at L1, one from tripping on the tarmac after using the slide at D2, and one from an unknown origin. Injuries included two passengers with bruised coccyxes, with other passengers receiving grazes on knees, hands and/or wrists, a pulled muscle in the neck, soft tissue damage to a shoulder, sprained ankles, sprained wrists, or bruised legs.

A survey of the passengers indicated that of the 26 passengers, 21 adults and an accompanying infant exited via the L1 slide. Many passengers and ground personnel reported that there was a pile-up of passengers at the bottom of that slide. Several of the injuries were sustained by passengers trying to avoid sliding into other passengers. Many of the other injuries were a result of rolling onto, or landing on, the tarmac at the bottom of the slide.

1.3 Damage to aircraft

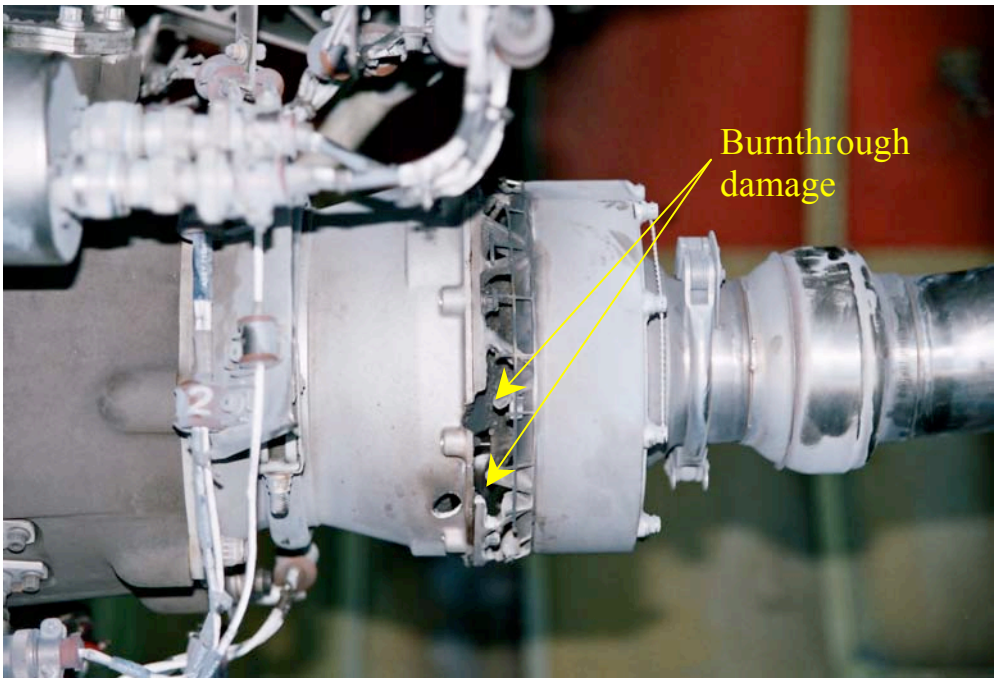
During the engine start, the right engine air-turbine starter failed, resulting in visible smoke and sparks issuing from the engine cowling. Damage to the aircraft was limited to the internal destruction of the air-turbine starter assembly and minor paint damage to the surrounding engine cowling.

1.3.1 Air-turbine starter failure

The right engine air-turbine starter assembly P/No ATS100-510 3505934-8, S/No. 0101-0850, failed during the engine start sequence (Figure 2). The starter was removed and sent to the United States (US) manufacturer for detailed examination under the supervision of the US National Transportation Safety Board (NTSB). The examination revealed that the starter failed as a result of a loss of lubricating oil from the starter while in-service. The oil loss was a result of an incorrectly installed starter output shaft seal retaining ring.

The right engine air-turbine starter had a total time in service (TTIS) of 8,522.3 hours and total cycles since new (CSN) of 6,996 cycles. The air-turbine starter had been removed in-service and installed on the right engine of VH-VQI 415.7 hours prior to the failure. The component maintenance manual for the starter output shaft retaining ring installation provided a schematic diagram of the correct ring installation orientation but did not highlight this requirement in the accompanying instructions.

Figure 2: Failed air-turbine starter on right engine



1.4 Personnel information

1.4.1 Flight crew

The PIC held an airline transport pilot (aeroplanes) licence and a command multi-engine instrument rating. He had accumulated a total of 9,724 flying hours, of which about 2,777 hours were on the aircraft type and about 76 hours were in the preceding 30 days. He stated that he had last conducted emergency procedures training in February 2005.

The copilot held an airline transport pilot (aeroplanes) licence and a command multi-engine instrument rating and had accumulated a total of 5,922 flying hours, of which about 1,800 hours were on the aircraft type and about 60 hours were in the preceding 30 days. He stated that he had last conducted emergency procedures training in October 2004.

1.4.2 Cabin crew

Cabin Crew Position:	Door Left 1/ (CM)	Door Right 1	Overwing Assist	Door 2
Experience in Total:	11 years	13 months	9 months	1 year
Experience in Role with the operator:	7 months	13 months	9 months	1 year
Last Emergency Procedures Training:	February 2005	February 2005	December 2004	February 2005

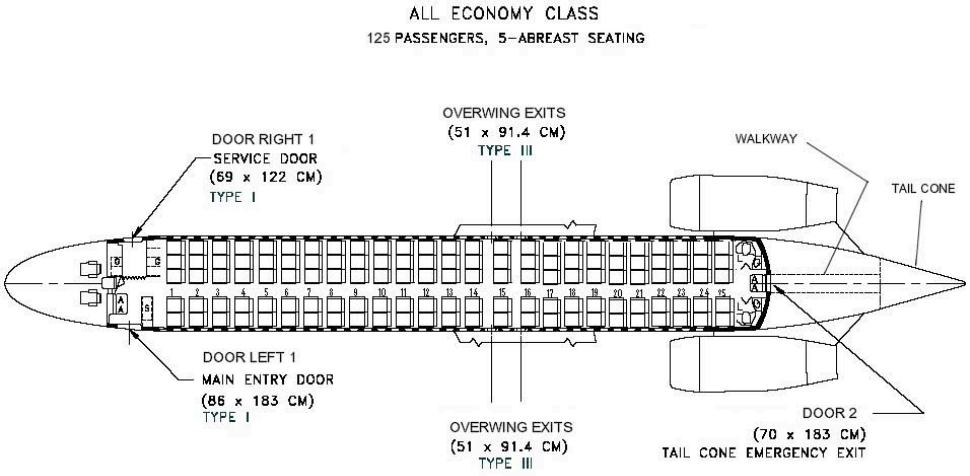
1.4.3 Aircraft dispatcher

The aircraft dispatcher involved in the engine start was a licensed aircraft maintenance engineer (LAME) and had been employed with the operator for 1 year and 10 months prior to the occurrence, and for a further 8 months prior to this as a contractor at another airport.

1.5 Aircraft information

The aircraft had a single-class configuration consisting of 25 rows with five seats per row, capable of holding 125 passengers (Figure 3).

Figure 3: Aircraft seating and exit layout



1.5.1 Cabin doors

The cabin had three floor level exit doors and four overwing exits (Figure 3). The main entry door (L1) was located behind the cockpit on the left side of the aircraft, and the service door (R1) was located directly opposite on the right side. Both of the forward doors were type 1[4] exits and each door contained an emergency escape slide designed to automatically inflate when the doors were opened in the armed mode. The L1 and R1 doors were 2.24 m and 2.23 m above the tarmac, respectively.

Door 2 was located in the rear of the aircraft, and opened into the tail section. When opened in the armed mode, the door was designed to eject the tail cone off and behind the aircraft, and inflate an escape slide from where the tail cone was located. A walkway with handrails and painted arrows on the floor pointing to the rear of the aircraft connected D2 to the edge of the tail section where the slide was located. The exit for D2 was 2.52 m above the tarmac.

4 Type 1 exits have a minimum width of 61 cm and a minimum height of 122 cm, with no step (floor level).

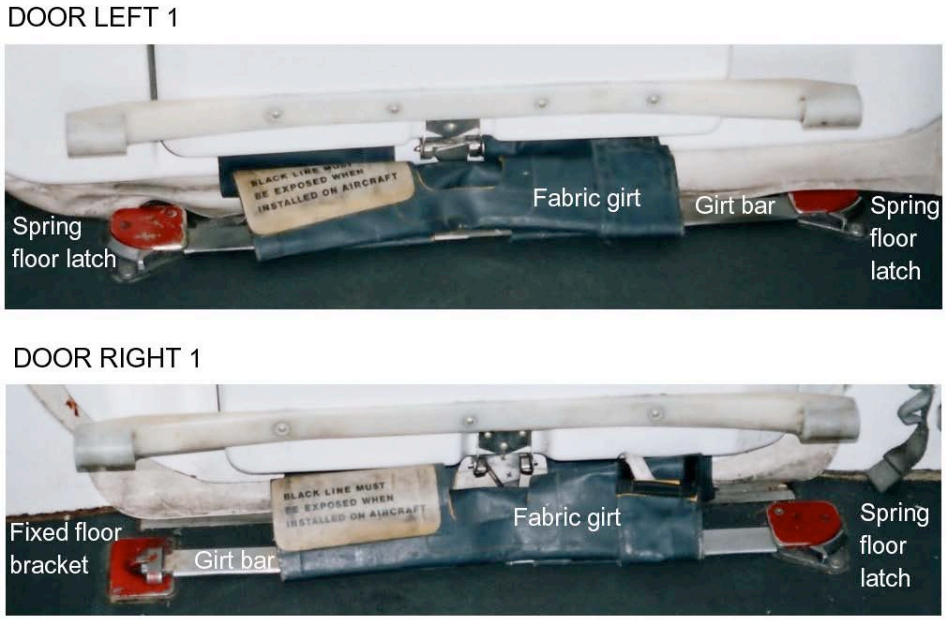
There were two type 3[5] overwing exits on each side of the aircraft, located at rows 15 and 16. These were plug-type exits, designed to be opened by passengers. There were no slides associated with the overwing exits. Exit via these doors required passengers to walk on the top of the wing, following painted arrows to the trailing edge of the wing, and then slide onto the ground over extended wing flaps. As there were no passengers seated at the overwing exit rows and there were a small number of passengers on board, the overwing assist flight attendant decided not to open the overwing exits.

1.5.2 Forward door arming

On the two forward doors (L1 and R1), the slide was located inside each door. To be in the armed mode, the slide had to be attached to the aircraft via a fabric girt to a girt bar which was attached to two floor latches (see Figure 4). If the door is opened in the armed mode, the girt bar remains attached to the floor and the slide is pulled out of the door by the fabric girt. Automatic inflation of the slide then follows.

The slide at R1 fell to the ground when the door was opened. It remained in its wrapping and uninflated, and the girt bar and fabric girt were still attached to the slide. An examination by an ATSB investigator and the operator's engineers revealed that the slide activation gas pressure was correct and that it was capable of normal operation.

Figure 4: Door L1 (top) and R1 (bottom) girt bar with door in armed mode



5 Type 3 exits have a minimum width of 58 cm and a minimum height of 91.4 cm, with a maximum step height of 50.8 cm. They are limited to overwing exits on the Boeing 717.

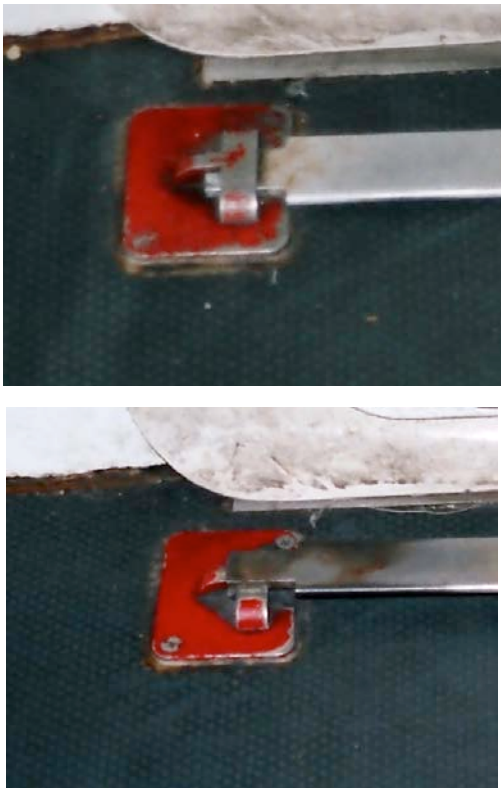
1.5.3 Girt bar brackets

The left and right floor brackets for attaching the girt bars were different for doors L1 and R1. For L1, both brackets were spring loaded latches. To arm L1, the girt bar needed to be pushed and locked into each latch in any order. For R1, the forward (left) floor bracket was a fixed bracket while the rear (right) was a spring loaded latch. To arm R1, the girt bar needed to be first slipped into the fixed left bracket and then clicked into the right latch.

It was reported by Boeing that the McDonald Douglas DC-9 aircraft (which was later developed as the 717) had two spring latches on each door, but the forward service door latch was replaced with a lower profile fixed floor bracket to reduce the service door pressure seal wear during operation, after operator reports of damage of this nature. All 717 aircraft operated by this operator had a fixed bracket for the forward R1 floor fitting. The differences between the L1 and R1 floor latches were not included in the operator's cabin crew manual. However, cabin crew trainers were required to highlight the difference between the L1 and R1 girt bar floor fittings during all cabin crew training in the classroom and during aircraft familiarisation.

The forward R1 fixed floor bracket on the incident aircraft was painted red, as were the spring loaded latches. However, the paint on top of the bracket had worn away. The girt bar was an un-painted, aluminium bar. It can be seen in Figure 5 that if the girt bar was placed incorrectly on top of the fixed bracket, it looked similar to when the girt bar was placed inside it as designed.

Figure 5: Girt bar floor bracket from R1 with girt bar in armed mode (top) and girt bar on top of floor bracket (bottom)

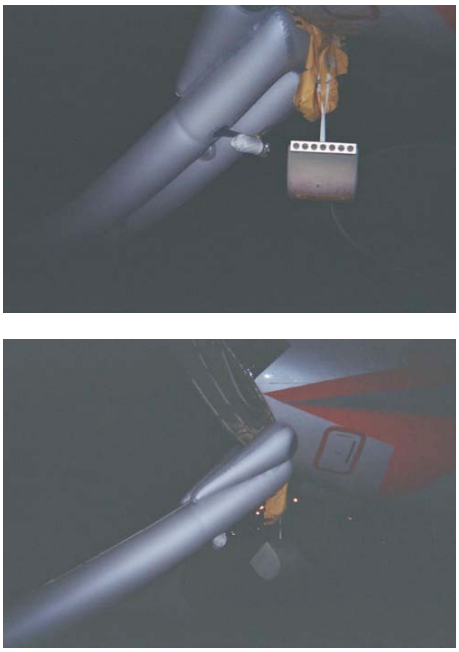


1.5.4 Escape slides

The Australian Civil Aviation Safety Authority (CASA) Civil Aviation Order 20.11 stated that aircraft must meet the requirements of the US Federal Aviation Administration (FAA) regulation FAR 25.803. This stated that during an emergency evacuation, a full load of passengers in an aircraft must be able to be evacuated within 90 seconds using only exits on one side of the aircraft. Furthermore, any exit above 1.83 metres must have a means of assisting passengers to the ground, such as escape slides.[6] The slides on VQI met all FAA certification requirements. These requirements include that escape slides need to be long enough for the lower end to be self-supporting on the ground regardless of landing gear collapse, and that they remain usable in a 25-knot wind with the assistance of only one person.

Many of the passengers, as well as the flight attendants and ground personnel, reported that the L1 slide was very steep and short. They had expected a cushioning section at the end of the slide. Ground staff reported that passengers were jumping onto the slide and only actually contacting the slide about a half or three quarters the way down. The escape slide at D2 was longer (as the exit was higher) and less steep at the end (Figure 6).

Figure 6: Slide from L1 (top) and tail cone D2 (bottom)[7]



1.5.5 Cabin lighting

The main overhead lighting in the aircraft cabin remained illuminated both prior to and throughout the aircraft evacuation.

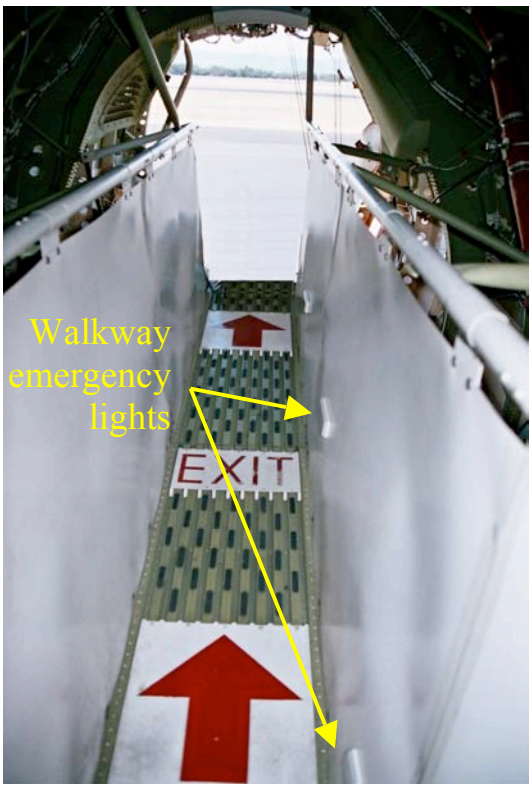
6 Federal Aviation Regulation (FAR) 25.810

7 Photographs used with permission of Hobart Airport rescue and fire fighting service.

1.5.6 Tail area

The D2 flight attendant reported that the tail area was dark and was only illuminated by the cabin lighting coming through the opened D2. The flight attendant reported that the painted arrows on the walkway (Figure 7) were difficult to see and she was concerned that passengers could fall down the side of the walkway due to the darkness. When the D2 door was opened, the flight attendant was also unsure, due to the darkness, if the tail cone had been ejected and if the slide had inflated. As such, she slowly walked to the end of the tail section walkway to confirm this before allowing any of the passengers waiting at D2 to enter the tail section.

Figure 7: Evacuation walkway in the tail section from D2 to the slide



1.5.7 Emergency lighting

Emergency lighting in the tail section included the tail compartment, walkway and tailcone evacuation slide area lights (Figure 7). The description of the darkness in the tail section by the D2 flight attendant indicated that these lights were not illuminated during the evacuation. Other emergency lighting in the aircraft included the inner edge of the aisle passenger seats which contained coloured lights to guide passengers exiting from a dark cabin. These lights were green, except adjacent to exits, where the lights were red. Some passengers reported that the aisle lights were not illuminated during the evacuation. Operation of the emergency lights was through the emergency light switch on the flight deck.

1.6 Communication

1.6.1 Flight crew – dispatcher communications

The operator reported that the role of the aircraft dispatcher was to inform the PIC of any abnormal events. As such, the operator did not provide dispatchers with any standard communication phraseology to communicate with the PIC concerning passenger evacuations.

The aircraft dispatcher involved in this incident advised the PIC that some action was needed regarding removing the passengers. The dispatcher reported that when he first said 'We'll have to get everyone off' to the PIC, he was thinking that he would organise for the portable stairs to be brought over to the aircraft. As a result, he indicated to the baggage handlers to retrieve the portable stairs. However, the portable stairs were not near the aircraft and it became apparent to him that the slides would be used and a full emergency evacuation conducted after the quickness of the PIC's reply and the continued presence of danger.

Previous evacuation incidents

In 2003, a Boeing 747-400 aircraft, belonging to a different operator, conducted an emergency evacuation at the terminal at Sydney Airport[8]. The evacuation was ordered by the PIC after the engineer reported and then confirmed that there was a brake fire. However, the engineer at no stage advised the PIC to evacuate the aircraft and the fire was small and self-extinguished before the first passenger had exited the aircraft. The extent of the fire was not relayed to the PIC before the evacuation was called. During that evacuation, ground personnel called out for the cabin crew to stop the evacuation.

1.6.2 Non-pertinent cockpit conversation

The flight crew were engaged in conversations not confined to the engine start process or other operational matters during both engine start sequences, until the first indication of a problem was given to the flight crew by the aircraft dispatcher.

The operator's sterile flight deck policy, outlined in its operations manual, indicated when all flight crew activities (including conversations) shall be strictly confined with the operation of the aircraft. This applied during the climb and descent phases of flight below 10,000 ft. The policy did not include the engine start sequence. The sterile cockpit procedures for cabin crew (determining when cabin crew can enter the cockpit) started after last external door close at the start of flight. However, other Australian airlines had sterile flight deck procedures for flight crew activities starting from last door close.

Previous accidents involving non-pertinent cockpit conversations

The US National Transportation Safety Board (NTSB) has investigated a number of aircraft accidents where it concluded that non-pertinent conversation between the

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8 ATSB (2005*) Boeing 747-438, VH-OJU, Sydney Airport, NSW, 2 July 2003*. (Investigation Report BO/200302980). Canberra: Australian Transport Safety Bureau.

flight crew contributed to the errors of omissions by the pilots that eventually resulted in the accident. Two examples are provided below.

On 31 August 1988, a Boeing 727-232 aircraft crashed shortly after takeoff from Dallas-Fort Worth Airport, Texas, without the wing flaps and slats being properly configured. The NTSB investigation report[9] stated that:

> The captain did not stop the first officer's interruptions of cockpit duties when he initiated nonrelevant conversation or made comments about his observations outside the cockpit while the airplane was being pushed back, while the engine start checklist was run, when the airplane was taxied from the push-back position and during the subsequent 25 minutes taxi time before takeoff clearance was received….. The Safety Board believes that, had the captain exercised his responsibility and asked the flight attendant to leave the cockpit or, as a minimum, stopped the nonpertinent conversations, the 25-minute taxi time could have been utilized more constructively and the flap position discrepancy might have been discovered.

On 19 February 1996, a Douglas DC-9-32 aircraft landed with the landing gear retracted at Houston Airport, Texas. The flight crew initially failed to properly complete the in-range checklist, resulting in a lack of hydraulic pressure to lower the landing gear and deploy the flaps. The flight crew failed to perform the landing checklist, failed to confirm that the landing gear was extended, and did not notice the 'master caution' light or zero-flap gauge that indicated the flaps were not operating as expected due to a lack of hydraulic power. The NTSB investigation report [10] stated:

> The topic of the captain's conversation indicates that his attention was directed outside the cockpit …..
>
> Although the Safety Board was unable to determine the specific reason why the flightcrew failed to detect the momentary illumination of the "MASTER CAUTION" light or the zero flap gauge indication, it concludes that the captain's distraction from his duties as pilot-in-command and his disregard for the sterile cockpit rule contributed to the pilots' failure to detect their hydraulic system configuration error when they selected 5° of flaps. The captain's disregard for the sterile cockpit rule also raises concerns that an operational climate tolerant of nonstandard conduct may have existed at [the operator].

1.7 Fire and rescue service

Civil Aviation Regulations (MOS Part 139H) specified the requirements for an Aviation Rescue and Fire Fighting Service (ARFFS) at an airport. The size of the ARFFS at an airport was determined by the size of the largest aircraft that normally used the airport. Hobart Airport operated as a Category 7 Airport, requiring it to have two fire fighting vehicles. Staffing levels were determined by there being

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9 NTSB (1989). *Delta Airlines, Inc. Boeing 727-232, N473DA, Dallas-Fort Worth International Airport, Texas, August 31, 1998*. (Aircraft Accident Report no. NTSB/AAR-89/04). Washington, DC: National Transportation Safety Board.

10 NTSB (1997). *Wheel-up landing, Continental Airlines Flight 1943, Douglas DC-9 N10556, Houston, Texas, February 19, 1996.* (Aircraft Accident Report no. NTSB/AAR-97/01). Washington, DC: National Transportation Safety Board.

enough trained staff for both vehicles to reach an incident or accident anywhere in the aircraft movement area of the airport within three minutes of an initial call.

It was reported that the normal staffing of two officers and four fire fighters were on duty that morning and two fire trucks were available. At about 0607, after being advised of a fire by the copilot, a controller at the Hobart Air Traffic Control tower alerted the ARFFS of an engine fire at Bay 5. The fire station alert alarm was sounded and both fire trucks and all firefighters immediately departed for Bay 5 (which was nearest the fire station). However, it was quickly realised it was the wrong bay and they continued to Bay 1. The controller also broadcast to the trucks as they reached Bay 5 to go to Bay 1. It was reported by ARFFS personnel that the first fire vehicle arrived at Bay 1 in about 40 to 50 seconds, with the second truck arriving about 10 seconds later.

The fire fighters reported that when they arrived all passengers had left the aircraft and that the aircraft dispatcher and PIC were already assessing the engine. Both fire trucks were parked at the front of the aircraft. Hoses were run out and charged ready for immediate use if required. However, as there was no visible danger, the fire commander walked up to the aircraft dispatcher and asked what had occurred. The fire crew remained at the engine while the cowling was opened by the aircraft dispatcher, after which they agreed the area was safe. No foam or chemicals were deployed. The fire crew then attended to passenger first aid needs in the departure lounge.

1.8 Organisational information

1.8.1 Evacuation categories

Two types of evacuations were available to the PIC: a precautionary disembarkation where passengers disembark the aircraft as quickly as is deemed safe using portable stairs or slides; and an emergency evacuation where passengers and crew are to exit the aircraft in the minimum amount of time using all available exits and slides. A fire that is not immediately extinguished generally leads to an emergency evacuation due to the possibility of the fire quickly spreading and the cabin quickly filling with smoke, fumes, and/or flames.

1.8.2 Flight crew procedures

The operator provided a quick reference laminated flight crew checklist card, dated 1 September 2004, which contained information regarding checklist actions to be taken in the event of a passenger evacuation.

The Passenger Evacuation Checklist stated:

If time permits, brief FA's and alert ATC & ground crew

"This is the Captain, Flight Attendants to your stations"

CABIN INTERPHONE Switch .....ON

Note: When required, contact cabin crew using PA

OUTFLOW VALVE.....VERIFY OPEN

PARK BRAKE.....SET

SPD BRAKE Lever.....RET

FLAPS/SLAT Handle .....25°/EXT

Note: Flap position is for unobstructed egress from airplane. If airplane is at gate and ramp is congested with service vehicles, use good judgement to ensure maximum safety of passengers.

EMER LT Switch .....ON

FUEL Switches.....OFF

ENGINE FIRE Handles.....PULL

Note: If required, discharge fire agent

"This is the Captain Evacuate-Evacuate-Evacuate"

APU FIRE CONT Switch.....OFF & AGENT ARM

BATT Switch.....OFF

The flight crew Abnormal Procedures Manual stated that the copilot, after notifying the air traffic control tower of the evacuation and reading the evacuation checklist, was to exit the cockpit, leaving the flight deck door open, and to exit the aircraft immediately from the forward most usable exit. From that point, the copilot's duties were to direct the evacuation from the ground, assist with passengers on the slides, and direct passengers away from the aircraft. Although it was not a written cabin crew procedure, a number of the cabin crew reported that they believed that the copilot was meant be the first to exit the aircraft. The cabin crew reported that they had expected that the copilot would be on the ground but did not know that he was not off the aircraft until after they had exited the aircraft themselves.

The flight crew Abnormal Procedures Manual also required the PIC to direct the evacuation if necessary, after the evacuation checklist was completed. However, both pilots were completing the checklist inside the flight deck, with the security door closed, until all of the passengers and cabin crew had exited the aircraft.

The eighth item on the Passenger Evacuation checklist required the flight crew to discharge fire agent if required. However, flight crew are trained not to discharge fire extinguishers when there was no cockpit indication of a fire. There was no evidence that the flight crew attempted to operate the right engine fire extinguisher bottles.

1.8.3 Ground personnel during ground starts

At Hobart Airport, the aircraft dispatchers for ground starts were always engineers, either a LAME or an aircraft maintenance engineer (AME). However, at some other ports, the operator used ground handling company personnel as dispatchers.

1.8.4 Ground crew evacuation education

It was reported that the operator had provided no training or awareness education to dispatch or other ground personnel about what to do in the event of an aircraft evacuation on the apron near the terminal. The operator stated that ground personnel were not expected to be involved in emergency evacuations. This was consistent with the evacuation procedures developed by the aircraft manufacturer, which involved flight and cabin crew only.

All of the ground personnel that assisted in the passenger evacuation gathered around the L1 slide. They assisted passengers from the slide and directed them towards the terminal. Several passengers exited by D2 and ran towards the edge of the apron without the knowledge of ground personnel.

At one stage during the evacuation, there was an accumulation of 5 or 6 passengers at the bottom of the L1 slide. One of the ground personnel assisting passengers tried to call out to the flight attendant to 'slow down' the flow of passengers. However, he could not see the flight attendant and did not establish communication with her.

1.8.5 Cabin crew evacuation procedures

Cabin crew evacuation procedures were documented in the operator's Operations Manual, volume 12 (Cabin Crew Manual), section 14. Section 14.7.2 of that manual required crew to assess the conditions outside the exit to determine if it was safe to evacuate via that exit. This was to be done by looking through the exit's viewing window before opening the door and then reassessing the outside conditions after the door was partially opened. All three cabin crew who opened an exit complied with this requirement.

Section 14.7.4 stated that before operating any door in an evacuation, crew should check the door is in the armed mode. All of the cabin crew believed the doors were armed as they had performed the arming procedure a few minutes earlier. However, none of the crew reported that they checked if the door was armed before opening their respective doors.

The flight attendant at R1 reported that before she started to open the door, she momentarily considered there may be portable stairs before realising they would be using slides. She reported that due to this, she may have started to unlatch the girt bar from the floor latches before rotating the door handle.

Section 14.7.5 of the Cabin Crew Manual stated that when opening an exit door, the flight attendant should physically guard the exit until it is ready for use by passengers. However, as the door was not power assisted, flight attendants needed to reach out of the exit to push it fully forward. Consequently, a passenger almost jumped from the door before the slide was inflated. The ATSB was advised that some overseas airlines had the additional command 'wait, slide inflating' to be used in conjunction with the door guarding procedure. Some of the cabin crew reported that they were unaware of any such commands.

The commands outlined in section 14.8.1 to be shouted by cabin crew operating floor level exits were: 'Unfasten seatbelts; leave everything behind; come this way' (once the exit was ready); 'jump and sit' (once the passengers were ready to exit); 'fold your arms' (once they are exiting); and, 'move away from the aircraft' (once

they were on the ground). If the door became blocked, such as R1, the commands were: 'blocked exit, go back, go across'.

Passenger recollections of what was said by the flight attendants differed markedly, but in general, reflected the written procedure.

Several passengers reported that crew said 'leave everything behind' and one passenger reported that a flight attendant stopped someone from retrieving bags from the overhead locker. The only luggage reported by passengers to have been brought down the exit slides were two hand bags and one book.

Wearing high heel shoes when exiting on an escape slide can puncture the slide. Although the Operations Manual did not include commands for passengers to remove their high heel shoes during an emergency evacuation, the operator reported that the "high heels off" command had been taught in emergency procedures training. (For a 'prepared' emergency evacuation[11], cabin crew were to inform passengers before the evacuation to remove high heel shoes.) Although some of the cabin crew indicated that there is no time during an emergency evacuation for the removal of high heels, it was reported that at least one flight attendant did shout "high heels off" at least once. The removal of high heel shoes was also indicated in the Safety Instruction card placed in every passenger seat. Only one passenger reported that she was wearing high heel shoes and she took them off before exiting the aircraft.

Section 14.8.3 of the Cabin Crew Manual stated that 'If egress of passengers is moving slowly at a particular exit, redirect passengers to exit(s) where evacuation is moving faster.' The overwing assist initially ushered passengers to the front of the aircraft. As no one was heading to the rear of the aircraft, the flight attendant then stood on a seat at about row 20 and called 10 to 12 passengers to the rear while D2 was being opened. When the D2 flight attendant was in the tail section, only 2 or 3 passengers were waiting at L1, so the overwing assist flight attendant shouted for some passengers to go forward, which half of them did.

After passengers had exited the aircraft, the Cabin Crew Manual required cabin crew to check their area of responsibility as outlined in Table 1 below. Before leaving the rear of the aircraft, the overwing assist shouted to the D2 flight attendant 'I'll check the cabin, just go', but the D2 flight attendant did not hear this. As such, the D2 flight attendant did check part of her area, while the overwing assist flight attendant checked the whole cabin while the other crew were still conducting their exit door responsibilities.

11 A prepared emergency is when cabin crew have time to prepare the passengers and cabin for an emergency landing and possible evacuation. The occurrence evacuation was an 'unprepared emergency' as there was no time to prepare the passengers and cabin.

Table 1: Cabin crew exit responsibilities

Cabin Crew Position:	Door Left 1/ Cabin Manager	Door Right 1	Overwing Assist	Door 2
Exit Responsibility:	Door L1	Door R1	Overwing exits (Passenger supervision and operation if required)	Door 2
Cabin Check Area:	General supervision Check Flight deck	Rows 1-8	Rows 9-16	Rows 17-25

When the cabin crew exited the aircraft, the two flight crew were in the cockpit with the flight deck door locked shut. The cabin manager (CM) had the responsibility to check if the flight crew needed assistance but reported that she forgot to do so. The last flight attendant to exit from the front of the aircraft reported that she did not check on the flight crew because it was not part of her procedures. As such, no one checked the flight deck before exiting.

Due to the flight deck door security arrangements, cabin crew did not have unlimited access to the flight deck. If the cabin crew had called the flight deck and there was no response from the flight crew, then they would have had to enter a security code and then wait for the required interval before the door could be opened from the cabin.

The Cabin Crew Manual required the flight attendants at D2 and L1 to collect a first aid kit and megaphone before exiting the aircraft (section 14.8.7). Neither flight attendant remembered to collect these. Once outside the aircraft, the passengers were brought to the terminal where a headcount was conducted and first aid was administered, as outlined in section 14.8.9 of the manual.

1.8.6 Cabin door arming procedures

Timing of door arming

When the aircraft was at a stand-off bay, the operator's procedures required the CM to call for door arming when the portable stairs were pushed away from the aircraft. For this incident, the doors were armed immediately before the engines were started. However, the operator's procedures allowed engine starts to occur on stand-off bays before the main door was closed for Boeing 717-200 aircraft (due to their high and rear mounted engines) and it was reported that at Hobart Airport, the Boeing 717-200 engines were started approximately half of the time while the portable stairs were still attached to the aircraft.

Forward door arming

The forward doors were each armed by the stationed cabin crew as per the operator's procedures. These involved placing a red strap across the viewing

window[12] and removing the slide girt bar from the door bustle and placing either end in a floor latch or bracket. When finished, the L1 flight attendant announced 'L1 armed'. The R1 flight attendant then replied 'R1 is armed' and looked at the L1 strap and girt bar from her position at the R1 door and confirmed 'L1 is crosschecked'. The L1 flight attendant inspected the R1 door strap and girt bar from her position at L1 and replied 'R1 is cross-checked'. The cross-check did not involve touching any part of the girt or brackets.

The responsibility for L1 for every flight was always that of the CM for that flight. The other three flight attendants on-board could be assigned on any day to one of three positions: D2, R1, and overwing assist. The flight attendant positioned at R1 on the incident flight reported that she only ever rotated between the R1, D2 and overwing assist positions and never operated L1, although technically she knew how to. However, when describing the door arming process subsequent to the incident, the R1 flight attendant described the R1 floor latches as both being spring-type latches and reported that the brackets were the same for L1 and R1. Furthermore, she described her personal cue to know that her door was armed was the sound of both latches clicking in. The operator reported that cabin crew were trained in the differences between the L1 and R1 floor brackets. The differences between the L1 and R1 floor latches were not addressed in the operator's cabin crew manual.

Other evacuation incidents involving opering un-armed doors

Two emergency evacuations investigated by the US NTSB[13] described cabin crew inadvertently disarming an armed door before opening it on McDonnell Douglas DC-10 aircraft. The report explained that both crew had well practiced habits of using the arming and disarming lever (done every flight), but not the door opening lever, as the door was usually opened by ground personnel. As such, the crew had reverted to their well rehearsed but inappropriate action of disarming the door.

The ATSB investigation (BO/200302980) of an emergency evacuation of a Boeing 747-400 at Sydney Airport in 2003 found that three slides did not deploy due to doors being opened in the disarmed mode. However, unlike the present incident, the investigation concluded that these errors related to the fact that the doors were in the disarmed mode when the evacuation announcement was made.

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12 The red strap served to warn anyone attempting to open the door that the door was armed, but did not contribute to slide inflation.

13 NTSB. (1992*). Flight Attendant Training and Performance During Emergency Situations* (Special Investigation Report No. NTSB/SIR-92/02). Washington, DC: National Transportation Safety Board.

2 ANALYSIS

2.1 Right engine starter failure

The right engine air-turbine starter failed during the engine start sequence leading to the streaming of sparks and a significant amount of smoke from the vicinity of the right engine. The starter failed due to the loss of lubricating oil, which was the result of an incorrectly installed starter output shaft seal retaining ring. The oil seal retaining ring can be installed in one of two directions and, if installed in the incorrect direction, can lead to loss of oil from the starter. The starter had been initially assembled at the component manufacturer and had been the subject of in-service removal and installation by maintenance personnel prior to the failure.

Without clear instructions provided in the component maintenance manual on the correct orientation of the starter output shaft oil seal retaining ring, it is likely that the retaining ring was installed incorrectly during the last installation procedure, some 417.5 hours prior to the starter failing.

2.2 Emergency evacuation

2.2.1 Communication and the initiation of the evacuation

As the pilot in command (PIC) had no flight deck indications of any problems, he was completely reliant on communications with the aircraft dispatcher involved in the engine start to determine the seriousness of the situation. The messages originally relayed to the PIC, including that the right engine was on fire, alerted the PIC to potentially greater consequences than the dispatcher may have intended. However, due to the lack of standard phraseology, the dispatcher had no unambiguous way of communicating what he saw, and the PIC did not attempt to obtain any further information about what the dispatcher could see. Furthermore, coupled with a lack of education in flight crew procedures, the dispatcher also had no way to clearly communicate what actions he thought were appropriate. By the time the dispatcher had realised the passengers would need to get off the aircraft and he said 'We'll have to get everyone off' to the flight deck, he had no idea that the PIC was ready to order an emergency evacuation having already placed the cabin crew on alert at the first indication of an engine fire.

The operator's aircraft dispatchers had not received education concerning pilot decision making in relation to calling an evacuation. As a consequence, there could be no expectation that dispatchers, unlike flight crew and cabin crew, would have an appreciation for the meaning of the word 'evacuation' as opposed to 'precautionary disembarkation'. Without providing dispatchers with such knowledge, confusion between pilots and dispatchers when communicating about critical events is likely. As also seen in the emergency evacuation of the Boeing 747-400 at Sydney Airport in 2003, engineers and dispatchers may not even realise the information they are providing to the flight deck is being used by the PIC to make a decision whether to conduct a full emergency evacuation. This lack of knowledge about pilot procedures can very easily lead to insufficient or untimely

information being passed to the PIC. However, this unfamiliarity can be addressed through education.

2.2.2 Flight crew procedures

The operator's Abnormal Procedures Manual required the flight crew to perform the Passenger Evacuation Checklist as their first action in every emergency evacuation situation. That checklist required for the wing flaps to be set in an extended position as the sixth item, for the emergency light switch to be set on as the seventh item, and for the evacuation public address (PA) announcement to the cabin as the tenth item. However, when the PIC confirmed with the dispatcher that he needed to evacuate the aircraft, he immediately called the evacuation command without initiating the checklist.

It is likely that the PIC instinctively ordered the evacuation and initially forgot the checklist because he was caught off guard by the information from the dispatcher. This was partially because there was no cockpit indication that there were any problems. In addition, as starting engines successfully is an extremely common event for any pilot, there can be a natural tendency for pilots to expect engine starts to run smoothly. The fact that the PIC was engaged in conversations not directly involved with the engine start process throughout both engine start sequences suggests that, while monitoring of the aircraft systems was occurring, his full attention was not being applied to his assigned role during this critical time. As seen in the aircraft accident investigations outlined in Section 1.6.2, non-pertinent conversations in the flight deck can lead to errors of omission. Unlike other operators, the operator's sterile cockpit procedures did not include the engine start period.

The checklist allowed time for the flaps to extend so that when passengers started to exit via the overwing exits, the flaps would have already been extended to 25 degrees, giving passengers a sloping surface to slide off the wing to a safe height above the ground. Twenty one seconds after the PIC called the evacuation, he realised that the flaps should have been extended first and called for this to occur.

The overwing exits were not used in this evacuation due to the small number of passengers. However, if enough passengers were on the aircraft to require the use of the rows containing the overwing exits, it is very likely that one or more overwing exits would have been used by passengers. If this was the case, given that the wing flaps take some time to move to the extended position, then it is also very likely that passengers would have been standing on the wing before the flaps were extended and/or while they were being extended. Some passengers may have been injured by jumping off the wing without the flaps extended, and other passengers may have climbed back into the aircraft after seeing the height of the unaided fall to the ground, slowing the evacuation. Both injuries and re-entering the cabin have been documented by the US National Transportation Safety Board[14] as occurring from overwing emergency exits without slides.

The evacuation checklist also ensured there would be aisle lighting showing passengers where the exits were and providing emergency lighting to the otherwise

14 NTSB. (2000). *Emergency Evacuation of Commercial Airplanes* (Report no. NTSB/SS-00/01). Washington, DC: National Transportation Safety Board.

dark tail section before the evacuation PA was made. However, the evacuation was commenced before the emergency lights were turned on by the flight crew. As the main cabin lights were still working, the lack of emergency lighting did not influence the evacuation process through the forward doors. However, the lack of emergency lighting in the tail section significantly slowed the rate at which the Door 2 (D2) flight attendant could commence the evacuation from the rear of the aircraft.

2.2.3 Cabin crew procedures

Door Arming

The Door Right 1 (R1) slide fell from the aircraft intact in its casing and there were no defects found with the slide, floor latches, fabric girt or girt bar. If the girt bar was attached to both floor latches (armed mode), the slide would have remained connected to the aircraft after the door was opened. If the girt bar was not attached to either floor latch (disarmed mode), then the slide would not have been pulled out of the door. The only way the slide could have been pulled out the door but not remained attached to the aircraft was if the girt bar was attached to one of the floor latches but not the other. The same result would have occurred no matter which end of the girt bar was attached to the floor latch.

There are two possible scenarios as to how the girt bar could be attached to one floor latch but not the other. First, the flight attendant at R1 may have begun to unlatch the girt bar when she first went to open the door. Such actions, where a person does a common and well-practiced (and usually appropriate) action in an unusual situation that makes the action inappropriate are common errors[15]. That is, the flight attendant disarmed the door before opening it every day, but on this occurrence, she needed to open it in the armed mode, but reverted to her usual action of disarming the door. These errors are common and have been previously documented involving inappropriate disarming of doors in evacuation situations. However, the flight attendant was never confident about this explanation, and she may have only thought this was what she had done to rationalise to herself why the slide fell to the ground.

The second possibility is that R1 was not properly armed during the earlier door arming procedure. It can be seen in Figure 5 that when the left end of the girt bar was placed on top of the fixed bracket, careful visual inspection was needed to confirm whether it was inside the bracket. This was partially a result of the worn paint on top of the floor bracket, revealing metal the same colour as the girt bar. Given that the door arming cross-check by the Door Left 1 (L1) flight attendant occurred from the other side of the aircraft, that the lighting at floor level was not very bright, and that the red paint was not a high enough contrast with the surroundings, an end of the girt bar could have been quite easily perceived as being inside the bracket when in fact it was on top. If the cross-check system involved flight attendants crossing the cabin and physically touching the girt bar where it was connected with the floor brackets, there would be a much greater chance of a partially armed door being discovered before flight.

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15 Reason, J. (1990). *Human error*. Cambridge: Cambridge University Press.

Further support for the possibility that an end of the girt bar was placed on top of the floor bracket comes from the R1 flight attendant's incorrect description of the R1 arming procedure involving two spring latches and of her using the click sound on each side as her cue to know the girt bar was in place. This suggests that although the operator reported that the difference between the L1 and R1 floor mountings was included in all cabin crew training, there was a gap in the flight attendant's aircraft knowledge that had not been corrected in recurrent training. The differences between the L1 and R1 floor latches were also not addressed in the operator's cabin crew manual.

If the girt bar was checked before the R1 door was opened (as required by the operator's cabin crew manual), a partially disarmed girt bar may have been discovered.

Door Guarding

The operator's Cabin Crew Manual required crew to physically guard an exit until it was ready for passengers to use. However, when L1 was opened, this probably could not occur as the door was being pushed open as the Boeing 717-200 door was not power assisted. As a consequence, a passenger almost jumped from the door before the slide was inflated. If the passenger was not physically restrained by the flight attendant from behind, it is probable he would have received a serious injury from the fall of 2.2 metres to the ground. The operator's written procedures did not have a command to direct passengers during the door guarding process (such as 'wait, slide inflating'), and some of the cabin crew reported they were unaware of any procedure that could be used for such a purpose.

2.2.4 Ground crew procedures

The operator's procedures called for the copilot to direct the evacuation from the ground. However, as he was still required in the flight deck, this was left up to ground personnel, including the aircraft dispatcher, a second dispatcher from an adjacent bay, four baggage handlers, and the operator's turn-around coordinator. None of these staff had received any awareness education about an aircraft evacuation on the apron near the terminal. As such, it is possible that they did not realise the importance of an expedient evacuation as a first priority over-riding concerns about minor injuries, and so tried to slow the evacuation down. The ground personnel also did not have any knowledge about the procedure to quickly move passengers away from the aircraft. Similarly, the lack of evacuation education resulted in all personnel concentrating at the front of the aircraft so they did not notice passengers running onto the apron from the rear of the aircraft.

As it is common for evacuations, when they do occur, to occur at an airport, it is also common for ground staff to have some involvement in most evacuations. Even if the copilot is directing an evacuation from the ground, the number of exits and the distance between these exits in modern high capacity jet aircraft will result in ground personnel assisting the evacuation without instruction from the copilot. As such, it is important for all operators of high capacity aircraft to provide airside terminal staff with education concerning how to react to evacuations at an airport.

2.2.5 Flight deck access

When the cabin crew exited the aircraft, the two flight crew were in the cockpit with the flight deck security door locked shut. This contributed to the cabin crew not establishing contact with the flight crew and not checking the flight deck. The operator's procedures were designed to place the copilot in the position to leave the flight deck (leaving the door open) and then to be among the first persons to exit the aircraft. However, as the PIC called for passengers to evacuate before the passenger evacuation checklist was completed instead of as part of that checklist, the copilot was not finished his duties and so remained inside the cockpit by which time all passengers and cabin crew had evacuated.

2.2.6 Engine starting

The starting of engines is a critical time when any mechanical problems that are present often emerge and sparks, smoke, fumes, and/or fire can result. In such situations, the cabin must be ready to evacuate passengers the fastest way possible, which means that escape slides on as many usable exits as possible should be used. This requires that engines should not be started until all doors are armed and cross-checked. However, at Hobart Airport where the operator used stand-off bays, it was reported that the operator's aircraft had their engines started approximately half of the time while the portable stairs were attached to the aircraft and before the doors were armed (as was allowed by the operator's procedures). If an emergency evacuation occurred during such a situation, it would be slow using portable stairs alone, passenger injuries may result from falling down the portable stairs, and the use of the two other type 1 exits could be limited as there is a higher chance of exits being opened unarmed when the evacuation is called (as seen in the evacuation at Sydney Airport outlined in Section 1.8.6).

2.2.7 Escape slides

The door L1 slide was very steep and short without a shallower section at the end of the slide. Some passengers commented that this design led to their injuries. The escape slide at D2, which was slightly higher when the landing gear was intact, was longer and less steep at the end compared with the slides at the front of the aircraft. In accordance with the US Federal Aviation Administration (FAA) regulations, this longer slide was designed to allow it to touch the ground in the event of a nose wheel collapse, where the height of the D2 sill would be higher than usual. The design of the L1 and R1 slides also take into account the angle of the slide from the aircraft to the ground if they were used with some or all of the landing gear collapsed.

Although longer slides at the front of the aircraft may reduce the number of minor passenger injuries in most circumstances, they would become too shallow if the landing gear is collapsed to allow passengers to escape quickly enough to meet the FAA's 90 second evacuation specification. As such, the L1 and R1 slides for Boeing 717 aircraft cannot be longer than they currently are.

2.2.8 Use of exits

In accordance with the operator's procedures, the PIC called the evacuation without notifying the cabin crew which exits to use or not to use due to the information he

had received about a fire in the right engine. Some passengers questioned the wisdom of this practice and thought that it potentially exposed them to danger. This issue has also been raised as an ATSB recommendation (R20050004) for the Civil Aviation Safety Authority (CASA) to consider following the ATSB investigation of a Boeing 747-400 emergency evacuation at Sydney in 2003 (BO/200302980).[16]

Using a standard evacuation call is a common practice in airlines. Its purpose is to ensure crew only need to remember a limited number of emergency commands so that when the commands are given, they instantly know what to do. They are trained to do the same actions during every emergency evacuation as this should increase the speed and accuracy of their responses. As the number of different scenarios that could lead to an emergency evacuation is high, and actual evacuations are very rare, differential training is also not realistic. Furthermore, several safeguards were incorporated into the operator's cabin crew emergency procedures to ensure passengers were not evacuated into an area containing fire. These were for cabin crew to look out of the viewing window for fire or smoke before opening the door, and then after opening the door a small distance, to check again. All cabin crew who opened exits during the evacuation followed this procedure. Likewise, for the passengers that sit in the overwing exits seats, written and verbal instructions were given about the operation of these exits that included looking for fire before the exit was opened.

As the passengers were sitting in the first 13 rows, it was natural for nearly all of them to go to the front of the aircraft when the evacuation was called. However, in accordance with the operator's Cabin Crew Manual, the overwing assist flight attendant redirected some passengers to D2 to reduce the proportion of passengers exiting from any one door. However, it took some time for D2 to be opened and then for the D2 flight attendant to assess that the slide had in fact inflated. When the D2 slide was ready, there were considerably more passengers waiting for D2 than were waiting at L1, so the overwing assist redirected half of the waiting passengers back to L1. Although these directions appeared to some passengers as reflecting that the overwing assist flight attendant was confused about where to send the passengers, these actions were in fact considered and created the optimal conditions for an expedient evacuation using one door at either end of the aircraft.

2.2.9 Evacuation progression

The copilot reported that the cabin was empty when he left the cockpit after the Passenger Evacuation Checklist was completed, and that this checklist was finished 64 seconds after the PIC made the evacuation PA announcement to the cabin. Therefore, it is very likely that the aircraft was evacuated within the 90 second requirement set by the FAA.

16 Available at www.atsb.gov.au

3 FINDINGS

3.1 Air-turbine starter failure

Contributing Safety factors

- The right engine air-turbine starter failed during the engine start sequence as a result of the loss of oil from the starter.
- The loss of oil from the air-turbine starter was a result of the output shaft oil seal retaining ring being installed incorrectly during installation.
- The output shaft oil seal retaining ring installation design permitted the ring to be installed in either of two directions.
- The output shaft oil seal retaining ring installation instructions did not adequately highlight the correct retaining ring orientation.

3.2 Emergency evacuation

Contributing safety factors

- The dispatcher informed the flight crew that there were sparks, smoke and fire emitting from the right engine. The flight crew had no other indication that there was a problem.
- The operator had no standard phraseology for an aircraft dispatcher to communicate how the urgent situation he could see could influence a possible passenger evacuation.
- The operator's written sterile flight deck policy for flight crew did not extend to any phase of flight before takeoff.
- The flight crew were engaged in conversations not confined to the operation of the aircraft during both engine start sequences until the problem with the right engine was first mentioned by the dispatcher.
- The pilot in command called for the passengers to evacuate the aircraft before the Passenger Evacuation Checklist was initiated.
- The operator's door opening procedures called for flight attendants to guard the door while they were being opened for an emergency evacuation. However, there were no written instructions for flight attendants to direct passengers to wait as the slide was still inflating and some cabin crew reported they were unaware of any such procedure.
- One passenger attempted to exit through the forward Door Left 1 while the door was still being opened and before the slide was inflated but was stopped by the flight attendant. The flight attendant probably could not fully guard the door while opening it.
- The forward Door Right 1 escape slide fell to the ground uninflated when the door was opened. It is probable that the door was incorrectly armed before the

evacuation. The Door Right 1 flight attendant was unaware that this door's girt bar had a fixed floor bracket rather than two spring latches.

- The red paint on the forward fixed girt bar bracket for the Door Right 1 slide girt bar had been worn away and the resulting metal surface was very similar in appearance to the girt bar.
- Most of the passenger injuries occurred on the Door Left 1 slide, which was short and steep. The slide design met the requirements of the US Federal Aviation Administration regulations that control slide design.

Other safety factors

- The operator's procedures allowed Boeing 717-200 engine starts at Hobart Airport to occur before the exit doors were armed, and this occurred approximately half of the time.
- None of the operator's ground personnel present had been given any awareness education about policy or procedures during an aircraft evacuation at the terminal.

Other key findings

- The operator's ground personnel assisted passengers at the bottom of the forward Door Left 1 slide and directed them back to the terminal building.
- All 26 passengers and the four cabin crew exited the aircraft through two doors in less than 64 seconds. The flight crew exited soon after.
- As per normal evacuation procedures, no direction was given to cabin crew and passengers by the pilot in command in regard to which exits to use. All cabin crew who opened an exit looked for the presence of fire before and during the door opening.

4 SAFETY ACTIONS

4.1 Air-turbine starter manufacturer

The air-turbine starter manufacturer has advised the Australian Transport Safety Bureau that it has initiated action to amend the component maintenance manual for the air-turbine starter assembly to highlight the maintenance requirements to ensure the correct orientation of the output shaft oil seal retaining ring, prior to installation.

4.2 Aircraft Operator

The aircraft operator advised the Australian Transport Safety Bureau that it has implemented the following safety actions:

- On 25 July 2005, the operator released a safety notice to all airport staff outlining their role in a non-normal situation in relation to the pilot in command (PIC). The notice outlined the two types of disembarkation available to the PIC in a non-normal situation, precautionary disembarkation and emergency evacuation. It also described what sort of information should be relayed to the PIC (size, location, colour, smoke density, smells, origin, and ground personnel actions) and what areas should be monitored (engines, undercarriage, auxiliary power unit), and to use the word 'fire' in such communications only when flames are present. The information on this notice will be incorporated into the Operations Manual chapter 15.
- Training is now planned to be provided for all aircraft dispatch staff in non-normal procedures. This training will include the clear communication of information regarding the extent of problems to the pilot in command.
- The operator's engine start procedures for all aircraft types have been amended to state that all doors and hatches must be closed prior to commencing engine start on stand-off bays.
- The period for which the sterile flight deck policy applies to flight crew has been altered in the operator's operations manual to:
    - The last door closed on departure until the seat belts sign is switched off
    - from the Prepare Cabin PA at 20,000ft to arrival at the terminal.
- Flight crew recurrent training now reinforces the need to follow the evacuation checklist accurately and has included a simulator training exercise that involved a passenger evacuation from the parked position at the terminal.
- The operator's Aircrew Emergency Procedures manual was modified to include a new procedure for flight crew to relay hazard location information to cabin crew before an emergency evacuation. The procedure states that when flight crew become aware of a potential risk or hazardous situation that may impact the safety of passengers during an emergency evacuation, this information should be relayed to cabin crew prior to initiating an evacuation. This is to be achieved by the command 'This is your Captain, cabin crew to your stations' being be followed by 'hazard rear', 'hazard left wing', or 'hazard right wing'. These hazards location alerts are designed to warn cabin crew of hazard locations so they can make a more educated assessment of their designated exit but do not

preclude the use of any exit following an assessment of external conditions by cabin crew.

- The cabin crew manual door arming section has been modified to highlight the differences between the floor brackets on the L1 and R1 doors with a picture of the forward (left side) L1 floor bracket and the following text:

  > The floor fittings on the forward entry door (L1) have a spring-loaded latch on each side into which the girt bar is placed and secured.
  >
  > The floor fittings on the forward service door (R1) have a spring loaded latch on one side only.

- Cabin crew trainers are now required to further highlight the difference in the girt bar floor fittings during all cabin crew training in the classroom and aircraft familiarisation.
- The cabin crew Operations Manual has been amended to encourage cabin crew to "use initiative to adapt commands to different situations" when issuing commands to passengers during an emergency evacuation.
- The cabin crew Operations Manual has been amended to include "High Heels Off" as a core command for cabin crew to give to passengers during both prepared and unprepared emergency evacuations.
- Cabin crew recurrent training now reinforces the need to operate doors in armed mode during emergency evacuations, including the need to not rush the opening of a door.
- The operator's Engineering and Maintenance section have raised a special inspection card requiring a visual inspection of the door L1 and R1 girt bar latches during maintenance C Checks, with any missing or faded red paint on these latches to be repaired.

4.3 Australian Transport Safety Bureau

As a result of this occurrence and the fact that the Australian B717 fleet are currently in the process of being transferred to another Australian operator, the Australian Transport Safety Bureau (ATSB) intends to brief the new operator on the safety issues identified during this investigation.

Copies of this investigation report will be forwarded to all high capacity regular public transport operators in Australia as well as being published on the ATSB website.

5 APPENDIX A - MEDIA RELEASE

ATSB Final Report into passenger evacuation at Hobart Airport on 17 May 2005

An ATSB investigation report has found that while an emergency passenger evacuation at Hobart was conducted rapidly and in a pro-active manner in the interests of passenger safety, there were problems with communication involving the pilots, ground crew, and cabin crew that created potential risk and has led to improved safety action for the future.

The Australian Transport Safety Bureau's final report into the Boeing 717 evacuation on 17 May 2005 found that a right engine starter had failed during the engine start due to loss of lubricating oil because a seal retaining ring was incorrectly installed. This resulted in smoke and sparks issuing from the right aircraft engine. The smoke and sparks were reported to the captain as a fire by the aircraft dispatcher, and the captain ordered an emergency evacuation.

The 3 floor-level aircraft doors were opened by the flight attendants but when the right front door was opened, the escape slide fell to the ground uninflated. The investigation found that the escape slide may not have been properly armed after the doors were closed and that this was not noticed when visually cross-checked. (The passenger operated over-wing exits were not used as there were no passengers sitting in these rows.)

All 26 passengers successfully exited the aircraft in less than 64 seconds, but 11 reported sustaining minor injuries.

The emergency evacuation was ordered before the relevant checklist had been completed. This resulted in a lack of emergency lighting in the rear emergency area and delay in the extension of wing flaps that would have been necessary had the over-wing exits been used.

As a result of this incident, the operator has undertaken several safety actions to enhance passenger safety. These include: improved aircraft maintenance procedures relating to markings on door slide brackets; defined phraseology to be used in emergency communications between aircraft dispatchers and pilots; door closure procedures for engine starts; improved policy on cockpit discussion restrictions after door closure; and improved cabin crew procedures and training.