N° 7
July 2008

HindSight

WEATHER

"Hindsight"
The ability or opportunity to understand and judge an event or experience after it has occured.

A WEATHER GHOST STORY
By Prof. Sidney Dekker
See page 8

NEW! CASE STUDY: "THE FIRST OFFICER IS MY MOTHER-IN-LAW"
By Bengt Collin
See page 16

50 YEARS AFTER MUNICH
See page 39

GET YOUR SKYbrary POSTER
See centre page

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Coding of Subject Matter

To help identification of subject matter, each article is coded and marked by a coloured icon which appears at its head.

- Loss of Separation
- Level Bust
- Runway Incursion
- Controlled Flight into Terrain
- Airspace Infringement
- Wake Vortex Turbulence
- Human Factors
- Air Ground Communication
- Other

ABOUT THE RAIN...

By Tzvetomir Blajev
Eurocontrol Co-ordinator Safety Improvement Initiatives and Editor in Chief of HindSight

Before coming to live in Brussels I liked the rain. The rain is still the same natural phenomenon, but my feelings towards it have changed.

The same reasoning, in my opinion, holds for aviation and weather. The weather has not changed very much since aviation was born a little bit more then a century ago. But aviation has changed tremendously over those hundred years - from Wright Flyer I to Airbus 380, from visual to instrument flights and from virtual "field flights" to modern air traffic control. People also claim that the weather has changed - some pilots have told me that they have recently experienced in Europe what they called "typical severe American weather - storms and fronts hundreds of miles long".

I have no intention of joining the discussion about global warming. My point is that changes in technology and the way we use it, and the information channels for weather reporting, de-icing, snow removal, etc. make purely weather-related incidents into system incidents. These events are no longer caused just by thunderstorms, lightning or standing water on the runway. They happen also because of the lack or failure of controls in our systems, for example for providing crews with the latest information about thunderstorms, for finding ways to measure the existence of standing water on the runway, or for building and maintaining sound practices for pilots and controllers for what are sometimes not habitual, but rare events.

I would like to invite you to read this issue of HindSight keeping in mind that "The Weather" is just a title and that our aim is to entertain you on the subject of "weather, aviation and air traffic control".

Enjoy the reading!

SKYBRARY AND THE WEATHER

I am sure you all know by now about the launch of SKYbrary - the single point of reference in the network of aviation safety knowledge. Take a look at the articles on weather listed at www.skybrary.aero/index.php/Category:Weather. Then, if you want to know more about particular meteorological phenomena (such as Cumulonimbus Clouds) you can follow the links in the main articles, or look through the list in the General - Operational Issues index at www.skybrary.aero/index.php/Image:General_OI.gif, or use the Search box on the top left of each page.

You will find other references to SKYbrary articles at various points in this magazine.

SKYbrary is still under development and we would welcome your feed-back, either by joining the discussion linked to each SKYbrary article, or direct to the editor at john.barrass@uve-ltd.com.

CASE STUDY

This issue of HindSight contains a new feature: Case Study. The article "The First Officer is my Mother-in-Law" was written by one of our regular contributors, Bengt Collin, based on personal experiences. The article was then circulated for comment. The response was most interesting and three of the comments reflecting different aspects of the story are published in this issue following the original article.

Case Study will not feature dramatic accidents or near escapes, but will concentrate on the sort of occurrence that happens somewhere in the world every day; it will try to bring these events alive by representing, as far as this is possible, the thoughts and emotions of the people involved. We hope that this feature will stimulate debate at your work-place and that you will contribute your point of view for publication in the next issue. You may even have a personal experience that you would like to contribute (anonymously if you wish) to Case Study.

www.skybrary.aero/index.php/Category:Weather
www.skybrary.aero/index.php/Image:General_OI.gif

FRONT LINE REPORT EVERYWHERE YOU GO, YOU ALWAYS TAKE THE WEATHER...[1]

By Bert Ruitenberg

Bert Ruitenberg is a TWR/APP controller, supervisor and ATC safety officer at Schiphol Airport, Amsterdam, The Netherlands. He is the Human Factors Specialist for IFATCA and also a consultant to the ICAO Flight Safety and Human Factors Programme.

One of my responsibilities in my IFATCA role is to participate in the annual meeting of the IATA Accident Classification Task Force (ACTF). The ACTF comprises representatives from safety departments in airlines and aircraft manufacturers, an avionics manufacturer and a provider of navigation charts, together with representatives from IFALPA and IFATCA. What this group does is review (preliminary) data from aviation accidents in the previous calendar year with the aim of identifying and classifying the threats, errors and undesired aircraft states that may have played a role in the accident scenario. The results of ACTF's work are analysed and processed by IATA, and eventually published in the annual IATA Safety Report.

This rather lengthy introduction is provided as background for the following observation: recently there have been several weather-related accidents that in hindsight (no pun intended) could have been easily avoided. And I'm not even referring to accidents that happened in foggy conditions, or in heavy storms. I'm referring in particular to runway over-runs and other runway excursions that happened during or immediately after a relatively short period of heavy rain or snow.

For some reason the aviation industry seems to have a problem communicating the actual runway conditions to pilots just when they need that information most: during the approach, just before landing. And yes, we as controllers are part of that aviation industry - so is there anything we can do to resolve this problem?

In order to answer this question we first have to determine where the information on runway conditions is available. Who knows whether a runway is wet, or contaminated with snow/slush/hail, and what the braking action is on that runway? In many cases, and in particular at the larger airports, this will be the airport authority. But how good is their information at any given moment, and how is it communicated to the pilots who may want to use the runway within the next 20 minutes?

In the case of the airport where I work, Schiphol Airport (Amsterdam, the Netherlands), it is the airport authority's responsibility to inform ATC about the runway conditions, and ATC in turn provides that information to the pilots. However, Schiphol has 6 runways, of which 4 are routinely used at the same time, and sometimes even 5. There is no way an airport authority officer can provide an actual report on the runway conditions on all those runways at the same time. First of all, there are never 5 AA officers on duty "in the field" at the same time. Secondly, one of our most frequently used runways is so remote from the rest of the airport that it may take an AA officer up to ten minutes by car to get from his office to that runway, even if the shortest available route is used. And once the AA officer is on a runway, all he can provide is an observation report on the runway conditions, possibly augmented by an opinion on the effectiveness (or lack of effectiveness) of his car brakes after testing them on the runway. For a real reading of braking action, another (specially equipped) car has to come to the runway and make two passes over the length of the runway (one in each direction) in order to obtain the official friction values. These values are interpreted by the AA officer, and subsequently communicated to the tower in terms of Poor, Medium, Good or anything in between. This information is then passed to the pilots, either via R/T or via the ATIS, which is fine for the runway concerned. But this same process has to be repeated for the other 3 (or 4) runways before we have a picture of the entire airport, and by that time the situation on the first runway may have

[1] Crowded House (Woodface, 1991)

changed again. I wonder if things are any different at other multi-runway airports in Europe?

At the beginning of this article I made the observation that several weather-related accidents could have been easily avoided in hindsight. All it would have taken (at least in some of the cases) was another 30 minutes or so in the holding pattern before starting an approach shortly after a heavy rain shower passed over the airport. And in other cases a decision to divert to a more suitable airport would also have saved the day, never mind the unhappy passengers - I bet they (or their relatives) were more unhappy about the way things turned out after the aircraft was unable to stop on the runway.

Maybe we as controllers, and in particular the tower controllers, should adopt a more proactive stance on informing pilots about the runway conditions - especially when there are rapid and significant changes in the weather that we can see outside our visual control rooms. By all means, let's try to get official runway condition reports from our AA officers, but let's also use our expert controller judgment to provide qualitative information to pilots on what we observe ourselves while waiting for those official values to come in.

Even a simple statement via the R/T that the runway looks snow-covered after a heavy snow shower may help pilots realise that the braking action values they heard from the ATIS twenty minutes ago may no longer be valid, and prompt them to re-think their plans. The same applies for the observation that there is a lot of water on the runway after a heavy rain shower - if you think the information could be relevant to the pilots, just give it to them. You'll never know it, but you may in fact be helping to reduce the number of cases the IATA ACTF will have to discuss next year.

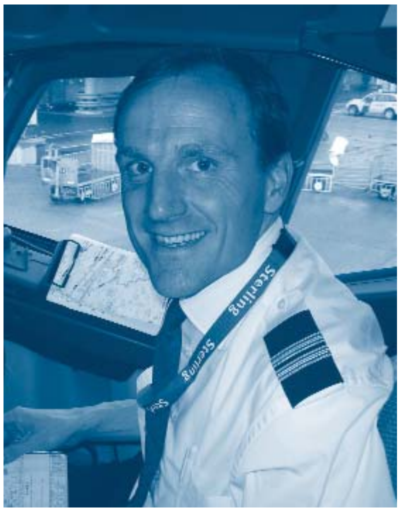
Editorial Comment

Several systems are becoming available which provide a remote indication of runway surface conditions, and others are under development. At present, these systems are not in widespread use and systems that provide an accurate indication of braking action seem a long way off.

A WEATHER GHOST STORY

by Professor Sidney Dekker, Ph.D.

Sidney Dekker is Professor of Human Factors & Aviation Safety at Lund University in Sweden. He gained his Ph.D in Cognitive Systems Engineering at the Ohio State University in the US. His books include "The Field Guide to Human Error Investigations" and "Ten Questions about Human Error". His latest book, "Just Culture: Balancing Safety and Accountability" has just appeared. He flies as a first officer on B737NG.



Two years after a fatal aircraft accident at Pikeville, Indiana, lawyers for the surviving family members claimed that the controller was to blame for the crash. It was raining and foggy at the time, and the controller was blamed for giving wrong information that got the pilot in a hurry. The small aircraft impacted ground a mile short of the runway, killing members of a prominent Kentucky family. The controller's employer, the Federal Aviation Administration, was recently asked to pay ten million dollars, since the family members would be alive if it hadn't been for their errant controller.

It is easy to dismiss such lawsuits as a mix of greed and grief, or even as an exclusively North-American phenomenon. But perhaps they offer a deeper window into our own soul too. The way we, people in general, handle the aftermath of an accident, the way we tell its story, the way we negotiate or fight about who stands to benefit from that version of the story, and how we then engage in penalising rituals after the accident - all of this gives the accident a meaning that perhaps goes beyond 10 million dollars or the avenging of a few people.

Collective tolerance for aircraft accidents, particularly fatal ones, has eroded in synch with our ever-improving safety record. Today, every untimely death in aviation seems to have to be put onto somebody's account. Occasional death is no longer accepted as the natural by-product of a (for humans) still profoundly unnatural activity. Intriguingly, our resistance to the notion of natural death ("natural" in the sense that it sometimes comes as a predictable side-effect of the activity we engage in) is remarkably similar to such resistance in what we westerners used to call "primitive" cultures. "Primitives" too tend to deny that people simply die doing what they are doing - instead some force (voodoo, disgruntled spirits, aggrieved ancestors) must be responsible, and penalising or purifying rituals are one way of placating survivors and keeping the spirits away.

You could argue that we, in western societies today, have translated such rituals and incorporated them into our own modern institutions. Just take the ten million dollar lawsuit: a legalised extortion by lawyers of extravagant sums of money for the air crash death of a few people. Or worse, look at the legalised, state-sponsored criminalisation of controllers who were on shift during a fatal accident or even a serious incident. Perhaps these rituals function in our society in a way similar to organised religion-"primitive" or otherwise. In that case, it is our legal system that inhabits the temples of this religion nowadays. It, after all, has its dogmas, traditions, rituals, a high priesthood, its own wardrobe, a sacred language, and a justifying narrative (Christian theologians call it a "salvation history") that revolves around dire prediction and salvation and redemption. Such a dynamic (predicting hellfire, promising salvation if you buy into a particular creed, offering redemption for those willing to submit) has worked for organised religion for thousands of years, and has offered countless people meaning in the face of terrible, inexplicable events.

But it may have a cost. Today, confronted with a death that society cannot afford to see as "natural," prosecutors get to preach the hellfire of human error. The aircraft crashed because the controller made a mistake! And then the legal system offers salvation for it to those willing to submit: Make the bad apples confess, punish them, extort their resources. This is not the legal system's doing, but our own. Because for the most part society actually goes along with the justice system's salvation narrative. Perhaps a part of society even hungers for it, hungers for a single local explanation of failure, death - lest everybody would have to admit that they are equally vulnerable. A Marxist, or any social critic, would of course add that pointing at, prosecuting and penalising an individual for system failure protects elite interests, that it leaves power configurations intact. Localised explanations of "human error," after all, avoid costly or politically unattractive changes to the larger system in which people work. Any reinterpretation of this narrative, it is feared, could disempower elites, upset vested interests.

But, more critically, a thorough reinterpretation would deprive society of the meaning and solace it so craves after a seemingly meaningless, untimely aviation death. Yes, we may demand change to the legal system, to the way it handles aviation accidents and the professionals involved in them - tort reform, just cultures - but we may not want *that* much change. For it would leave us with an existential dread that even we cannot cope with. Death has to have some reason, it cannot simply happen because somebody chose to fly or control aircraft in lousy weather, because somebody was simply doing her or his job. Because if dying were that easy, then anybody could die anytime, ourselves included. Indeed, it is quite comforting, quite safe, to be told that a death occurred because somebody did something wrong. Anything else could quickly become a dreadful nightmare. The rituals that we allow our societies to enact after death are not just about exorcising the source of that death (the ancestors' aggrieved spirit, the errant air traffic controller). More importantly, they are about keeping our own fear of death at bay. Stories of human error - simple, convenient stories with an evil-doer in the lead role (the Pikeville controller for example) - are about us, about our anxieties, and about how we choose to ward off that nightmare. Yet stories of human error, of bad apples responsible for an accident, are bogus. They are part ghost stories with which we scare ourselves at bedtime. And they are part nightly prayers with which we then go to sleep.

With thanks to James Carroll for inspiration.

121.5
SAFETY ALERTS

SAFETY REMINDER MESSAGE SUMMARY

TCAS II RA AT VERY LOW ALTITUDE

Origin: EUROCONTROL Mode S & ACAS Programme
Issued: 21/12/2007

EUROCONTROL MODE S & ACAS PROGRAMME REMINDER

Recently, a report was received of a case where a TCAS II Resolution Advisory was posted at approximately 100 feet AGL. The technical cause appears to be related to a radio altimeter data malfunction. Radio altimeter data is used to recognise when TCAS is too close to the ground to issue RAs. Aircraft operators and flight crews are reminded that:

- TCAS II design progressively inhibits resolution advisories (RAs), depending on the height above ground level (AGL) provided by the radio altimeter, as follows:
  - "Increase Descent" RAs are inhibited below 1,550 ft AGL (± 100 ft)
  - "Descend" RAs are inhibited below 1,100 ft AGL (± 100 ft)
  - All RAs are inhibited below 1,000 ft AGL (± 100 ft).
- If a "Descend" RA is in progress while the aircraft is descending through 1,100 feet AGL, the RA will change to an "Adjust vertical speed" RA.
- TCAS limitations are explained in JAA TGL 11 Rev1 "Guidance For Operators On Training Programmes For The Use Of Airborne Collision Avoidance Systems (ACAS)". TGL 11 Rev1 can be accessed at: www.jaat.eu/operations/public_area.html, or www.eurocontrol.int/acas

www.jaat.eu/operations/public_area.html
www.eurocontrol.int/acas

SAFETY REMINDER MESSAGE SUMMARY

CPDLC INCORRECT CALLSIGN ON LOG-ON

Origin: Air navigation service provider
Issued: 9/01/2008

WE HAVE BEEN INFORMED

- Flight YYY777 sent a CPDLC logon request using incorrect aircraft identification YYY772.
- A flight plan having the aircraft identification YYY772 was already active in the ATC flight data processing system. This aircraft was not logged on with the ATS system.
- Consequently the logon request was automatically accepted by the ATS system and automatically associated with the flight plan of YYY772.
- Therefore the uplinked ATC clearances intended for YYY772 were actually received by YYY777.
- Voice readback of the CPDLC instructions and other communications with the aircraft involved triggered the recognition of the mismatch and the situation was clarified and resolved on the voice frequency.
- When queried as to whether they received the CPDLC messages, the crew of YYY772 did not highlight the fact that they were not CPDLC connected at the time.

AIRCRAFT OPERATORS ARE REMINDED TO

- Ensure that the correct aircraft identification (ICAO flight plan Item 7) is used for all airborne systems, including CPDLC log-on.
- Ensure that, when required, voice readback is used as specified in the respective AIPs for profile-changing CPDLC messages.
- Ensure that crews revert to voice in the case of <u>any</u> uncertainty regarding the receipt of a CPDLC message.
- Ensure that crews are aware of their CPDLC status and, in the event of any doubts, report this via voice.

SAFETY REMINDER MESSAGE SUMMARY

TCAS RAS GENERATED DUE TO TRANSPONDER TESTING ON THE GROUND

Origin: European airline, European ANSP
Issued: 27/02/2008

BACKGROUND INFORMATION

- TCAS II interrogates, within its range, all Mode S and Mode A/C SSR transponders squawking altitude. That includes ground-based transponders operated for testing or maintenance.
- If these transponders respond with an altitude report close to that of aircraft flying in the vicinity, their TCAS II traffic display will show a 'ghost' target and, more seriously, could generate TAs/RAs against such targets.
- Recently, events have been reported in which RAs were generated by transponders that were being tested on the ground.
- These unnecessary RAs were disruptive to the flight crew and air traffic control.

EUROCONTROL MODE S & ACAS PROGRAMME ADVICE

- TAs/RAs due to transponder testing on the ground are disruptive and potentially hazardous and must be prevented.
- To avoid these TAs/RAs, special caution and appropriate procedures are required during transponder testing and maintenance.
- In order to prevent the transmission of a virtual altitude which could then be mistakenly used by airborne systems, the followings steps are recommended:
  - Use effective screening or absorption devices on the antennas or physically connect the ramp test set to the antenna system.
  - Where possible, perform the testing inside a hangar to take advantage of any shielding properties it may provide.
  - Manually set the altitude to a high value (e.g. over 60,000 feet) or unrealistically low (e.g. negative 2000).
- Select the transponder(s) to 'OFF' or 'Standby' when testing is complete.
- The simulation of TCAS operations must not be carried out by the radiation from an antenna located on, or remotely based from, a workshop.

ADDITIONAL INFORMATION AND ADVICE

- ICAO Annex 10, vol. IV
- ICAO Manual of Secondary Surveillance Radar (SSR) Systems (Doc 9684)
- JAA TGL 8 - Certification Considerations for the Airborne Collision Avoidance System: ACAS
- JAA TGL 13 - Certification of Mode S Transponder Systems for Elementary Surveillance
- EUROCAE WG49 guidance for ground test and maintenance

REQUEST FOR SUPPORT MESSAGE SUMMARY

SID CONFUSION

Origin: LVNL - ATC the Netherlands
Issued: 22/01/2008

INFORMATION FROM ATC THE NETHERLANDS

- At Schiphol Airport (EHAM) we have identified a steady number of cases where flight crews execute different SIDs from the one given to them by ATC and acknowledged by the crew. We have even had cases where the correct SID was provided to the crew by data link and where the correct SID was mentioned again by the TWR controller when clearing the a/c for take-off, after which the crew read back the correct SID with the take-off clearance, and still flew a different (and incorrect) SID when airborne.

- At LVNL/ATC the Netherlands we have a strong suspicion that an underlying cause of this type of error can be found in the fact that many operators provide their crews with "ready-made" operational flight plans before the start of the trip, in which the dispatchers have made assumptions about the runway in use and the corresponding departure route. If crews try to be as efficient as possible in managing their workload it may happen that FMS inputs/preparations are done based on the company flight plan BEFORE the actual ATC route clearance (including the SID) is obtained. After obtaining that clearance the crew for whatever reason subsequently omit to change the setup of the FMS, and the result is that the a/c follows an incorrect SID when airborne.

- To date this problem has not resulted in any dangerous situations, although there have been several cases where ATC had to intervene (by issuing heading and/or level off instructions to other aircraft in the vicinity) in order to maintain separation standards. The potential for a situation where safety is compromised is very real however.

TRIAL

- For one particular set of SIDs (from one particular runway) that often seems to be interchanged at Schiphol Airport, a trial was held by one of the major operators at the airport in which the reference to a specific SID in the ready-made flight plan was replaced by the words "check SID". This trial was considered a success, for since this modification there have been zero cases with this airline where this particular mistake occurred. Other airlines sometimes deviate from cleared SIDs.

Readers were to share their national and company experiences and to suggest a joint approach to resolve the problem. A summary of the responses may be viewed on the Skybrary website at http://www.skybrary.aero/index.php/SID_Confusion_Safety_Alert

Coincidentally, at about the same time as this safety alert was generated, Gerhard van Es of the NLR Air Transport Safety Institute submitted the article *Flying the wrong SID - Why does it happen?* for publication in HindSight. The article is published immediately after this item.

http://www.skybrary.aero/index.php/SID_Confusion_Safety_Alert

FLYING THE WRONG SID - WHY DOES IT HAPPEN?

by Gerard W.H. van Es

NLR-Air Transport Safety Institute - Amsterdam, the Netherlands

"On April 29, 2001, an MD-83 was on a flight from Vancouver to Seattle, taking off on runway 08R of Vancouver International Airport. When the clearance delivery controller issued the clearance he incorrectly gave a Standard Instrument Departure (SID) RICHMOND 6. However he wrote down the correct SID, VANCOUVER 2, on both the digital and paper strip. The tower controller, seeing VANCOUVER 2 on his strip, assumed that the Alaska airlines MD-83 would follow that SID. After take-off, the MD-83 turned right to a heading of 140 degrees as called for by the RICHMOND 6 SID. The MD-83 now came into a conflict with a DASH-8 which had taken off ahead, also on a RICHMOND 6 SID. The tower controller noticed the conflict and instructed the MD-83 to turn left. The separation had reduced to 2 nm whereas 3 nm is required." Source: NLR-ATSI Air Safety Database.

A Standard Instrument Departure (SID) is an IFR departure procedure that provides a transition from the runway end to the en-route airway structure. There are many operational advantages in using SIDs, both for the pilot and for the air traffic controller. For the pilot, a relatively complicated route segment may be loaded from a database and flown using the Flight Management System (FMS), whilst being assured of proper clearance from obstacles, ground or other traffic. Air Traffic Control may clear the aircraft for the SID, thereby reducing the need for further instructions during the initial climb phase of the aircraft, greatly reducing the controller/pilot workload and frequency congestion. SIDs are first and foremost designed to comply with obstacle clearance requirements, but are also often optimised to satisfy ATC requirements and may serve as minimum noise routings as well. Small deviations from the assigned SID occur on almost every SID flown. This is quite normal and poses no immediate threat to flight safety. However large deviations from the assigned SID or flying the wrong SID can be hazardous and may lead (and have led!) to:

- Close proximity to terrain or obstacles.
- Close proximity to other aircraft.
- Airspace violations.

There are many different reasons why an aircraft significantly deviates from an assigned SID. A recent study conducted by the NLR-Air Transport Safety Institute showed that there are 38 different causal factors that are associated with significant SID deviations. However this study also clearly showed that by far the most important factor is that the pilots used the wrong SID, accounting for 20% of the analysed occurrences. Flying the wrong SID can be a very hazardous situation, especially when there are multiple take-off operations in place (e.g. parallel departures).

Let us consider SID blunders more closely. Why would a pilot use the wrong SID? Again there is no single causal factor. However, there are some that are more important than others as they occur much more frequently. The NLR-Air Transport Safety Institute safety study showed that similar-sounding SID names are often involved in cases where the pilots used the wrong SID. This should not come as a big surprise when there are other SIDs available with a similar-sounding name. Often the difference is only a single letter or number. For instance ELBA 5B looks very much the same as ELBA 5C and can easily lead to mistakes when selecting either one. When using the FMS NAV mode for flying the SID the pilot selects the SID from the FMS database. Depending on the type of FMS, a list of runways is presented which has to be selected first, after which a list of corresponding SIDs is given. It is also possible that a list of SIDs is listed first which are automatically linked to the corresponding runway. It is often impossible for the pilots to realise that they are flying a wrong SID: in the cockpit all instruments indicate that the aircraft is exactly on the pre-defined route! Usually ATC notices such errors much earlier than pilots. The following example illustrates the problem clearly:

"Before departure the crew received ATC clearance from Rwy 12, PEPOT 1F SID. It was read back to ATC as IPLOT 1F without any correction from the controller. After departure, ATC monitored the departure well and took corrective action without delay when the controller noticed that the aircraft was flying the wrong SID. The SID should have been PEPOT 1F. Because of the prompt action by ATC no conflict with other traffic happened. IPLOT and PEPOT sound very similar when heard by radio."

This last example also shows another important factor identified in many occurrences related to flying the wrong SID. That is the readback/hearback error in which the pilot reads back the incorrect SID and the controller fails to notice this. This is a classic air-ground communication error. In the above example, the pilots were cleared for the PEPOT 1F SID but read back the IPLOT 1F SID, which was not noticed by the controller.

Another classic error related to flying the wrong SID is crew expectation, as shown in the next example.

"The planned SID for the flight was a DAKE departure, as had been used for years for this runway. After departure ATC informed the crew that they were supposed to fly ELBA SID, as this had been the cleared departure. The crew stated that their minds had been set for a DAKE departure and that they did not change the SID in the FMS."

Clearly the crew expected to fly a particular SID, as they had always done for this runway. When the controller instructs a completely different SID the crew fails to notice and often reads back the correct SID. The controller will only notice that the crew are flying the wrong SID after they have taken off.

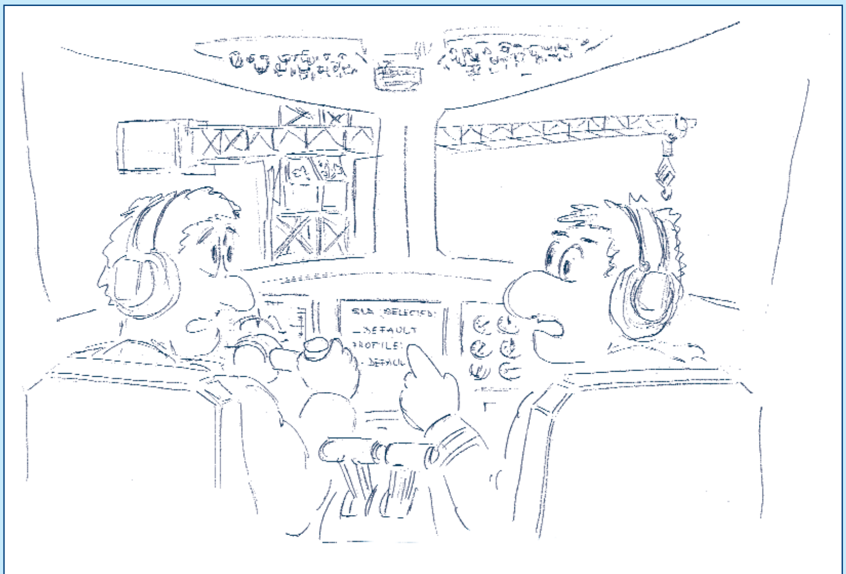
Finally, another important factor is illustrated by the following example.

"An ELBO 1A SID for Rwy 25R was inserted into FMC according to the operational flight plan. This was also passed by the clearance delivery. However when the aircraft was taxiing to Rwy 25R the departure runway was changed to 25L with a BEKO 1F SID. The pilot not flying forgot to change the ELBO 1A SID that was originally programmed into the FMS. The aircraft flew the SID of Rwy 25R after takeoff."

Late changes of the SID or departure runway are another important factor related to flying the wrong SID. In the example above, the pilot not only needs to change the runway/SID in the FMS. He also has to make new take-off performance calculations for the new runway. Often the SID is completely forgotten in this process and the FMS uses the originally programmed SID.

As shown in this brief article there are several reasons why pilots use the wrong SID. In many cases the pilots play a crucial role. However, controllers can also be part of the chain of events resulting in the wrong SID being flown.

(NOTE: In some of the examples the names of the SIDS and runways have been changed due to the confidentially of the original data. However, all examples are based on real cases).



- Are you sure that you put the cleared SID in?
- Sure, I did it as usual, and anyhow, it has been the same for the last two years...

CASE STUDY #1

THE FIRST OFFICER IS MY MOTHER-IN-LAW

By Bengt Collin

Bengt Collin works at EUROCONTROL as an expert on the Advanced Surface Movement Guidance and Control System (A-SMGCS) Project, part of the Airport Operations Programme (APR), and also for the Directorate of ATM Programmes (DAP/SSH).

THE OUTBOUND CAPTAIN

He could hear the screaming sound from the engines as they taxied down the taxiway, through half a metre of snow. The first officer (who was his mother-in-law) reminded him not to forget his overcoat when disembarking the aircraft. "It is freezing cold out there and I do not want you to get a cold this close to Christmas," she said, and smiled. The alarm clock rang, it was 4.30 in the morning, check-in at the crew base 5.45; he hated early mornings.

THE GROUND CONTROLLER

The morning traffic had been hectic as usual, nothing special, just another day in his life. They used the parallel runways in single-mode operations, landing on the left one, departing on the other. Since the peak period was over, traffic had dropped significantly, but they had changed runways three times. This actually drove him nuts; "Some stupid political guys have decided on this environmental noise procedure; they change runways four times more often than they need to nowadays, and therefore increase the environmental impact from emissions on the ground instead," he thought. Intense traffic was great, low traffic with a lot of disturbing extras was not. He liked to complain, it made him feel better.

He had only one aircraft on the frequency, it was a departure, an ATR parked on a remote stand. Normally he would instruct the pilots to taxi a long, long way to the right parallel runway, but instead the flight crew requested the left runway, which was used for inbound traffic; he had expected this and had already started doing the necessary coordination when the pilot called; there were only a few inbound aircraft and it would save five minutes for the flight.

THE INBOUND CAPTAIN

He had just finished another cup of coffee, after the early morning check-in; this was his third flight of the day. The weather was OK, a bit windy but that was normal for this time of year. The first officer checked the ATIS, "They've changed runway again," he said, "what are they doing? This is the third change in 45 minutes and now we get tail wind on approach and landing, unbelievable!" They were passing FL100 on their descent, he thought about his new date that he would spend the afternoon with; they were certainly not going to play bingo for sure. "Let's do the Approach Check List," he said to his First Officer.

THE OUTBOUND AIRCRAFT

"After Start Checklist completed". "OK, ask for taxi and the left runway," the captain said to his first officer in a friendly but serious way. "It will save a lot of fuel. Besides, I hate to taxi all the way to the right runway," he added after a few seconds and laughed.

"Tower, D-Jet 123 request taxi, is runway XX left available without delay?" Nothing happened; he was going to ask again when they received the taxi clearance they had asked for; they were cleared to a rapid exit taxiway some six hundred metres down the runway; it was used on and off for departing aircraft like the Dash 8 and ATR. Remaining runway length from the intersection departure was more than enough.

The ground controller instructed them to contact the runway controller.

THE RUNWAY CONTROLLER

"Can you name horses whatever you like," he asked his colleague? "I thought I had heard everything, but 'The Eager Beaver!'". His colleague looked at him with empty eyes; the look on his face would make Oliver Hardy seem intelligent. "I like the name", he said, as he handed over the departure to him.

The next inbound aircraft called downwind; it had a long way to fly so he instructed the crew to report on finals. This was how they were taught; always ask for a report if the aircraft is far out,

COMMENT ON CASE STUDY #1

so as not forget about it. The wind increased, it was almost ten knots tail wind at touch down. He re-cleared the outbound aircraft; a new clearance was necessary after the change of runway for departure; the ground controller should have done that but was busy with his horse betting. "The pilots are taxiing slower than normal," he thought. One of the pilots asked for confirmation of the squawk; he confirmed and instructed the aircraft to line up. Of course the stop bar was still on; he knew it, he did switch it off but the *#@% HMI was just not good enough; this time he needed to press on the screen three times before the lights went off; irritating.

THE INBOUND CAPTAIN

They had just passed five thousand feet descending and completed the Approach Check List by inserting the correct QNH. The approach controller turned them to the right, instructed them to descend to two thousand feet, and asked them to report field in sight. They were still three thousand feet descending when they saw the airport on their left side, passing abeam the airport on the down wind. "Cleared visual approach runway XX Left, keep speed up, number two on eleven miles". Should be no problem, he thought, as he instructed the first officer to read the Landing Check List. "Contact tower 120.0." He advised the cabin crew, increased the rate of descent and called the tower, "report on finals." The speed was still high, he needed to turn inbound soon, gear down, they slowly got all green; they were on the base now still descending, speed reducing, flaps 2; they turned finals at 1100 feet descending, "we are too fast for flaps 3," the first officer said, "no problem, we'll make it," he said. 700 feet descending on finals, a bit high but the runway was long; 500 feet, flaps 3 at last, they were close to the threshold, an aircraft was lining up ahead of them, how could they have missed it before?!

THE OUTBOUND AIRCRAFT

Four hundred metres before the runway they received their new clearance. The first officer immediately started re-programming the FMS. "Did you get the squawk?" he asked; "I'll ask the tower," the captain answered and grabbed the microphone; they did not use headsets, they never did; this was not required by the company. Tower confirmed the code and instructed them to line up; "Before Departure Check List," the captain instructed, they were on the RET; "please switch off the stop bar"; waiting, they slowed down even more, "the stop bar is still on", finally the red lights went off; they slowly entered the runway. The sound from the aircraft passing just above them could have wakened the dead.

By Bert Ruitenberg

Bert Ruitenberg is a TWR/APP controller, supervisor and ATC safety officer at Schiphol Airport, Amsterdam, the Netherlands. He is the Human Factors Specialist for IFATCA and also a consultant for the ICAO Flight Safety and Human Factors Programme.

My first observation is that arguably this is not a safety incident at all. Admittedly the tower controller misjudged the available time to allow an outbound aircraft to depart ahead of a landing one, but 1) there was no landing clearance issued yet, and 2) there was no take off clearance issued yet either, only a clearance to line up. Because of those two factors the inbound aircraft could safely execute its "get out of jail free" option and perform a go-around, while the outbound aircraft remained stationary on the runway. The standard ICAO procedures are adequate for this, without a requirement for any additional safety recommendations.

But could this event have been avoided? In the narrative there are a number of aspects that seem relevant in order to answer this question. The many changes in the runway(s) in use; the non-standard use of the

COMMENT ON CASE STUDY #1

designated landing runway for a single departure (just to avoid some taxiing); the tailwind component that made the aircraft on final perhaps go faster than usual; the request from the approach controller to the inbound pilot to make it a short circuit, which caused the flight to end up a little high and a little fast on final; the late re-clearance transmission to the outbound aircraft; the problems with the HMI to control the stop bar; the ground controller who is occupied with things other than his primary job.

All of these items are Threats that require attention in order to manage them, and according to the narrative most of them were indeed managed or being managed - either by ATC or by the pilots of the two aircraft involved. The fact that the inbound aircraft came on short finals (without a landing clearance) at the same time as the outbound aircraft was lining up could be called an Undesired State, which - as noted above - was resolved by a go-around as per standard procedure. (NB The narrative doesn't say whether the go-around was ordered by the tower controller or initiated by the inbound pilot.) In any case the outcome was inconsequential, except perhaps for the inbound aircraft having to fly an extra circuit.

If despite all this, if I were asked to give one single recommendation to avoid similar situations in the future, my choice would be to prohibit departures from a runway that is designated for landings only at this airport.

By Rickard Jörgensen

Rickard Jörgensen is an air traffic control expert with the Air Navigation Services Division of the LFV Group.

In this incident an aircraft landed at the same time as another aircraft lined up on the runway. The most obvious cause of the incident is that the landing aircraft landed without a landing clearance. The easiest thing would be to blame the pilots for this and close the case. But would it result in increased safety? Would it reduce the possibility of a reoccurrence? Certainly not. All contributory and causal factors must be identified and considered in order to reach conclusions and suggestions that will meet acceptance and have an effect on safety.

In this case, it's obvious that the frequent changes of runway in use resulted in increased workload for both pilots and ATCOs. Environmental pressure nowadays more often leads to situations where safety might be compromised. Departures and landings are more often made in tailwinds and besides that transitioning from multi-runway operation to single-runway operation is in itself a critical factor. As in all changes in working methods, the transition time means an increase in risks due to the time it takes to create a complete and correct picture of the new situation. To mitigate the risks a specific runway change procedure should be developed.

The function of the stop bar control panel also contributed to increased workload for the controller. The equipment should be checked and fixed to be considered in operational status.

The procedure to ask pilots to report on final is good procedure but is vulnerable as it is easy for a pilot to forget it. The controller failed to monitor the approaching aircraft and based the decision to allow a departure before the landing more on assumptions than on facts. When this happened in combination with the pilot forgetting to report on final it resulted in the incident. The request from the approach controller about high speed and short approach are causal factors. These requests should have been mentioned in coordination between the approach controller and the tower controller.

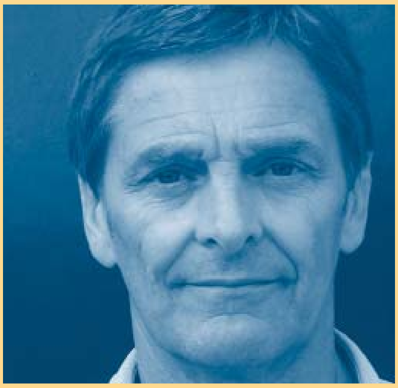
RECOMMENDATION:

The ATC unit should develop and establish a specific procedure to ensure that a change in runway(s) can be made in a controlled and safe way

COMMENT ON CASE STUDY #1

By Captain Ed Pooley

Captain Pooley is an experienced airline Captain who for many years also held the post of Head of Safety for a large short haul airline operation. He now works as an independent air safety consultant and acts as Validation Manager for the safety web-site - SKYbrary.



Both flight crews in this story appear to have been in 'comfortable territory' prior to the lead in to the incident. They were in their familiar environment with everything going normally. There is plenty of evidence too that each crew is getting along with each other just fine. The two Captains are 'can-do' people, a quality most Operators understandably look for when promotion to 'command' is made.

But then this 'can-do' takes over and, for both crews, it all goes badly wrong. The underlying reason for this seems to be an absence of a sufficient SOP framework to keep the 'can-do' desire under control. 'Individual style' did not succeed in delivering either 'active safety' for the inbound crew or 'defensive safety' for the outbound crew.

The Outbound flight crew knew the rules. They were not using headsets because they weren't required to. They knew they had to have the right squawk set before taking off and they were never going to cross a red stop bar. Their Company would have been pleased that they were keen to take any opportunity to stay on schedule.

But there the problems start. There is no evidence that this crew had any appreciation of the implications of their can-do approach. The late re-clearance and FMS re-programming was to be expected - allow time to get it right! Despite getting a 'landing runway' for departure and an RET entry point which prevented an easy visual check of 'short finals' they weren't listening to the Tower frequency ATC, they didn't check their TCAS for any inbound traffic and were so keen to get onto the runway that manoeuvring their aircraft in order to be able to see up the approach was not considered.......

The Inbound flight crew knew the rules too and they began their arrival with normal 'situational awareness'. Their Company too would have been pleased that they were keen to minimise flight time! But there the problems start. Visual contact approaches raise the flight crew workload because they make the handling pilot think hard and the non handling pilot work hard! For pilots, this is part of their 'fun factor'. But the evidence here is that the Operator did not have enough SOPs to make a safe visual contact approach likely. Focussed on go-down and slow-down, the absence of Company-set stabilised approach 'gates' for a visual approach meant that the high workload was allowed to interfere with both communication with ATC and overall situational awareness. No call on finals. No apparent concern at the absence of a landing clearance or why that might be.

And finally, what about the roles of the 'monitoring' co-pilots. Was CRM effective? Was the authority gradient in both flight decks too steep? I'd go for a 'no' and a 'yes'. Neither co pilot seems to have acted as a true 'monitoring pilot' - they either didn't see trouble ahead or didn't have the confidence to say something.

Of course we can also say that these crews didn't get much help from the Runway Controller. But that would be no more than an excuse. If the organisational frameworks are good enough, they will succeed in constraining the inevitable lapses in human performance.

So, both Companies have work to do. They urgently need better normal operations SOPs which also achieve an effective monitoring role for the 'non flying pilot' when that pilot is the First Officer, mother in law or not!

GETTING THE WIND UP

Bengt's story in this edition of HindSight (The first officer is my mother-in-law) touches on an issue that is very important to pilots - perhaps more important than some controllers realise. That is the question of the surface wind, its strength and direction relative to the runway, and the different ways in which it affects the take-off and landing phases of flight.

There are several closely interrelated aspects of the surface wind which are of particular interest to pilots: its direction relative to the runway direction; its strength; its variability - i.e. the extent to which its direction and strength vary in gusts; the way in which its direction and strength vary with height; and the vertical component of the wind - updrafts and downdrafts. When the wind changes significantly over a short time period, this is known as wind shear; wind shear may occur in a vertical or a horizontal sense, but the effect of vertical change is likely to be more dangerous because it is more uncommon and therefore unexpected. Extreme vertical movements of air, usually occurring in the region of thunderstorm clouds, are called microbursts.

Although new technology is becoming available, wind is usually measured using cup-and-vane anemometers, which have not changed much over the years. Most aerodromes have a number of anemometers positioned at strategic positions; this allows the wind to be measured as close as possible to the landing runway and provides redundancy in case of failure. This is especially important at airports where the terrain produces widely different wind conditions in different positions. Conventional anemometers are vulnerable to extreme weather conditions and have been known to fail just when they are most needed; this was the case in the 2005 runway overrun accident at Toronto, referred to in the article 'Predicting Thunderstorm Activity'. At some airports, combinations of anemometers are used to predict wind shear.

CONTROLLABILITY

The wind characteristics affect flight in several different ways. First, there is the question of control. The lower level of the atmosphere is always somewhat turbulent for a variety of reasons; if the wind is strong, then as it blows across the surrounding countryside its speed and direction are constantly changed by the obstacles it meets, so that a strong wind is never stable and the already existing turbulence is increased. This makes handling difficult, especially on the approach and landing phase.

Strong wind shear, too, can generate control problems. If the wind strength or direction changes considerably as the aircraft descends, it may be difficult to maintain the optimum descent profile accurately. In extreme cases, the aircraft may become uncontrollable and a go-around must be commenced without delay. Some airfields and most modern aircraft are equipped with wind shear warning devices so that action may be taken before a dangerous situation develops.

STABILISED APPROACH

Stability is really only an extension of the controllability issue. It is an established fact that good landings result from good approaches, while bad approaches often lead to uncomfortable or even dangerous landings. This is why in the flying world, so much attention is paid to the principle of a stabilised approach. Put simply, the aircraft must be in a stable condition and prepared for landing by the time it reaches a specified height; if not, the approach must be abandoned and a go-around flown.

If the approach is unstable, and the pilot does the right thing and goes around, fuel is wasted, the passengers get cross and maybe the rest of the day's schedules are delayed. So even if he/she should not, the pilot may be strongly tempted to press on and make the most out of a bad situation.

Wind is important in establishing a stabilised approach. In gusty or strong cross-wind conditions, it may be difficult to maintain the approach profile accurately, especially if wind shear is present.

Landing gear, flaps, slats, etc. usually have critical maximum speeds above which they may not be extended; extension of these devices increases drag which assists in the slowing down process, so in tail-wind conditions, the pilot must allow extra time to configure the aircraft for landing. If a marked change in wind is un-forecast and/or is not noticed by the pilot, he/she may have difficulty in main-

taining the correct speed and approach profile.
Runway choice must take into account the wind direction and should aim to provide a head-wind component for landing. It is easy to forget that although the wind may be light on the surface, a few hundred feet higher a tailwind may exist. When there is a tail component of 5 kt on the runway the tailwind at 1000 ft may be 10 or 15 kt.

AIRCRAFT PERFORMANCE

Aircraft take-off and landing performance is affected by many factors, among them the following:

- Manufacturer's or operator's limitations (e.g. maximum permitted take-off or landing weight, maximum crosswind or tailwind component);
- Airfield elevation;
- Runway length;
- Runway width (a wide runway is especially welcome in a strong crosswind);
- Runway slope (uphill is always preferred);
- Obstacle clearance data;
- Ambient temperature;
- Braking action (especially, when the runway is contaminated[2] by rain;
- Surface wind.

As I said before, a strong wind is never constant, so performance calculations always assume that a headwind will drop or a tailwind increase from the mean at the critical moment.

Most modern aircraft can make a safe landing or take-off even when conditions are quite adverse, but we have only to read the report of the August 2005 A340 runway overrun at Toronto[3] to remind ourselves that things can go very wrong even for highly experienced pilots at major international airports.

Lots of safety factors are built into performance calculations for very good reasons, but they cannot cope with every situation, so pilots are required to recalculate data for each take-off and approach and if the runway (or other important data) unexpectedly changes. The following is a true story - only the details have been changed (to protect me from prosecution!)

BIGJET 123

The captain of the Boeing 747 freighter was very experienced. He had learnt his craft in the military and had flown on many combat missions, in fighters at first, then on bombers, and later, on heavy transport. The first officer was a young man, new to the type and anxious to learn. He had heard some of his captain's war-stories and knew that this was a man he could trust.

They had planned the inter-continental flight with care. They did not expect any trouble at the departure end, but there were warnings of deteriorating weather at their destination so they wanted to carry as much reserve fuel as possible. Their take-off weight would not be much below the maximum, calculated for the runway in use (Rwy 26L) and the expected weather conditions. At the aircraft, they did their checks, copied the ATIS, got their ATC clearance and requested start.

As they taxied out, ATC informed them that the wind was backing and asked them if they were happy to stay with 26L or would prefer to wait while they changed the runway. "The wind will give us a 5 kt tail component on take-off," the first officer reported, "we'd better wait for the new runway." "No, it'll be alright," the captain replied, "I don't want to waste time and fuel holding and taxiing to the other end of the runway; besides, Rwy 08 slopes downhill. Tell them we'll stay with 26."

The first officer did as he was told, and got out his books to recalculate the take-off data, but now they were close to the runway threshold and the captain told him to run the take-off checks.

As they accelerated down the runway, a flock of birds rose from the side and flew across their path. One went into the No 4 engine, causing it to stall. As they had not quite reached the decision speed (V1) the captain abandoned the take-off, calling for reverse thrust on Nos 2 & 3 engines and applying full braking.

They only overshot the end of the runway by a few feet, but the heavy aircraft sank into the wet turf and had to be unloaded before it could be towed out. Rwy 26L/08R was out of use for the rest of the day, but fortunately the parallel runway was unaffected.

You will know (and the inquiry agreed) that the captain was wrong to take off

[2] For JAR-OPS definitions of runway conditions see the article "9√P and All That".

[3] The February 2008 edition of Aero Safety World contains a useful summary of this report. See http://www.flightsafety.org/asw/feb08/asw_feb08_p40-45.pdf

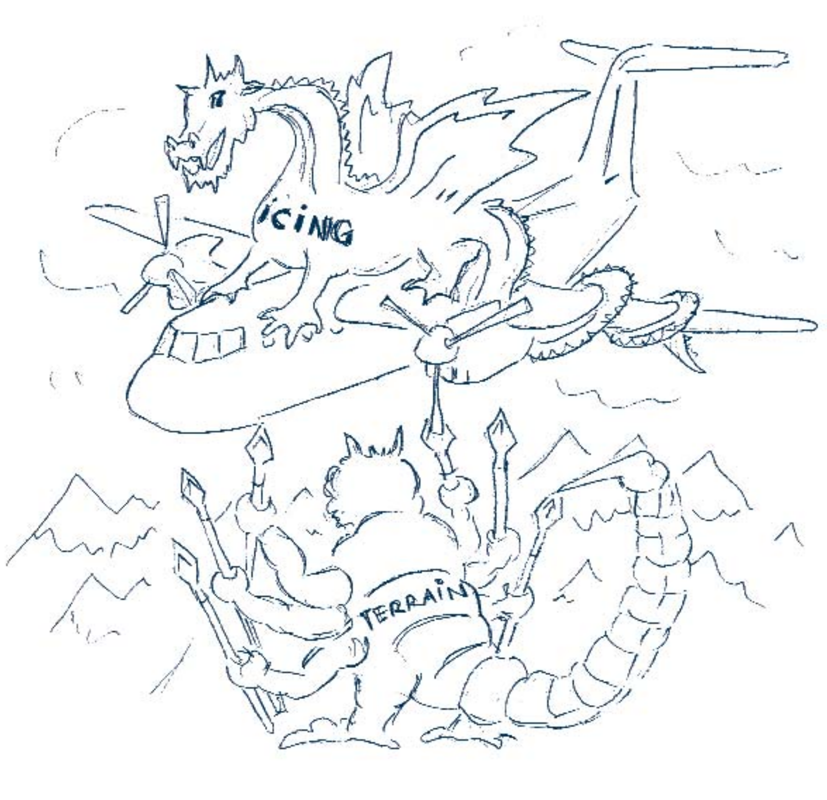
from the out-of-wind runway without first checking his take-off performance, especially as he knew they were close to maximum take-off weight. It did not help that the inexperienced co-pilot was too trusting and insufficiently confident in his own judgement to insist that they should do so, but he would probably have been overruled anyway. The controller did everything correctly (he might possibly have been able to warn earlier that the wind was shifting, but that is speculation and certainly not criticism).

So what is in this story for air traffic controllers? Well, just to make sure you understand that the wind component is a critical factor in take-off performance calculations. If an aircraft is lightly laden or the runway is long, then it can usually take off in either direction, though into-wind is always preferred, especially if the runway is wet. But if the runway is short, or the temperature is high, or the plane is heavy, then a few knots of tailwind where headwind had been expected creates a problem. This is especially true for high airports. Changing the runway can also adversely affect other critical factors; not just the runway slope, as the captain correctly pointed out, but also the runway length and the stopway and clearway details.

So, if the runway must be changed because the wind has changed, that is fine and it is up to the captain to re-calculate his take-off performance if necessary. But if a runway change is being considered for environmental reasons, there are other factors to consider besides an adverse wind component, like the pressure a pilot may feel under to accept the change even though for safety reasons he/she should not. It is all very well to say that the pilot can insist on the into-wind runway, but in the real world he/she knows the problems this will create for the airport and for other aircraft and may well take a chance.

CAUGHT BETWEEN SCYLLA AND CHARYBDIS

This article is based on the official report of an incident described in UK AAIB Bulletin No: 9/2003. This may be viewed at
http://www.aaib.gov.uk/cms_resources/dft_avsafety_pdf_023894.pdf



In Greek mythology, Scylla and Charybdis were two sea monsters who lived on either side of the Straits of Messina, which separate the toe of Italy from Sicily. Scylla was a 6-headed monster who sat on a rock and ate anyone who came within reach. Charybdis, who lived under another rock, created whirlpools by sucking in and blowing out huge quantities of water from its enormous mouth. In Homer's Odyssey, Ulysses was forced to choose a route between these rocks: if he sailed too close to Scylla, he would lose some of his sailors; but if he got too close to Charybdis, the whole ship would be lost. The story that follows is not a myth: it is a true story that happened only a few years ago; and the aircraft crew found themselves in just as dangerous a position as Ulysses.

The story begins in November 2002 when the crew of an HS748 twin-engine turboprop aircraft was tasked to position from Paris to Rome, fly the aircraft from Rome to Pisa, and then on to Paris Charles de Gaulle. The crew was not very experienced in flying in this part of Europe and neither pilot had flown from Rome or Pisa before.

The company did not operate a computer-based flight planning system, so a set of flight plans and pilot navigation logs (PLOGs) for the routes had been manually produced and copies of these were on board the aircraft. However, the crew were unable to find the PLOG from Pisa to CDG and a copy was faxed to them in Rome. Flight plan information, usually annotated on the PLOG, was missing on this faxed copy; therefore the crew were unaware of the cruising level that had been filed for them.

At Pisa, the commander supervised the cargo loading whilst the first officer, who was to be the handling pilot for the next sector, planned the route. He became concerned that one leg of their route had a Minimum Safe Altitude (MSA) of 15,900 feet and the aircraft they were flying had an operational ceiling of 15,000 feet. The pilots discussed this and decided to fly the planned route at FL160. The commander told his first officer that he had been told that a senior pilot within the company had successfully flown the aircraft to FL180.

The take-off from Pisa was normal and they climbed to FL160 following a non-standard departure to 'SPEZI' waypoint. During the climb Milan Control offered a re-route to the north via 'CANNE' waypoint in the Swiss Alps, as opposed to their flight planned route to the west. The commander accepted the re-route but mistook 'CANNE' waypoint to be the CANNES/TANNERON VOR that is positioned close to the town of Cannes in southern France.

Although the crew followed ATC instructions, which continued to take them northbound, they were unsure what their final routing would be.

http://www.aaib.gov.uk/cms_resources/dft_avsafety_pdf_023894.pdf

Approaching Genoa (GEN) VOR on the Italian coastline, the crew received a GPWS 'PULL UP' warning and initiated an immediate climb. As they climbed through FL180 the first officer pressed the radio altimeter test button which immediately cancelled the GPWS warning. The GPWS warning was spurious but probably added to the crew's anxiety.

The aircraft was levelled at FL180 and the crew decided to remain at this height as they were now heading towards an area with a higher MSA. A few moments later they noticed ice forming on the windscreen wipers and wings. All their anti-icing and de-icing equipment was switched on and according to their instrumentation was functioning correctly, but the rapid build-up of ice continued. They estimated that the ice thickness reached 4-5 inches (10-13 cm) on the windscreen with a 'clear area no bigger than a letter box to look through'. Power was increased to the maximum continuous limit on both engines but the speed slowly decayed from 150 kt to 120 kt. A descent was requested along their route but this was denied by ATC because of the height of the terrain ahead. At 120 kt the stick shaker activated and they were unable to maintain level flight. At this point they had passed 'CANNE' waypoint and were heading directly towards the Luxeuil (St Sauveur) 'LUL' VOR. Terrain within 10 miles of their track reached a height of 14,100 feet. The airspeed was stabilised with the stick shaker activating intermittently but this resulted in a descent with a vertical speed of approximately 500 feet per minute. In response to a further request for descent ATC vectored the aircraft to the north-east and authorised descent to FL160. At this level there was clear air which allowed the ice to dissipate and the airspeed to increase.

Eventually the aircraft was re-cleared to route to the 'LUL' VOR. When the crew altered course the aircraft re-entered cloud and almost immediately ice began to adhere to the airframe again and although the airspeed was indicating 160 kt the stick shaker activated. The crew were cleared to descend to FL100. The speed was increased in the descent to 205 kt before the stick shaker cancelled.

After levelling at FL100 the flight continued in clear air to CDG with the ice clearing. The landing, carried out with approach flap, was without incident. Visual inspection after landing revealed large lumps of ice remaining underneath the fuselage.

It would appear that this crew tried to emulate Ulysses without understanding the perils they might encounter. For them, Scylla was represented by the icing, which caused them to lose height, and approach dangerously close to the high ground that represented their Charybdis. But unlike Ulysses, who knew what lay ahead and planned his journey accordingly, the crew were poorly prepared and at one point did not seem to know where they were going. The official report of the incident comments that 'On the actual route flown, the crew flew through an area with an off-route MSA of 16,400 feet and along an airway with a base of FL125. If they had experienced a single engine failure, their stabilising altitude, in the prevailing conditions, would have been approximately 4,000 feet *below* the base level of the airway'. If they had lost an engine, this story would probably have had quite a different ending.

Because most aircraft cross the Alps (and similar mountainous areas) without event, it is tempting to think of this as a 'one-off case'. But the dangers associated with flying a route like this are not confined to older, lower-powered aircraft. If an engine is lost on a heavily-laden modern jet, it will be forced to descend and may enter icing conditions where the excess power required to operate the anti-icing systems will force it even lower. Loss of pressurisation is a rare event these days, but it would have the same effect of forcing the aircraft to descend. The effects of turbulence and mountain waves extend well above the usual safe terrain clearance and prudent pilots apply 1000 or 2000 ft to the normal MSA to give an additional safety factor.

Of course, older turboprops can safely navigate these routes, but only if the crews are properly familiar with the terrain and its perils, and choose their route having regard to the meteorological forecast and their aircraft's performance. Their companies must support them with appropriate training and with the clear understanding that they will not be criticised if they decide for safety reasons not to follow the most direct route.

Breaking the rules by, for example, departing without full knowledge of the filed flight plan, or deliberately exceeding Aeroplane Flight Manual limitations is never acceptable. Topographical maps must be studied. Safe descent paths, critical points, engine-out stabilising altitude and drift-down calculations may be necessary so that should the aircraft suffer an engine failure, the crew will know immediately whether to go on or to divert. Of course, if things go wrong, the commander remains responsible for safe terrain clearance, although assistance from air traffic control, especially when MSAW is available, will always be welcome.

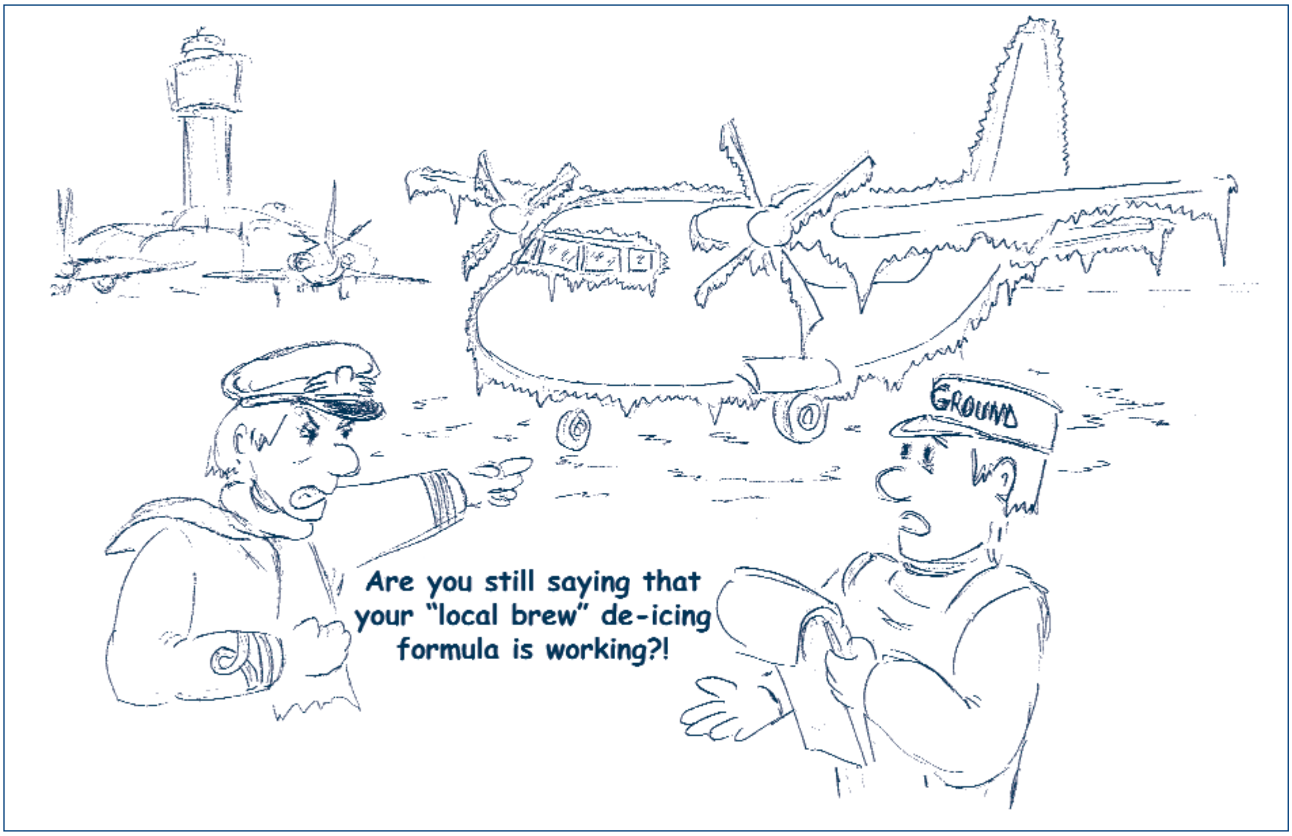
For the controller, there are several messages, in addition, I hope, to an enhanced understanding of aircraft performance and meteorological hazards:

- Flight in icing conditions is fraught with danger. Unlike most limitations (e.g. crosswind, tailwind, maximum take-off mass, etc.) deciding whether icing conditions are light, moderate or severe, and therefore whether they should proceed is a subjective decision based on a pilot's airmanship and experience. Moreover, actual icing conditions may vary considerably from those forecast, so that pilots may find themselves in difficult conditions without warning.

- Although most of the pilots that transit through your sector will be familiar with the airway structure, some will not and many will be quite unfamiliar with the topography; they may need a little help, especially if a proposed re-route passes over higher terrain.

- If an aircraft requests descent below its cleared level, this may be the first sign that it is in difficulties. The pilot may not immediately declare an emergency, but perhaps he should make at least a PAN call; so if the requested descent takes it towards higher ground, a little encouragement may be necessary.

- Finally, it is worth mentioning that some SIDs require rates of climb which are beyond the capability of older aircraft. Be prepared to offer alternative routes in such cases. By the way, where SIDs specify a minimum rate of climb, this is usually expressed in feet per mile, which is difficult for pilots to convert to feet per minute.



WIND, FRIEND AND FOE

By Dennis Hart

Dennis Hart is the EUROCONTROL Aviation Meteorology Expert. In summer 2007, Dennis Hart was recruited by EUROCONTROL with the clear task to facilitate the needed interaction between the MET and ATM community to better integrate meteorological information into ATM decision making.

Some of the stories in this edition of HindSight clearly demonstrate that surface wind and wind at lower altitudes is of real significance for day-to-day operations. What has become apparent is the clear need for fit-for-purpose information on the wind to support the different phases of flight and flight support in general, translated in the most suitable way possible for the situation. One could argue that the wind information provided today is already insufficient to cater for some of today's ATM needs and the decisions we are forced to make in our daily operations.

So wind information itself, and the interpretation and the overall translation of this information into the decision-making processes both for aircraft and on the ground, are certainly issues to be considered as we gradually move towards a completely time-ordered ATM system: an ATM system where the 4-D trajectory will prevail and the need for truly fit-for-purpose wind information will be paramount. Clearly, we have to move away from the traditional type of 'ICAO wind information' and introduce the ability to measure, forecast and report wind information that can fully support this 4-D trajectory approach to ATM.

As we have already seen, wind and its turbulent nature heavily influence the take-off and landing phase, even of modern aircraft. We have moved some distance away from the time when a light gust of wind could cause serious structural damage to an aircraft, such as the break-off of a wing which happened to one of our early aeronautical pioneers (Otto Lilienthal — 1848-1896) and resulted in a fatal injury. Still, strong winds have been a major contributor to a number of take-off and landing-related incidents and accidents over recent years and contribute significantly to weather-related delays at European airports.

In addition to the accident described in 'Getting the wind up', we could also mention the 1999 China Airlines MD11 Hong Kong, the 1999 American Airlines MD80 Little Rock and the 1997 Transavia Airlines Boeing 757 Schiphol Airport events as a demonstration that high-wind environments can be a significant contributor to accidents, some of them with fatal consequences. Besides the immediate impact on flight operations, airports such as Frankfurt and Schiphol operate in an environment where relatively high crosswinds are day-to-day occurrences necessary to meeting the required demand for capacity; factual wind information is key to ensuring that this is done safely.

It is fair to say that the common practice of reporting the surface wind near touchdown and 'working' with forecast surface winds extracted from a TAF will not be sufficient for the future ATM world; as already stated, one could argue that it is already insufficient for today's operations. A clear need is seen, not only for detailed wind information - observed and forecast - at surface level, but also for levels aloft, to determine the 'perfect' 4-D trajectory, at least from a meteorological perspective.

Courtesy: Dutch Transport Safety Board/Dutch Airpolice

Courtesy: Dutch Transport Safety Board/Dutch Airpolice

The current methodology of wind observations, forecasts and reporting practices is based on guiding principles laid down by both ICAO and the World Meteorological Organization (WMO). But before discussing these guiding principles, it is worthwhile having a closer look at the wind itself. This will provide increased understanding of why today's wind information is what it is!

Wind is commonly referred to as the movement of air from one place to another, but may be viewed in detail from different perspectives and scales. For take-off and landing, interest is focused on the lower levels of the atmosphere where wind is variable, as we all witness every day. Scientists call this 'the turbulent mixing of momentum in the atmospheric boundary layer, which is stochastic by nature'. In other words, wind in the lower levels of the atmosphere is synonymous with 'turbulence'; moreover, it is a random phenomenon and therefore could never be described in a deterministic way. The latter is the most important message to be conveyed; surface wind is a random phenomenon and therefore needs to be characterised using a statistical method. This is the key element when moving from the phenomenon, surface wind (turbulence), towards wind measurements and wind information required for ATM decision-making.

According to ICAO and WMO requirements, the characterisation of wind near the earth's surface shall be described as a two-dimensional (horizontal) vector specified by two numbers representing direction and speed. The extent to which wind is characterised by rapid fluctuations shall be referred to as gustiness, and single fluctuations are called (peak) gusts.

Without going into too much detail on instruments and the overall process of obtaining a discrete sequence of measurements of wind, there is something which should be kept in mind when moving towards describing surface and lower-level winds, or in other words, describing boundary layer turbulence. An important question is: when might wind fluctuation influence our operations or even be seen as harmful? This directly relates to the 'mixing of momentum' described earlier, and the related energy to move or damage structures; it can be easily understood that a gust with a short duration has neither the time nor the power to exert its full effect on an aircraft. Averaging the wind over a 3-second period is more useful in describing potentially harmful conditions for structures such as aircraft.
Another consideration concerns the time period over which the wind should be averaged to give the best characterisation of its turbulent nature. This brings us immediately to the next question: why do we need an average for wind speed and direction and why don't we use the instantaneous read-out as a prime source for our decision-making? Having an average speed and direction available is essential to understanding the turbulent environment in which we have to perform our operations, and this brings us back to one of our first observations: turbulence can never be described in a deterministic way. This adds up to the fact that an atmospheric variable in general can never be actually measured or sampled. In general, sensors respond more slowly than atmospheric changes over time, which is certainly true for wind. Therefore, techniques such as averaging, filtering and smoothing should be applied to provide a wind report that is representative in time and space.

In the quest to obtain the most representative observation of the wind with an acceptable degree of certainty in the estimation of its true value as it was seen decades ago, taking the mean of a large number of independent samples is often used. In addition, by applying the ICAO recommended time period for averaging of 2 minutes, we achieve spatial representativeness for the entire touchdown zone; with a 10-minute averaging time period, the spatial representativeness broadens to the whole airport. Returning to the instantaneous read-out, it gives an idea of the windspeed and its variability but is subject to major errors when the reporting of wind with the appropriate level of (spatial) representativeness and certainty is required. Again, wind is a random phenomenon and is difficult to capture in the deterministic way we all like.

Moving away from wind measurements and the statistical processes for providing the most representative observation of wind, we enter the area of wind reporting. This is the exclusive domain of ICAO; they set the criteria for wind reports as part of Local Reports (ATIS), METAR and TAF. In general, these generic criteria are also used in the display systems used by air traffic controllers and other ATM stakeholders.

I would invite you to read the relevant chapters of ICAO Annex 3 on wind reporting and see if, in combination with the theory behind wind provided in this article, they still match up to the interpretation you formed when you last looked at the wind information provided to you.

ABSTRACT (ED.) FROM APPENDIX 3 CHAPTER 2.3 AND 4.1, ICAO ANNEX 3 16TH EDITION, JULY 2007

In Local Reports:

a) variations from the mean wind speed (gusts) during the past 10 minutes shall be reported when the maximum wind speed exceeds the mean speed by 10 kt or more, they shall be reported as the maximum and minimum values of the wind speed attained.

b) variations from the mean wind direction during the past 10 minutes shall be reported as follows, if the total variation is 60° or more:

   1) when the total variation is 60° or more and less than 180° and the wind speed is 3 kt or more, such directional variations shall be reported as the two extreme directions between which the surface wind has varied; or

   2) when the total variation is 180° or more, the wind direction shall be reported as variable with no mean wind direction;

An intermediate report should be issued:

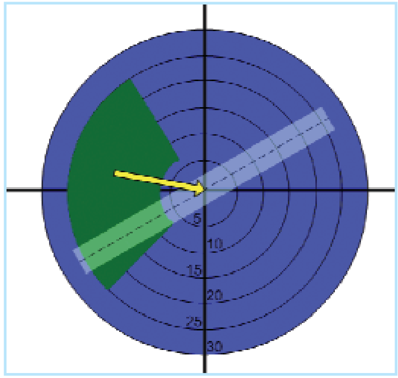
a) when the mean surface wind direction has changed by 60° or more from that given in the latest report, the mean speed before and/or after the change being 10 kt or more;

b) when the mean surface wind speed has changed by 10 kt or more from that given in the latest report;

c) when the variation from the mean surface wind speed (gusts) has increased by 10 kt or more from that given in the latest report, the mean speed before and/or after the change being 15 kt or more.

EXAMPLE

Imagine a display with a wind report stating a 2-minute average direction of 280 degrees and a speed of 16 knots. The actual wind could already been changed to a direction somewhere between 230 and 330 degrees or changed in speed too a value between 7 and 25 knots in for instance the 30 minutes between regular reports. As a consequence, the wind could already be in the North-Northwest quadrant reaching the upper limits for desired or allowed cross wind operations without a 'warning' in the actual wind report. The following illustration depicts this graphically and includes a virtual runway 24-06. The actual wind could be in the green area where only the yellow vector is reported.



So the reasoning behind why we do the things the way we do today is now made somewhat clearer. Hopefully, this will shed new light on wind, wind information and its limitations. But will these limitations hinder safe operations in today's working environment and the future, as envisaged by the different ATM strategies around? Is the spatial representativeness and associated uncertainty of observed and forecast wind direction, speed and gustiness achieved by applying the WMO and ICAO guidelines to the letter? Should we look at it as something developed in the 50s but unable to support future needs? Or is the problem in the reporting of wind information instead of the actual measurements, forecasting and processing?

It is fair to say that the performance of meteorological systems for the measurement and forecasting of wind has improved over the last decades, but we are by no means fully able to utilise these developments. Perhaps this is due to the lack of supporting regulations, but more probably it is because of a lack of awareness of the ATM world and a failure to envisage the best utilisation of the available information. So before jumping to generic statements such as 'we need more accurate wind information' we should also focus on what can be made available today.

We read already about the sophisticated (remote) sensing systems for wind at surface level and along the glide path at Hong Kong. Furthermore, meteorological service providers are already looking into (short-term) wind forecasting at vertical and horizontal resolutions of a couple of hundred metres; but are we as yet able to use this information, in the sense of having a common situational awareness of the wind we need to improve our operations? At the moment, there are no harmonised guidelines on how to exchange and use the information from these new or improved systems; moreover, the focus today is basically on surface wind only.

We are not at a stage where the answer to all the questions posted can be answered. This is an area where different disciplines should work together to find the optimum choices of information, its utilisation and the improvements we should make when moving towards that 4-D trajectory - and the associated tripling of air traffic in a safe and cost-effective environment. A major step may result from the planned METATM Symposium from 24 to 26 November 2008.

EUROCONTROL, on behalf of ICAO's EANPG and supported by WMO and FAA, will host this symposium, which will address the current and future capabilities of aeronautical meteorology and ATC, and will define the new user requirements for MET.

CUMULONIMBUS - MORE FRIGHTENING THAN BENGT'S MOTHER-IN-LAW?

By John Barrass

John Barrass served for 20 years in the UK Royal Air Force and Canadian Forces in a variety of flying, instructional, and command appointments. Now an established aviation consultant, John is the current editor of SKYbrary.

The number one killer in aviation in the 1990s, controlled flight into terrain (CFIT), is still a major cause of fatal accidents but the advent of ground proximity warning systems has reduced the number of CFIT accidents dramatically. As the years pass by, we as an industry are certainly getting safer and, as we approach the end of the first decade of the 21st century, Loss of Control (LOC) is now the focus of concern for those involved in aviation safety. However, looking back over recent years' accident statistics, a contributory factor in many CFIT and LOC accidents is weather. Failure to ensure the adequate de-icing of an aircraft prior to departure has been a recurring cause of LOC accidents over the years, and several recent accidents have occurred when an aircraft encountered severe thunderstorms (cumulonimbus clouds) and the associated downbursts, or microbursts.

In 2007 there were a number of accidents which occurred in weather conditions which included thunderstorm activity:

- On 5 May 2007, a Kenya Airways B737 departing Douala, Cameroon crashed shortly after take-off in a thunderstorm.
- On 16 September 2007, a One-Two-GO MD82 crashed at Phuket while attempting a go-around in heavy rain and strong crosswinds associated with a severe thunderstorm over the airport.

Both of these accidents are still the subject of investigation, and the primary cause of the accidents may not be weather. Nevertheless, these accidents serve as a reminder of the powerful nature of weather associated with cumulonimbus clouds, particularly downbursts, and the threat they pose to flight safety.

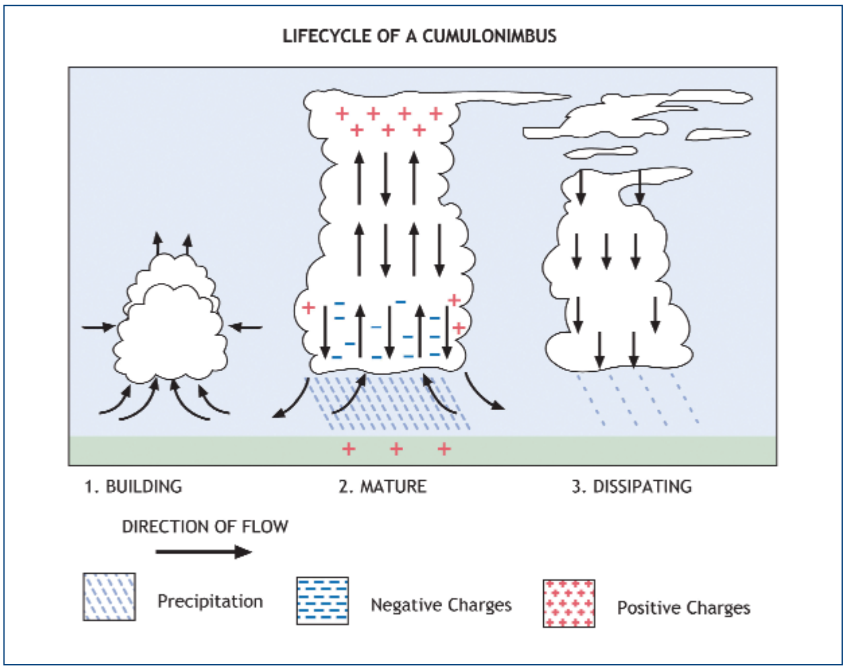
> **Cumulonimbus:** A heavy and dense cloud of considerable vertical extent in the form of a mountain or huge tower, often associated with heavy precipitation, lightning and thunder. The mature cumulonimbus cloud has a distinctive flat, anvil-shaped top.
> http://www.skybrary.aero/index.php/Cumulonimbus

Cumulonimbus clouds form when warm, moist air rises in unstable atmospheric conditions. The rising air draws more warm air up into the cloud where it continues to rise and condense into cloud and precipitation. Strong updrafts within the cloud carry rain

and ice particles (hail) aloft. The tops of the cloud may reach, and breach, the tropopause. The hail and rain falls towards the surface and may be carried back aloft by further updrafts of air. As this cycle continues, the droplets and hail become heavier and larger and static charges build up within the cloud, which discharges as lightning. In severe cases, where the vertical updrafts in the cloud become cyclonic, tornadoes can form underneath the cloud.

As the cumulonimbus cloud matures, the rain and hail eventually falls to the surface dragging cold upper air with it. At this stage in the lifecycle of the cloud, strong updrafts and downdrafts within the cloud create severe turbulence. The downdrafts can be very powerful, with vertical winds of 6,000 ft per minute. When a strong downdraft, referred to as a downburst or microburst, hits the surface, the wind diverts horizontally outwards. Downdrafts ahead of a cumulonimbus cloud push warm surface air upwards, a little like a cold frontal system, often

http://www.skybrary.aero/index.php/Cumulonimbus



creating a wall of cloud commonly referred to as a gust front.

In time, the downdrafts of cold air choke off the supply of fresh warm air entering the cloud and the cloud begins to dissipate. This whole process may last less than 1 hour but many storms contain numerous cumulonimbus cells in various stages of development.

Downburst: A downburst is created by an area of significantly rain-cooled air that, after hitting ground level, spreads out in all directions producing strong winds.

Microburst: A type of downburst affecting an area 4 km in diameter or less (term defined by severe weather expert Tetsuya Theodore Fujita) http://www.skybrary.aero/index.php/Microburst

http://www.skybrary.aero/index.php/Microburst
http://www.skybrary.aero/index.php/Wind_Shear

Downbursts are a particular hazard to aircraft at low level, especially on take-off or landing. An aircraft approaching a downburst will first encounter a strong headwind, which will lead to an increase in indicated airspeed. When trying to fly a set airspeed on approach, a pilot might therefore be tempted to reduce power. This would be very dangerous because, as the aircraft passes thorough the downburst, the wind becomes a tailwind and the indicated airspeed and lift drops. The significant downward force of air in the downburst may be enough to force the aircraft into the ground or at least cause it to lose a significant amount of height. The subsequent loss of performance, as the aircraft encounters tailwinds, may cause further loss of height and be enough to cause the aircraft to stall. Once caught in a downburst, escape is only possible by flying straight ahead; whichever way an aircraft turns, it will encounter the tail winds and the associated performance impact. If the aircraft is in a turn at that point then the stalling speed will be higher, possibly making the situation worse.

Wind Shear: a sudden change of wind velocity and/or vector. Wind Shear may be vertical or horizontal, or a mixture of both. http://www.skybrary.aero/index.php/Wind_Shear

Detecting a downburst is not easy. The effects are usually localised and, if the precipitation evaporates before reaching the ground (Virga), may not necessarily be associated with heavy rain or hail. Many airports which experience regular severe thunderstorms have systems in place to detect wind shear, often comprising anemometers in a network around the airport. In the USA, this system is known as low-level wind shear alerting system (LLWAS). This type of system detects the variability of the wind in a horizontal layer which is an indication for wind shear and/or microburst. A limitation of such systems is of course that it only detects wind shear at ground level. Hong Kong airport has a sophisticated system for detecting wind shear which combines a network of anemometers with Doppler weather radar and a LIDAR (LIght Detection And Ranging) wind shear warning system which can detect the movement of much smaller particles than a conventional weather radar, like dust particles, and therefore can more effectively detect wind shear in dry air. This is particularly important at Hong Kong where wind shear is caused by terrain effects as well as weather.

Many modern aircraft, such as the B777, have predictive wind shear (PWS) warning systems which collect wind velocity data gathered by the weather radar to identify the existence of wind shear. These systems have a short range, and are dependent on the radar picking up velocity data from water and ice particles ahead of the aircraft and so don't work in dry conditions, but they are effective, providing the pilot with an opportunity to abort take-off or carry out a missed approach.

Thorough weather briefings, contingency planning , appropriate use of the weather radar, listening to ATIS at regular intervals, access to up-to-date actual weather conditions, warnings and forecasts, asking for reports from other pilots, as well as looking for the visual clues (cumulonimbus clouds, mammatus clouds, gust fronts, heavy precipitation, lightning, etc), and familiarity with local weather phenomena (at certain times of the year, some airports have predictable thunderstorm activity which can be avoided by careful scheduling of flights), all help to provide the flight crew with the best chance of avoiding downbursts and making the right decisions to safeguard the safety of the flight.

Mammatus Clouds: Lobes or pouches of cloud which hang down from the base of a cloud. The name comes from the Latin mamma which means breast. Mammatus clouds are normally associated with severe Cumulonimbus clouds and are indicative of Wind Shear. http://www.skybrary.aero/index.php/Mamma

Mammatus clouds are an indication of an extremely unstable air mass (and the associated shear) with the likelihood that cumulonimbus clouds could develop

http://www.skybrary.aero/index.php/Mamma

Imagine trying to read a complex terminal approach plate, maintain an instrument scan, at night, in poor visibility, and in moderate turbulence, while also trying to assimilate information from the weather radar, air traffic control and other aircraft on frequency. Even without the potential loss of control that can occur when encountering a downburst, the workload and physical stresses placed on a crew flying in bad weather should not be forgotten, especially by the crew themselves! The trick of course is not to get into that situation in the first place - and that is dependent on 2 things, the accuracy of the information and the airmanship (decision-making skills) of the crew.

In the end, it is the aircraft commander's decision whether to continue, hold, or divert. In these days when a crew have numerous means of communication available to them, information and advice are easier to come by, improving the decision-making of the captain. The decision to carry out a missed approach, or divert, clearly has a commercial implication. It is not unreasonable for a captain to confirm with his company operations what they would prefer him to do given the options he has available to him, but that preference does not ever constitute an instruction - the responsibility and authority remains with the aircraft captain.

PREDICTING THUNDERSTORM ACTIVITY

*We are indebted to **Captain Bertrand de Courville** for drawing our attention to the important issue discussed in this article. Captain de Courville is Head of Flight Safety at Air France and Chair of the IATA Safety Group.*

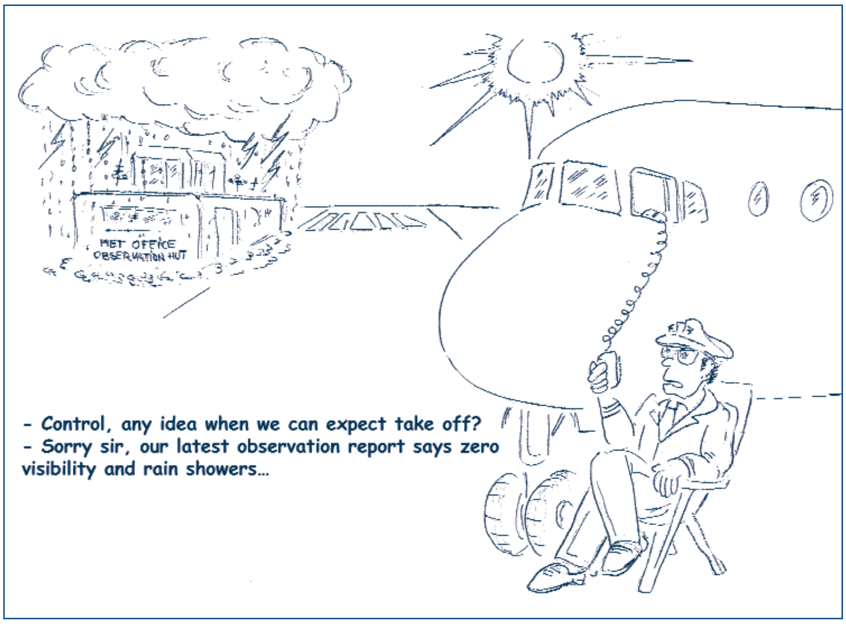
Meteorology is a notoriously exact science. Based on years of accurate observation and making use of the most advanced equipment and the best experience available, scientists have developed ways of predicting precisely what the weather should be doing at any time or place in the future. The only problem is that the weather often takes no notice of the clever formulae and mathematical models and does just what it wants! That is not a criticism of the scientists or their methods, nor of the forecasters, who are only too happy when the weather turns out exactly as they said it would. It is a simple statement of fact.

In order to manage our knowledge of the meteorological situation, regular observations are made and entered on the central computers. This enables forecasters to have warning of changing conditions and to know when and how the weather is deviating from what was expected. Armed with this information they can advise pilots and air traffic controllers of the progress of events, and more importantly, of any unforeseen hazards. This system works pretty well most of the time, but there is one gap in our knowledge that has not yet been bridged, although exciting work is under way on both sides of the Atlantic.

The exception to the rule is in the important area of thunderstorm activity. We know how and why a cumulonimbus cloud develops; and we certainly know what hazards are likely to be associated with it: updrafts, downdrafts, turbulence, wind shear, heavy precipitation, icing, lightning, etc. But if new equipment is on the way, it is not yet in general use, so that the forecaster cannot predict with anything like the desired precision where, when and at what speed the clouds will build or decay; nor has he/she a sufficiently good idea of the nature and intensity of the hazards that will arise at any given time. Moreover, an observer just a short distance away from a runway might experience quite different conditions from an aircraft landing or taking off.

There have been several accidents and serious incidents in which this weakness was a significant factor. These include the 1999 Bangkok runway overrun described in the article "9√P and All That". The most recent to come to light was the runway excursion involving Air France Airbus A340 (AF358) which took place at Toronto/Lester B Pearson airport on 2 August 2005. The report of the investigation board has just been released and may be viewed on the Transportation Safety Board of Canada website[4]. The report makes interesting reading, with findings that bear on many aspects of flight operations.

AF358 departed Paris on a scheduled flight to Toronto, Ontario, with 297 passengers and 12 crew members on board. Before departure, the pilots obtained their arrival weather forecast, which included the possibility of thunderstorms and loaded some extra fuel to give added holding time at Toronto. While approaching their destination, they were advised of weather-related



[4] For the full report, see http://www.tsb.gc.ca/en/reports/air/2005/a05h0002/a05h0002.pdf. A summary of the full report was published in the Air France safety magazine, Sûrvol, a translation of which is published on SKYbrary at http://www.skybrary.aero/index.php/Air_France_358:_Runway_Overrun_at_Toronto

delays. Some aircraft were diverting to their alternate aerodromes. By the time they were cleared for an approach their fuel state was low with only just enough for a diversion to their alternate aerodrome, Ottawa.

As they proceeded on their ILS approach the crew were advised that the aircraft landing ahead of them had reported poor braking action. Their weather radar was displaying heavy precipitation encroaching on the runway from the northwest. At about 300 feet above the runway threshold, the wind changed from a 90 degree crosswind to a tailwind of about 10kts. The aircraft deviated above the glideslope and the groundspeed began to increase. The aircraft crossed the runway threshold about 40 feet above the glideslope.

During the flare, the aircraft travelled through an area of heavy rain, and visual contact with the runway environment was significantly reduced. There were numerous lightning strikes occurring, particularly at the far end of the runway. The aircraft touched down about 3800 feet down the runway, reverse thrust was selected about 12.8 seconds after landing, and full reverse was selected 16.4 seconds after touchdown. The aircraft was not able to stop on the 9000-foot runway and departed the far end at a groundspeed of about 80kts. The aircraft stopped in a ravine and caught fire. All passengers and crew members were able to evacuate the aircraft before the fire reached the escape routes. A total of 2 crew members and 10 passengers were seriously injured during the crash and the ensuing evacuation.

The official report includes the following paragraphs:

2.5.5 WEATHER INFORMATION FOR PREDICTING CONVECTIVE WEATHER

The ability of flight crews to develop an accurate assessment of the current and future state of the weather is critical to effective decision making. Due to increasing time pressure nearing top of descent and during approach and landing, information should be presented in a format that minimizes the amount of synthesis and interpretation required of the user. Given the aim of developing situational awareness, the weather information presented should also allow the user to project into the future and anticipate the future state of the weather.

This occurrence clearly demonstrates how the changeable, unpredictable nature of convective weather makes it difficult to achieve these aims. In this occurrence, although the crew made a concerted effort to gather information with respect to the current weather conditions and although they were offered additional information with respect to wind and runway condition by the tower before landing, they were very surprised by the intensity of the weather encountered as they approached the threshold.

The perception of the crew during the approach was in contrast to the perception of many who were in a position to view the intensity of the storm from the ground in the minutes before the accident. The difference in perception of the storm was not limited to the accident flight crew in that they were one in a line of aircraft on approach for landing. Aircraft landed on Runway 24L approximately 9, 6, 4, and 2 minutes before the landing of AFR358 and there was at least one additional aircraft on approach behind the occurrence flight. It is noteworthy that all these crews had also elected to conduct their approaches in conditions similar to those encountered by AFR358.

Therefore, when dealing with convective weather, the information available to a flight crew on approach does not optimally assist the crew in developing a clear idea of the weather that may be encountered later in the approach. Given the localized, changeable nature of thunderstorms, the weather experienced by those close to or under the storm may not be anticipated by those approaching the storm.

$9\sqrt{P}$ AND ALL THAT

by Ian Wigmore

After thirty years flying with the Royal Air Force, Ian Wigmore commenced a career in civil aviation, working for two airlines before joining ERA as Air Safety Manager. He currently works as an aviation consultant specialising in airline safety. He is Editorial Secretary of HindSight and was until recently the editor of SKYbrary.

$9\sqrt{P}$- what is that all about? Well, you shall see. This is a story about a Boeing 747 that overran the runway in Bangkok in 1999 - and $9\sqrt{P}$ was very much a factor in that accident.

First, a few facts about wet runways - especially the sort that have standing water on them. The presence of water on the runway affects the friction between the tyres and the runway, reducing the braking action. The brakes don't work as well even if the runway is only damp, but the reduction in braking action if the runway is wet is considerable; in fact pilots have to take this into account when calculating critical take-off and landing data.

Take-off and landing performance is calculated taking into account the runway surface conditions, which are defined in JAR-OPS 1.480 as follows:

Contaminated runway. A runway is considered to be contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following:

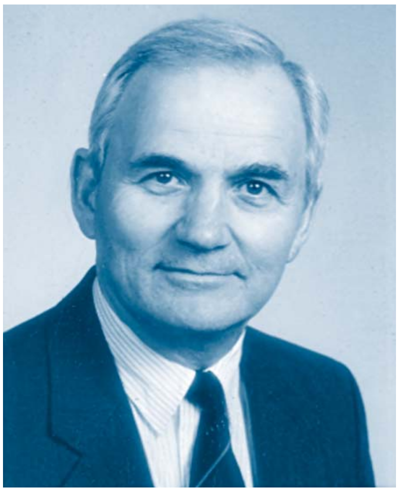
1. Surface water more than 3 mm (0·125 in) deep, or by slush, or loose snow, equivalent to more than 3 mm (0·125 in) of water;
2. Snow which has been compressed into a solid mass which resists further compression and will hold together or break into lumps if picked up (compacted snow); or
3. Ice, including wet ice.

Wet runway. A runway is considered wet when the runway surface is covered with water, or equivalent, less than specified above or when there is sufficient moisture on the runway surface to cause it to appear reflective, but without significant areas of standing water.

Damp runway. A runway is considered damp when the surface is not dry, but when the moisture on it does not give it a shiny appearance.

Dry runway. A dry runway is one which is neither wet nor contaminated, and includes those paved runways which have been specially prepared with grooves or porous pavement and maintained to retain 'effectively dry' braking action even when moisture is present.

I expect you know about aquaplaning - or hydroplaning as it is also known; after all, it applies just as much to driving a car as to landing an aeroplane. Aquaplaning is a generic term covering different aspects of an aircraft sliding over a wet surface. In case you are a little rusty, here are a few facts:



- **Viscous aquaplaning** refers to the reduced friction coefficient that occurs due to a thin film of water on the runway acting as a lubricant. It can occur on damp to contaminated runways, and at speeds down to low taxi speeds. It is most severe on runways with a smooth texture.

- **Reverted-rubber aquaplaning** occurs when a wheel 'locks up' (or stops rotating) and is dragged across a wet surface, generating steam. The steam pressure lifts the tyre off the runway surface. Heat from the steam causes the rubber to revert to its unvulcanised state, leaving a black, gummy deposit of reverted rubber on the tyre. This type of aquaplaning can occur at any speed above about 20 kts and results in friction levels equivalent to an icy runway.

- **Dynamic aquaplaning** occurs when the tyre is lifted off the runway surface by water pressure and acts like a water ski. It requires surface water depth greater than tyre-tread depth and sufficient ground speed to prevent the water escaping from the tyre's contact patch or footprint. Under these conditions, the tyre is wholly or partly buoyed off the pavement by hydrodynamic force and results in a substantial loss of tyre friction. Dynamic aquaplaning can occur in depths of water as little as 3 mm. This is the type of aquaplaning we shall talk about in the rest of the article.

- If the tyre has deep tread, or if the runway is grooved, this will help shed the water from beneath the tyre, providing good friction with the runway surface even in wet conditions, but if there is not much tread on the tyre the water has nowhere to go.

- The likelihood of dynamic aquaplaning increases with speed and with the depth of the water. Low tyre pressure also increases the risk for aquaplaning. This is where $9\sqrt{P}$ comes in, because someone has worked out that aquaplaning is likely to take place at speeds (in knots) above this figure, where P is the pressure of the tyre in pounds/square inch. In fact, aquaplaning can take place at speeds as low as $7.7\sqrt{P}$[5]: that's the speed at which aquaplaning commences; once it has begun, it may continue at much lower speeds. So if the pressure in your car tyres is 36 psi, then aquaplaning is possible at speeds above 46kts (about 86 km/hr), and on a plane like a Boeing 747 with tyre pressures of 210 pounds/square inch, the aquaplaning speed is about 111kts.

Now to our story. This concerns a Boeing 747 landing at Bangkok, Thailand. The official report has 186 pages and contains much important information. In this article I have concentrated on the bits about wet runways and aquaplaning and left the rest for you to read. The full report may be viewed at http://www.atsb.gov.au/publications/investigation_reports/1999/AAIR/aair199904538.aspx or a good summary by the Flight Safety Foundation is at http://www.flightsafety.org/ap/ap_june01.pdf .

On 23 September 1999, a Boeing 747-400 aircraft, Qantas One, was on a scheduled passenger flight to Bangkok carrying 391 passengers, 16 cabin crew, and three flight crew (captain, first officer and second officer). The first officer was the handling pilot (Pilot Flying) for the flight.

Before commencing descent, the crew obtained the Bangkok Airport weather information. The wind was from 240 degrees at 10kts, and visibility was 9 km. It was raining at the airport and there were thunderstorms in the area.

At about 2216 local time Qantas One commenced descent from FL350. At 2219 the crew were advised that they would be landing on runway 21L, behind a Thai International Airbus A330. The crew briefed for the approach and appropriate selections were made on the auto-brake system. At some point after this another Boeing 747 - Qantas 15 - was vectored ahead of Qantas One, although the crew were not informed of this.

The auto-brake system allows the pilots to select a rate of deceleration appropriate for their landing conditions. The actual rate of deceleration is monitored after touch-down and brake pressure is automatically applied to maintain the selected deceleration rate. For the auto-brake system to operate, engine power must be at idle within 3 seconds of touch-down, but manual braking is available if this limit is exceeded. The aircraft was also fitted with an anti-skid system, which works in a similar way to a car's ABS system.

At 2226 ATC advised that there was heavy rain at the airport, but the visibility from the control tower was 4 km. The crew were not concerned about the weather at this stage of the approach. Rain and thunderstorms were common events at Bangkok and it was still about 20 minutes before landing. The visibility was well within the first officer's limits (1500 m).

At 2233 the crew completed the approach checklist. The planned landing configuration was flaps 25 with a final approach speed of 154kts. They changed frequency to Bangkok Arrivals, descended to 2500 ft and proceeded towards the runway final approach path. At 2236 they were informed that there was heavy rain over the airport. Two minutes later, the flight was cleared for an ILS/DME approach to runway 21L.

[5] According to the accident report.

http://www.atsb.gov.au/publications/investigation_reports/1999/AAIR/aair199904538.aspx
http://www.flightsafety.org/ap/ap_june01.pdf

Between 2237 and 2239, the second officer obtained Information Tango. This included information from the routine weather observation taken at 2230, including the fact that there was a thunderstorm situated over the airfield. It also stated that tower and ground controller training was in progress.

At 2239 the captain informed the crew that he could see the thunderstorm cloud overhead the airport. After they had turned inbound he had a clear view of the runway environment. They were not in cloud at that point and there was no rain; however the storm cell over the airport was clearly visible and was also evident on the flight deck weather radar display. Such conditions were a common occurrence in Bangkok and other tropical locations and the crew were conscious of the possibility of turbulence, wind shear and reduced visibility.

Over the next three minutes the first officer began to slow the aircraft down using speed brakes to assist in this. At about the same time a special weather observation was taken: the visibility was now 1500 m and the runway visual range (RVR) was 750 m. The arrivals controller did not advise the crew of this, nor did he tell them that the ATIS information had changed.

At 2242 Qantas One began to descend on the glide-slope. The crew were told to contact Bangkok Tower when they reached the final approach point (about 4.1 nm from touchdown). Shortly afterwards Qantas 15 informed Tower that they were going around, but the crew of Qantas One did not hear this transmission as they had not yet reached the final approach point, nor did the controller inform them of this. The primary reason for the go-around was loss of visual reference in heavy rain.

At 2243 the landing gear was extended and shortly afterwards, when the aircraft was at 1900 ft and 165kts, flap 25 was selected. As they reported at the final approach point the controller advised 'caution runway wet and braking action reported by Airbus Three (the Thai aircraft) is good'. And cleared Qantas One to land. The crew assumed that the Airbus mentioned by the tower was the immediately preceding aircraft and considered that they had no reason to think the runway conditions were not appropriate for landing. At this stage the crew had not flown through any rain. The crew completed the landing checklist and configured the aircraft for landing.

At 2245 the speed was still 166kts and the first officer commented that the aircraft 'doesn't want to slow down'. Although still above the target speed, the speed was still decreasing. The engine power had been reduced to below the normal setting but the first officer did not want to reduce it further. The captain was aware that the speed was a little high but thought the situation was under control. Shortly afterwards, light rain was encountered and the windscreen wipers were selected 'On'.

From 2246 onwards the rain became heavy. The approach and runway lights were now only visible for brief intervals as the windscreen wiper blades passed across the screen. The first and second officer later said that the rain was the heaviest either of them had ever experienced during an approach.

Passing 140 ft the speed had increased to 170kts and the rate of descent was 600 ft/min. The aircraft began to deviate above the ILS glide-slope. The captain commented 'you're getting high now'. He later reported that he had noticed the rate of descent had decreased after they hit the heavy rain. The captain said 'you happy?' and the first officer replied 'ah, yes'.

They were still high and fast as the aircraft crossed the runway threshold. The captain said 'get it down, get it down, come on, you're starting your flare'. The first officer began to retard the thrust levers in preparation for landing. At 10 ft and 157kts the captain instructed the first officer to go around. The first officer manually advanced the thrust levers but did not activate the 'TO/GA (takeoff/go around) function, which automatically advances the engine power to the correct setting.

A few seconds later the aircraft touched down at 156kts, one third of the way along the runway, 636 m beyond the ideal touchdown point. At the same moment the rain intensity decreased and the captain could see the length of the runway. He assessed that there was sufficient runway remaining to stop and cancelled the go-around by retarding the thrust levers, without saying anything. This resulted in confusion amongst the other pilots, and contributed to the crew not selecting (or noticing the absence of) reverse thrust during the landing roll.

Unfortunately, the captain accidentally failed to retard the No 1 thrust lever. This had two serious effects:

1. Automatic spoiler deployment was delayed, and,

2. Because more than 3 seconds elapsed before all engines were selected to idle, the auto-brake system did not activate (although manual braking was applied).

Due to these and other factors, the aircraft's speed did not decrease below the touchdown speed (154 kts) until the aircraft was halfway down the runway.

The aircraft overran the runway end at 96kts and entered the stop-way. At 79kts it collided with the ILS localiser antenna about 100 m beyond the end of the stop-way. It continued for a further 100 m through very wet boggy soil before coming to a stop.

The aircraft sustained substantial damage during the overrun. The collision with the ILS localiser antenna initiated the collapse of the nose and the right wing landing gear. Loss of the right wing landing gear caused the aircraft to adopt a slight right wing low attitude, allowing the right inboard engine nacelle, and then the right outboard engine nacelle, to contact the ground as the aircraft slowed. No significant injuries occurred during the landing or subsequent precautionary disembarkation.

The investigation established that, during the landing roll, the aircraft tyres aquaplaned on the water-affected runway. This limited the effectiveness of the wheel brakes to about one third of that for a dry runway. In such conditions and without reverse thrust, there was no prospect of the crew stopping the aircraft in the runway distance remaining after touchdown.

EDITORIAL COMMENT

Well, the airline and the pilots certainly learned a lot from this accident, but you may be asking yourself if they received all the help they deserved. If I had been flying that 747, I think I would have liked to be told that the weather conditions had deteriorated severely, to the extent that the aircraft ahead of me had elected to fly a go-around. And I might have been happier if controller training had not been in progress in these difficult conditions.

What do you think? Your comments would be most welcome.

50 YEARS AFTER MUNICH

On 6 February 1958, Manchester United football team were returning home to England after a European Cup match against Red Star Belgrade. They were flying in an Airspeed Ambassador aeroplane chartered from British European Airways (BEA) and captained by Captain James Thain. The aircraft stopped to refuel at Munich, where the runway was covered with slush.

Captain Thain tried to take off twice, but both attempts were aborted due to engine surging. When a third take-off was attempted, the aircraft did not accelerate sufficiently, and after take-off it failed to gain adequate height. It crashed into the fence surrounding the airport and then into a house. The left wing and part of the tail was torn off. The house caught fire. The left side of the cockpit hit a tree. The right side of the fuselage hit a wooden hut, inside which was a truck filled with tyres and fuel, which exploded.

23 of the 44 passengers and crew on board died, either at the time or shortly afterwards. These included 8 members of the football team, as well as the co-pilot, a steward and 8 journalists. Of the 9 surviving team members, two never played again. This accident has entered the folklore of British football as "The Munich Air Disaster" and is an example of aircraft accident prevention - and investigation - of which we cannot be proud.

In his book, The Naked Pilot[6], David Beaty states that the Canadian authorities and KLM were aware of the problems associated with slush-covered runways but "BEA took no notice". Captain Thain was held to be responsible, his airline transport pilot's licence was taken away and he was dismissed by BEA. It was not until 1968 that a new British commission cleared Captain Thain of all blame.

Understanding of the effects of ice, slow and slush contamination on runways and taxiways, and also on aircraft in the air, has increased enormously over the last 50 years; but we still do not know all the answers. The reality is that the presence of ice, snow or slush anywhere near an aeroplane must be regarded as a serious safety hazard and treated accordingly.

There are two main areas of concern:

- Runway and taxiway contamination; and,
- Ice on a parked or taxiing aircraft.

RUNWAY AND TAXIWAY CONTAMINATION

The hazards associated with an aircraft parked on an icy stand are fairly obvious. Engineers, ground crew and flight crew run the risk of falling and injuring themselves. Vehicles unable to stop may crash into the aircraft. When engines are started, the aircraft may slide from its parked position even if the brakes are applied and may push the wheel chocks out of the way. The push-back, too, will be dangerous due to poor adhesion between the tug's wheels and the tarmac.

Taxiway contamination is not systematically assessed in the same way as for runway condition. Once taxiing has commenced, there will be difficulty maintaining directional control if the taxiway is contaminated; braking will also be problematic. If snow or slush obscures taxiway markings, the aircraft may take a wrong turning or proceed further than the taxi clearance allows. Snow, ice or slush may be thrown up from the taxiway by the blast from the engines or by the mere passage of the tyres through the contaminant; this may damage aircraft components or contaminate the aircraft itself.

Take-off from a contaminated runway poses additional hazards. The presence of even a very thin film of snow or slush on the runway will reduce acceleration, delaying the time taken to reach take-off speed. Maintaining directional control using nose-wheel steering alone may be difficult, especially in the presence of a cross-wind. If the take-off has to be abandoned, then the effectiveness of the aircraft brakes will be greatly reduced. Finally, contamination of the underside of the aircraft, especially the landing gear and wing flaps, by spray thrown up from the runway will be hard to avoid.

Once in the air the problems are not over. If the aircraft has been contaminated by spray from the taxiway or runway then its aerodynamic properties will have changed, increasing drag and reducing lift. Snow or slush thrown up onto the landing gear or flaps will not necessarily prevent retraction, but it will probably freeze in flight and may prevent subsequent extension. Recommended

[6] The Naked Pilot by David Beaty, first published by Methuen in 1991.

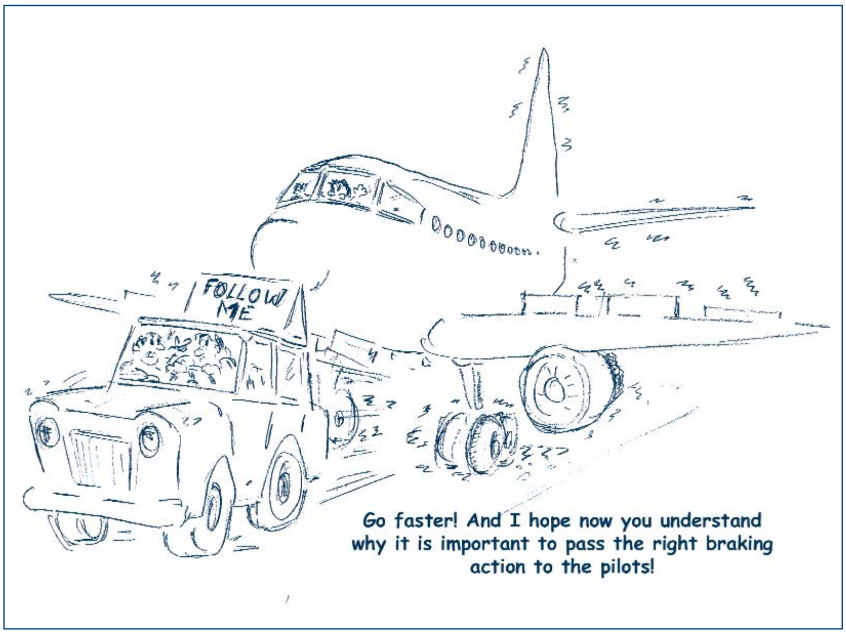
practice these days is to recycle the landing gear several times before final retraction to shed as much contamination as possible. Contamination of sensors, for example, the pitot head or static vents, will result in erroneous information being fed to aircraft instruments and to the different aircraft systems that rely on their output.

When it comes to landing, the main problem will be maintaining directional control and stopping before the end is reached. Other than that, similar hazards to those listed above will be present, although there will of course be an opportunity to clean away any contamination once the aircraft has parked.

If operations are to be maintained while snow is falling, frequent checks must be made of all paved surfaces and any adjacent areas over which engines may pass. It will usually be necessary to clear any fallen snow or change the taxiing plan so that aircraft do not have to use contaminated areas. If drains are not kept clear, then pooling water melting from the paved surface may pose as big a problem as snow or ice contamination.

At aerodromes where snow is present for a large part of the year, the use of ice or compacted dry snow (gritted or ungritted) may be authorised, in which case special conditions will apply and must be rigorously applied.

Runway inspections must be supplemented by frequent checks of braking action; this is particularly important in the presence of precipitation, which may cause quite rapid changes to runway conditions. Braking action on snow and slush can be measured fairly accurately; at present water contamination cannot.



Because of the hazards, some operators prohibit or severely restrict operation from contaminated runways. Where they are permitted, the pilot will need to know the depth and type of contaminant as well as the braking action, for use in making performance calculations. It is essential that the assessment of runway conditions is accurate at the time of operations as take-off or landing performance may be marginal.

Pilots must be notified immediately if conditions deteriorate, even if information provided is provisional while a detailed assessment of conditions is being conducted.

ICE ON PARKED OR TAXIING AIRCRAFT

Ice or other contamination on parked aircraft can have two main effects: it may alter the aerodynamic properties of the aircraft and it may affect aircraft components. In addition to the aerodynamic effects, ice on control surfaces may prevent their free movement, while wet contamination may freeze after take-off preventing normal operation. Landing gear and flap contamination has already been mentioned.

Contamination of the pitot-static system is a particular problem if covers have been left off the sensors for some time while precipitation is in progress. Moisture may enter vents and freeze, causing blockage and erroneous readings.

Clearing ice and snow from parked aircraft is a specialist task. First, loose snow is brushed from the wings and fuselage, then the aircraft is treated using a spray of de- and anti-icing fluids (sometimes heated). Holdover protection is achieved by a layer of anti-icing fluid remaining on and protecting aeroplane surfaces for a period of time. With a one-step de-icing/anti-icing procedure, the holdover time (HOT) begins at the commencement of de-icing/anti-icing. With a two-step procedure, the holdover time begins at the commencement of the second (anti-icing) step. The holdover protection runs out:

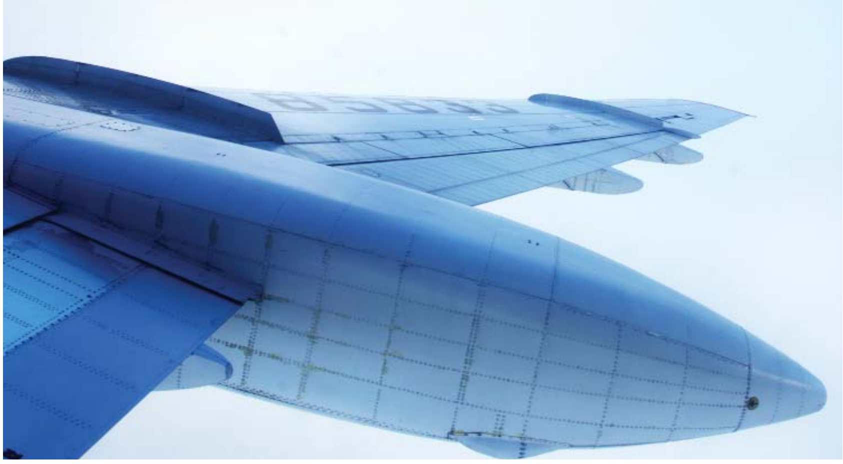
- At the commencement of take-off roll (due to aerodynamic shedding of fluid) or
- When frozen deposits start to form or accumulate on treated aeroplane surfaces, thereby indicating the loss of effectiveness of the fluid.

Strangely enough, there are no international standards for these fluids, but in Europe, an AEA (Association of European Airlines) working group carries out an annual review of available products and publishes a guidance document, which may be downloaded from their website[7]. This document lists recommended procedures and best practice as well as the characteristics of each type of available fluid. These characteristics include the period of time for which a de-icing operation may be valid before repeat application (holdover time).

Once an aircraft has been de-iced, delay before take-off must be kept to a minimum to ensure the contaminant does not re-freeze before take-off. On the take-off run, the fluid is shed from the wings and other surfaces so that its presence does not affect the aerodynamic performance in flight. At some airports, de-icing is carried out at a remote de-icing stand on the aircraft's route to the take-off point; this permits the collection and ecologically safe disposal of surplus fluid.

Some de-icing fluids remain on aircraft after landing and the dried deposits may collect in aerodynamically quiet areas. These deposits must be washed from aircraft with unpowered flying controls as they may re-hydrate and freeze at a later point in suitable environmental conditions, causing jamming of control surfaces.

Once taxiing of an uncontaminated aircraft has commenced, falling snow may build up on the aircraft. This is likely to become dangerous if departure is delayed for any reason. Therefore, pilots should be informed immediately if accretion is observed by controllers on taxiing aircraft; in this case, it may be necessary for the aircraft to return to the de-icing bay for re-treatment.



CONCLUSION

Although we have come a long way since 1958 in our understanding of icing problems, the annual toll of accidents resulting from this hazard demonstrates that the problem is not yet under control. Only by continued application of best practice and constant vigilance by all members of the flying team - pilots, air traffic controllers, meteorological forecasters, engineers and airport staff - can the target of zero icing-related accidents ever be achieved.

[7] The publication: Recommendations for De-icing/Anti-icing of Aircraft on the Ground is available from the AEA website www.aea.be.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