September-October 2008

Safety

A Corporate Safety Publication

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Pakistan International Airlines
A Corporate Safety & QA Publication

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Making incursions

CASA and Airservices Australia are releasing new runway safety resources in July: a booklet and DVD which look at five busy training aerodromes; and the interactive 'Runway Challenge' online. As a preliminary to their release, *Flight Safety* takes a look at the growing issue worldwide of runway incursions.

In relation to the number of global aircraft movements, runway incursions are thankfully rare. However, there is evidence that they are on the rise, as a result of increased traffic volume. And as the runway incursion which occurred at Tenerife in the Canary Islands in 1977 tragically demonstrated, they can have disastrous consequences.

That accident, which led to the loss of 583 lives when two Boeing-747s collided on the runway, remains the world's worst aviation disaster. The potential for another disaster of that magnitude is ever-present, something recognised by aviation safety bodies around the world in coordinating runway safety awareness programs.

Such programs were further driven by the 2001 runway incursion accident in Milan, which resulted in the loss of 118 lives; and an increasing number of runway incursions as traffic levels grew. Accordingly, the International Civil Aviation Organization (ICAO) commissioned a runway safety study group to develop best practice guidance material for states and other aviation organisations.

Since then, ICAO has been active in trying to reduce the incidence of runway incursions through the implementation of various safety measures, and wide-ranging educational and awareness campaigns.

Last year, for example, ICAO released its 'Manual on the Prevention of Runway Incursions' as a response to recommendations at runway safety seminars held in Asia, the Pacific and Middle East between 2002 and 2005, for a manual containing runway incursion prevention guidelines.

The push by ICAO has also led to a standardisation in the approach to preventing runway incursions. The ICAO* definition of runway incursions is widely adopted, and there is now a standard classification scheme for assessing the severity of runway incursions. This means the ability to collect more meaningful data, and to use this in turn to drive more effective prevention measures.

Runway incursion prevention has also been on the United States' National Transportation Safety Board's (NTSB) 'most wanted list' of safety improvements since that list began in 1990. The NTSB held a runway incursions forum in March last year on

into runway safety

the 30th anniversary of Tenerife, with a dozen or so speakers representing investigators, regulators, ATC, pilots and airports.

The Airline Pilots' Association International's Captain Mitchell Serber, chairman, airport ground environment group, was one of the industry speakers. According to Serber, 'Approximately one runway incursion occurs each day in the United States, and the potential for a catastrophic accident is "unacceptable", according to the Federal Aviation Authority's (FAA) risk/severity matrix.'

He went on to explain that, 'The likelihood of runway incursions grows exponentially as a function of air traffic growth, which is on the increase in the United States. From 1988 to 1990, traffic volume at towered airports in the United States increased 4.76 per cent, but the runway incursion rate at these airports increased more than 43 per cent. From 1990 to 1993, traffic volume suddenly decreased 5.34 per cent, and the runway incursion rate quickly dropped by 30 per cent.

Then, reversing the trend once again, from 1993 to 1998, traffic volume grew only 2.41 per cent, but the runway incursion rate climbed an incredible 67 per cent.' Serber also drew comparisons between various studies which have been performed worldwide. 'Numerous studies have been performed on the runway incursion problem, both in and outside of the United States. The studies share a great deal of commonality with respect to causal factors and solutions.'

Runway incursion:

Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, person, animal or object on the protected area of a surface designated for the landing and take-off of aircraft.

***ICAO definition**

Speakers at the NTSB forum examined a range of options for reducing runway incursions. The recurring theme was the need not just for a single system or program, but a structure consisting of what Serber described as 'layers of information and alerts': moving-map displays, runway status lights, surface movement radar, perimeter taxiways, training and communications, and visual aids. Together, these would work together to provide multiple layers of protection.

Some of these technological solutions have already been implemented, or are in the process of being implemented. As of 23 March last year, the FAA approved a quicker certification process for a Class II electronic flight bag with an airport moving-map, which shows an aircraft's precise position on the airfield. While new aircraft currently have this function, the certification process meant previously that it was too costly for airlines to retrofit to their aircraft fleet.

Runway status lights under test in the USA at Dallas-Fort Worth, and in San Diego, are also proving effective in averting runway incursions. The lights, installed at runway and taxiway intersections, and at runway departure points, are surveillance-driven, illuminating automatically to show pilots when it is unsafe to cross or depart from a runway. The lights have received a 'thumbs-up' from pilots, ATC and the airport operators, and the FAA supports their accelerated deployment.

But the human component – providing 'low-tech' solutions to runway incursions – is proving to be more challenging. Captain Robert Bragg, the first officer on the Pan Am 747 involved in the Tenerife accident, speaking at the NTSB forum last year, listed the 'low-tech lessons' he took away from that day thirty years ago:

- anyone can make a mistake, no matter how qualified (Robert Bragg, now retired, has clocked up 33,000 flying hours)
- communications must be effective and readily understood
- when in doubt, don't
- check, double-check and recheck
- continue emphasis on crew resource management.

The human factors side of the equation receives considerable emphasis in the latest Australian runway safety material due for release in July. Although thankfully Australia has not suffered any aviation fatalities as a result of runway incursions, there have been numerous near-misses, with the potential for disastrous consequences.

> 'Take-off and landing average four per cent of flight journey time, but account for 70 per cent of all accidents.'

Given the runway incursion prevention initiatives occurring at the global level, Airservices Australia decided to take similar action to mitigate the risk of runway incursions in Australia, by establishing a group to take a national perspective on runway incursions and to improve awareness. The Runway Incursion Group, formed in 2005, now comprises Airservices Australia, CASA, the Australian Transport Safety Bureau and Defence, among others, working together to coordinate runway safety initiatives.

The Runway Incursion Group promotes local runway safety teams established at controlled aerodromes and comprising representatives from the aerodrome operator, the air traffic service provider and aircraft operators. The group undertakes a survey of each aerodrome to identify factors which may trigger runway incursions. It reviews signage, markings, layout, etc, comparing these with other aerodromes to identify best practice. To date, all the aerodromes visited have agreed to establish runway safety teams.

Airservices also published a booklet, *Runway Safety: a*

Recurring runway incursion scenarios

An aircraft or vehicle crossing in front of a landing aircraft;
An aircraft or vehicle crossing in front of an aircraft taking off;
An aircraft or vehicle crossing the runway-holding position marking;
An aircraft or vehicle unsure of its position and inadvertently entering an active runway;
A breakdown in communications leading to failure to follow an air traffic control instruction; and
An aircraft passing behind an aircraft or vehicle that has not vacated the runway.

ICAO Manual for the Prevention of Runway Incursions

Runway incursions – a growing trend

Fiscal year (FAA definition)	Total incursions (FAA definition)	Rate per 1 million ops (ICAO)	Total incursions
2000	405	5.9	
2001	407	6.2	
2002	339	5.2	
2003	323	5.2	583
2004	326	5.2	504
2005	327	5.2	530
2006	330	5.4	806
2007	371	6.07 (estimate)	887 (preliminary)
2008*	110 (Oct & Nov 2007)		

* FAA adopted the ICAO runway incursion definition, which includes the words 'incorrect presence' on 1 October 2007, the beginning of the 2008 fiscal year.
However, the latest FAA report on runway trends and incursions shows that over the years 2003-2006 (i.e. the FAA fiscal year, 1 Oct-30 Sept), the FAA met its targets to reduce the most severe (category A & B) runway incursions.

pilot's guide, in 2006, and together with CASA, has developed the interactive online 'Runway Challenge', due to go live by July. (Also see p13 of this issue.) To reinforce this material, CASA has produced a DVD and visual aid booklet also due for release in May. CASA's kit focuses on four busy general aviation aerodrome procedures (GAAP) airports: Bankstown, Jandakot, Moorabbin and Parafield, as well as Cairns, in recognition of the number of runway incursions reported at these sites. Interviews conducted with ATC, flying instructors, CASA aerodrome personnel and aerodrome operators led to the production of resources which identify each airport's unique features.

The booklet will include local information on each of the five aerodromes, including requirements specific to each location; ground, tower and ATIS frequencies; a large simplified airport diagram; and analysis of the hotspots at each. While instructors and pilots who have seen the draft material have given very positive feedback, especially on the simplified airport diagrams, the booklet is in no way intended to replace the En Route Supplement Australia (ERSA) information or procedures.

The accompanying DVD features interviews with ATC, flying instructors and CASA aerodrome inspectors at the various localities, expanding on the issues summarised in the booklet. Those interviewed identify numerous factors implicated in runway incursions, many common to all five aerodromes represented.

As Mike Pottier, the chief pilot for the Royal Aero Club of Western Australia explains, 'Jandakot is a training aerodrome, with a large number of student pilots. The layout of the airfield is complex, and there is a large number of aircraft movements. 'Pilots need to be more aware of the layout of the runways'.

Severity classification scheme

A A serious incident in which a collision is narrowly avoided, or the event results in a collision.

B An incident in which separation decreases and there is significant potential for collision, which may result in a time-critical corrective/evasive response to avoid a collision.

C An incident characterised by ample time and/or distance to avoid a collision.

D An incident that meets the definition of runway incursion, such as the incorrect presence of a single vehicle, person or aircraft on the protected area of a surface designated for the landing and take-off of aircraft, but with no immediate safety consequences.

E Insufficient information or inconclusive or conflicting evidence precludes a severity assessment.

Sally-Anne Scott, chief flying instructor with the North Queensland Aero Club.

Someone who reinforces these factors is Gary Smythe, chief pilot for Moorabbin Flying Services. 'Runway incursions occur at GAAP-type aerodromes, because they're often training-type aerodromes. You have inexperienced pilots going solo at 15-18 hours – there is a lack of familiarity.' However, he says, the 'ATC at Moorabbin has 20-25 years of experience, and is conversant with the fact that it is a training aerodrome, and errors do occur.'

Mike Pottier also points to a gap in VFR training, which could contribute to runway incursions involving student pilots. 'There's nothing in the syllabus about taxiing,' he says.

This comes back to something the instructors, pilots and ATC all emphasised: the necessity for pre-flight planning. Jeff Hatcher, ATC at Bankstown, and one of the driving forces on the Runway Incursions Group, says 'ATC, CASA, the average pilot and the instructors, all need to consider the emphasis on the taxi part of the flight. It's a complex issue, but something we need to address. You can't be a pilot who switches off the aviator before switching off the engines,' Jeff says (*Flight Safety* 2004).

All agree you should familiarise yourself with the ERSA charts and plan your taxi route, especially if you're at an unfamiliar airport. This should include listening to the automatic terminal information service (ATIS) and reading all relevant NOTAMs, so you don't miss important information.

'Pilots are unfamiliar with the airport, and not studying the ERSA in enough detail,' Sally-Anne Scott, chief flying instructor with the North Queensland Aero Club based at Cairns airport, argues. 'It's a trap pilots who have done a lot of flying at country airstrips and who are not used to multiple exits, fall into.' Lloyd Mais, the CASA northern region aviation safety advisor, agrees. 'You should try and make yourself familiar with the airport, but if you're still having problems, talk to ATC, so that they know. Their communication style will change if you're a local pilot, versus an itinerant pilot.'

As an international airport, the potential for runway incursions with severe consequences is high at Cairns, where 767s, 737s and SAABs share runways with GA aircraft and students from local flying schools. As Craig Bradshaw, aka 'Bones', pilot and Cairns ATC, describes, 'Airports are very busy places to be manoeuvring around, especially with a lot of checks to be done. Often ATC are asking lots of questions, and it can be a very busy time for pilots when they're taxiing. As both a pilot and ATC, Craig is very aware of the pressures place on pilots in surface movements; he was one of the driving forces behind having Cairns hotspots included in the ERSA charts.

Pre-flight planning is critical—**before** you arrive at the airport

Before you arrive at the airport:

- familiarise yourself with the airport layout and airfield markings
- plan your taxi route, and note any hotspots – runway crossings or parallel markings which might be easily confused
- have a frequency management plan
- plan to ask ATC for help if things change, or you're unsure.

All those interviewed stressed the role of effective communication in preventing runway incursions. Sadly, miscommunication was a major factor in the 1977 Tenerife incursion. The KLM 747 pilot used the phrase, 'We are now at takeoff,' which the ATC took to mean that the aircraft was at the holding point waiting for clearance to take off, rather than actually taking off. The controller did not warn the KLM pilot of the Pan Am 747 which was already on the runway, obscured by fog.

Before you start taxiing, test your radio, then listen to the ATIS for active runways and further information. Jeff Hatcher argues that radio congestion is a problem in any busy environment, especially at GAAP aerodromes, and

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 any 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.

that you're not going to eliminate it completely. But keeping your transmissions brief will help.

'Think about your transmissions – plan ahead; listen before you talk and don't jump in when it's someone else's turn. If you're changing frequency, think ahead; listen first and find out what's happening on that frequency. Wait until that conversation is finished, and then take your chance,' he says.

It's also critical to use standard phraseology on the radio, and to monitor ground frequency when manoeuvring, as short term activation and deactivation of runways will be broadcast on this. Always confirm ATC direction too, as incidents have occurred because of mistaken call signs. Above all, the message came through loud and clear: 'If you're unsure, ask ATC for assistance'.

In the complex dynamic environment of a busy GAAP aerodrome, situational awareness – knowing where you are, and what's around you – is vital. Sally-Anne Scott emphasises this when she advises pilots 'to keep your head up and look outside for holding points'. In recognition of the importance of situational awareness in preventing runway incursions, an area has been allocated for pre-flight checks at Moorabbin. 'Don't do vital checks on the run,' Moorabbin CFI, Gary Smythe, explains. 'Concentrate on your checks first, and then taxi with your head up'. It's not rocket science, but it's easy to miss a holding point if you're distracted.

Seeing signs is one thing, but you must know what they mean, and be familiar with variations in signage. Familiarise yourself with the relevant aerodrome in the aeronautical information publication (AIP). Moorabbin has updated its signage recently, but some other GAAP aerodromes have more limited signage, including Bankstown.

Take the 'Runway Challenge'

Airservices Australia's web services team leader, Damian Heffernan is coordinating the development of a new online interactive 'Runway Challenge', which is due to go live by July. Go to **www.airservicesaustralia.com** for updates, and to be directed to the Challenge.

Bankstown, with its number of aircraft movements, and hotspots, was used to develop the initial template. It is envisaged that further GAAP and other aerodromes will be added, as well as scenarios involving not only aircraft as at present, but airside vehicles etc.

The Challenge will allow 'pilots to taxi around the

10 WAYS YOU CAN HELP PREVENT RUNWAY INCURSIONS

1	Plan your surface movements as carefully as you would plan your flight
2	See the 'big picture'. Maintain situational awareness – look around, and minimise 'heads-down' activities while taxiing. Monitor both ground and tower communications where possible.
3	Transmit clearly. Test your radio before entering the taxiways, and plan your transmission, paying attention to standard terminology and phraseology.
4	Listen carefully. Listen to the ATIS for active runways and further information.
5	Confirm ATC direction, as incidents have occurred because of mistaken call signs. Read back required elements of the clearance, and end your transmission with your call sign.
6	Know your location. Keep a current airport diagram handy, and read all relevant NOTAMs, so you don't miss important information.
7	Maintain a sterile cockpit. While on the ground, and at cruising altitude, talking should be kept to a minimum.
8	Know your signs. Be aware of what the various airport signs, markings and lights mean, and what action to take.
9	Never assume. Don't take clearances for granted. Look both ways before entering or crossing taxiways and runways.
10	Follow procedures. Operating procedures are designed for your safety. Follow them.

WHEN IN DOUBT ASK ATC FOR ASSISTANCE

Know the colour-coding and meanings of runway signs

1. Mandatory instruction signs

White inscription on a red background.

Identifies the entrance to a runway, or critical area, and areas prohibited for use by aircraft.

Red and white: runway in sight

2. Information signs–location

Yellow inscription on a black background.

Identifies the taxiway you are located on.

Black square: you're there

3. Information signs–destination

Also black inscription on a yellow background.

Arrow identifies direction to specific destinations on the airfield, such as runways, terminals.

Yellow array: points the way

4 Information signs–direction

Black inscription on a yellow background.

Identifies taxiway leading out of an intersection with an arrow indicating direction required to align the aircraft on that taxiway.

Yellow array: points the way

Runway markings are white... although yellow taxiway centrelines may lead on to, or lead off, or cross, the runway). Taxiway markings are yellow.

aerodrome, where they will be faced with a number of pre-set, real-life scenarios. 'Pilots' can select different levels: 'easy', 'medium' and 'hard', which will then determine the number and type of scenarios they face as they manoeuvre around the aerodrome. For each level, pilots can only lose a specified number of points before they fail – with some dangerous or illegal practices resulting in automatic failure.

'It will be very realistic,' Damian says, 'because we're working off recent satellite pics which are only a few months old. If you select the camera icon, you'll be able to have a 360-degree spin-around of the runway.

'The plane will go a bit faster than real-time', he continued. 'Probably for the easy levels, it will be about two minutes, with the longer, more difficult scenarios taking about four minutes.'

The Challenge requires the correct phraseology to be used; if you choose the incorrect option, you'll immediately lose 100 points, thereby reinforcing the importance of standard phraseology for effective communication. It will also reinforce a broader understanding of correct taxiway and runway procedures because at the end of each scenario, pilots will be shown 'Here's what you did wrong'. They can then re-do the scenario to get a perfect score, and then level 2 will open up. Pilots will also be able to print out the scenario detailing all the correct phraseology, which it is hoped will benefit student pilots of non-English-speaking background. ■

Screen shots of the new 'Runway Challenge'.

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...

Geriatric Jets

Twenty years on, **Macarthur Job** looks at the background to one of the milestone cases in aircraft structural integrity.

Six metres of fuselage structure blew off an Aloha Airlines Boeing 737-200 in April 1988, taking with it one of the flight attendants. Seven passengers and another flight attendant were seriously injured. Greatly weakened, the aircraft just held together for an emergency landing at Honolulu's International Airport. Corrosion and fatigue cracking had caused the failure.

Aloha's island network had few ports of call and extremely short stages. Indeed, since jets had replaced its turboprops, stages between the six main Hawaiian islands had shrunk to only about 20 minutes.

For their day's flying in one of the company's older 737s, the five crew members arrived at Honolulu airport before first light. With their aircraft standing on the apron in the pre-dawn darkness, the first officer completed an inspection under the apron floodlights.

The first three return trips for the day were uneventful, and at 11am the 737 landed at Honolulu for the third time. The new-rostered first officer was one of Aloha's women pilots. The next flight was to Maui, where there was a stop-over of two hours, before continuing to Hilo on the main island of Hawaii. The return trip to Honolulu, a distance of 190nm, was to be flown direct.

The turnaround at Hilo was brief, both pilots remaining in their seats, and at 1.25 pm, with the first officer flying, the Boeing 737 lifted off, climbing in fine weather with 89 passengers aboard. Twenty minutes later, it levelled out at 24,000 feet.

Explosive decompression

Seconds afterwards there was a violent report like an intense clap of thunder, accompanied by screams and a loud 'whooshing'. An instant later, the wind noise became deafening as the cabin violently decom-

An Aloha Airlines Boeing 737-200 in 1987

pressed, filling the flightdeck with dust and debris. The captain took control, the pilots donning their oxygen masks. The flightdeck door had been wrenched off, and blue sky was showing where the ceiling of the first class cabin had been.

Reducing power and extending the speed brakes, the captain began an emergency descent towards Maui, less than 40 nm distant. Meanwhile the first officer selected the transponder to emergency code 7700. The pilots could communicate with each other only by hand signals.

Communication difficulties

Attempting to call Honolulu proved impossible and the first officer tried Maui Approach. Again there was no response, so she switched to the Tower. The radio exchanges continued with difficulty as follows:

Aircraft: 'Maui Tower – Aloha 243. We're inbound for landing – descending out of 13 thousand and we are unpressurised – declaring an emergency!'

Maui Tower: 'Aloha 243 – say your position.'

Aircraft: 'We're just – ah – to the east of Makena Point – request clearance for landing – request the (emergency) equipment!'

Tower: 'Aloha 243 – OK, the equipment is on the way.'

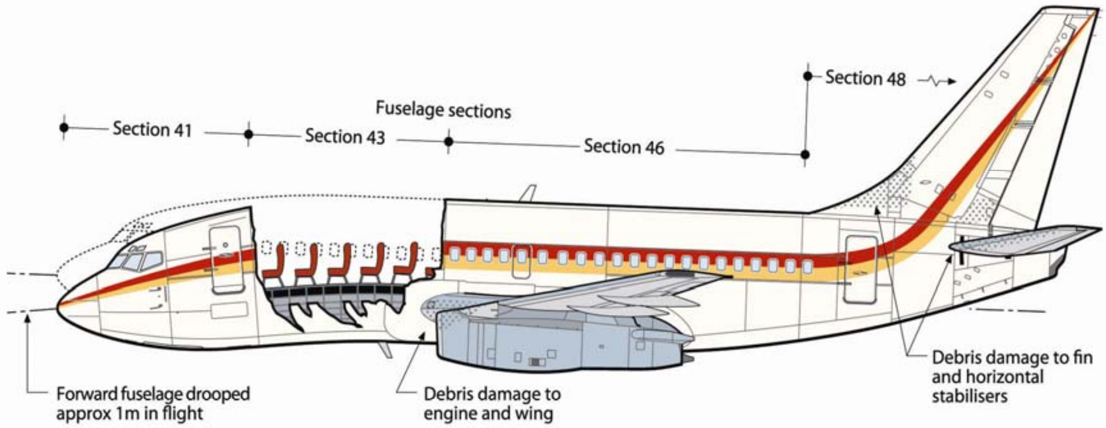
At 10,000 feet, the pilots removed their oxygen masks and, with the airspeed now coming back to 210 knots, the captain motioned for 'flaps 1', and shortly afterwards, for 'flaps 5'. With the wind noise reduced, the crew found they could communicate by shouting.

Tower: 'Aloha 243 – wind 040 at 15 [knots], altimeter 29.99 – plan straight ahead for Runway 02.'

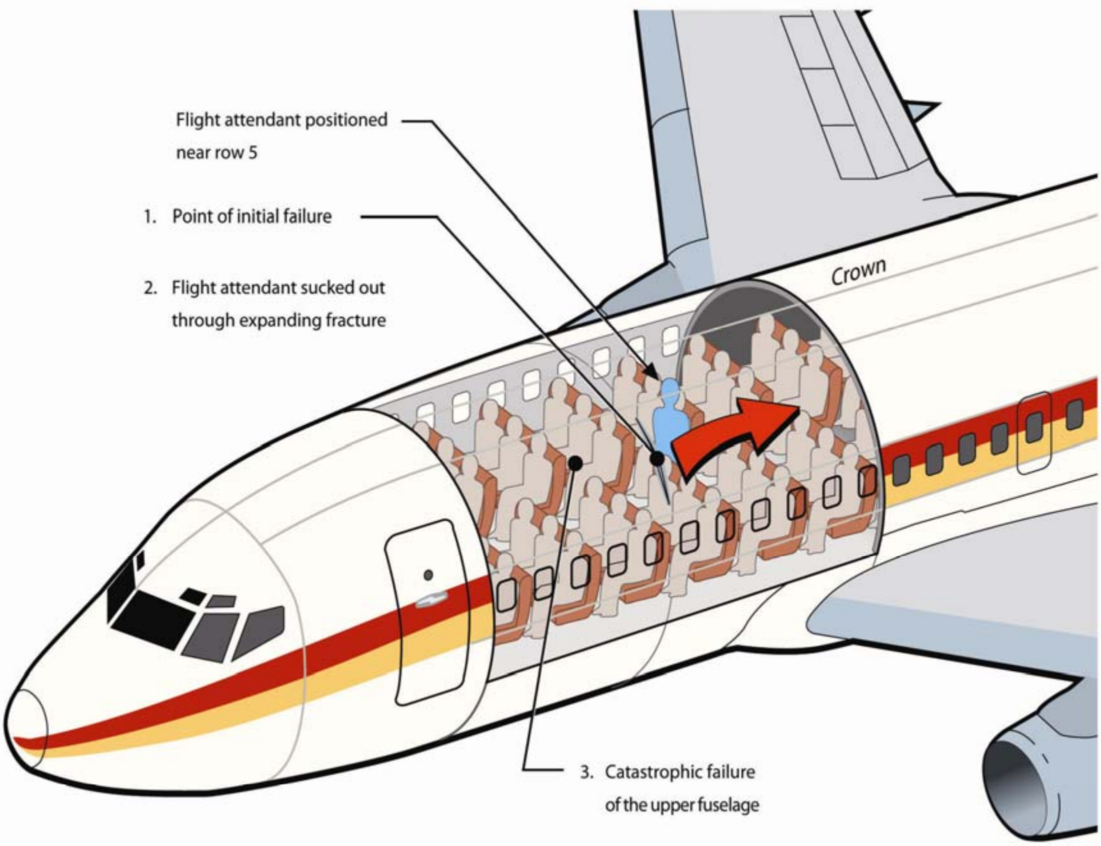
F/O: 'Aloha 243. Can you hear us? It looks like we've lost a door – we have a hole in this – left side of the aircraft.'

Tower: 'Aloha 243 – cleared to land – wind 040 at 20.'

Capt: (shouting above wind noise): 'Tell him we'll need assistance to evacuate.'



Cutaway views showing the areas of damage during the explosive decompression in which a flight attendant was swept from the cabin to her death.



F/O: 'Maui Tower – we're going to need assistance – we can't communicate with the flight attendants – we'll need assistance for the passengers when we land.'
Tower: 'OK – understand you're going to need an ambulance.'

Undercarriage problem?

Capt: 'Let's try flying with the gear down here.'

Although the main undercarriage indicated down and locked, the nose leg indicator failed to illuminate. When the first officer pulled the manual extension handle, the green light still did not illuminate, but the red 'unsafe' light extinguished.

Tower: 'Just to verify, you do need an ambulance? Is that correct?'
F/O *(to Capt with exasperation)*: 'They still don't understand!" *(then to Tower)*: "Affirmative!'
Tower: 'Roger – how many do you think are injured?'
F/O: 'We have no idea – we can't communicate with our flight attendants.'
Tower: 'OK – we'll have the ambulance on the way – wind now 050.'
F/O: 'OK – be advised we have no nose gear – we are landing without the nose gear.'
Tower: 'OK – if you need any other assistance, advise.'
F/O: '**We**'ll need all the equipment you've got.'

On final

On a long final approach in its 'flaps 5' configuration, the aircraft was shaking slightly, rocking gently, and felt 'springy'. But when the first officer selected 'flaps 15', the aircraft became markedly less controllable.
F/O: 'Is it easier to control with the flaps up?'
Capt: 'Yeah – put them back to five.'
Tower: 'Aloha 243 – wind now 050 at 20.'

The captain found the aircraft becoming less controllable below 170 knots, and decided to fly the final approach at that speed. Runway 02 was 2133 m long, so stopping would not be a problem. Advancing the power levers again, the captain felt the aircraft yawing – No 1 engine had failed. He attempted to restart it, but it did not respond.

Incredible revelation

At 1.59 pm, to the astonishment of watching rescue crews, the Boeing 737, visibly 'broken', with the forward fuselage drooping alarmingly, touched down smoothly at high speed, the nose leg holding as it came to a stop on the runway.

Only as the pilots moved back into the cabin did they realise the incredible extent of the structural failure. Immediately behind the entrance vestibule, not only the roof of the first class section, but the sides of the cabin down to floor level, had disappeared, leaving the first six rows of passengers totally exposed to the savaging wind during the emergency descent.

On the starboard side, some of the jagged-edged fuselage structure framing the cabin windows, shattered and bent, remained attached. But on the port side, the cabin sides, including the overhead lockers, down to floor level and beyond, had completely disappeared. The portside cabin floor was distorted and buckled upwards, pushing some of the seats into drunken attitudes.

An awful realisation

Lying on the floor was a flight attendant, suffering concussion and severe head lacerations. Passengers in the six exposed seat rows were injured and traumatised, some unconscious. Others, their heads and faces covered in blood, were moaning in pain. Further back, many of those nearest to the break in the fuselage had varying degrees of injury, mostly lacerations from debris. Many too, had damaged eardrums.

An 84-year-old woman in seat 5A on the port side had the most serious injuries: skull fractures and numerous lacerations. One row in front of her, passengers in both window seats had concussion and multiple lacerations, as did those in rows 5, 6 and 7. But those in the centre and aisle seats of row 4 suffered only lacerations.

Further forward, debris and flailing electrical wiring had injured passengers in seats 2A and 2C. The passenger in seat 6A, directly beneath the aft end of the fuselage fracture, suffered a broken arm, facial lacerations and blood effusion in both ears. Passengers in rows 8 to 21 received minor injuries.

While the first officer opened the main door and deployed its escape chute, the captain went to help the injured. But of the other two flight attendants, only one came forward to help. The captain then found to his horror that the third flight attendant was gone.

For three days, helicopters and a Coast Guard cutter searched the area, but her body was not found.

'She was drawn upwards and swept violently out through a jagged hole in the port side. A moment later, the entire cabin structure was carried away.'

INVESTIGATION

At the time of the explosive decompression, seatbelt signs were illuminated. Passengers said the missing flight attendant was standing at seat row 5 and, as the cabin roof failed, she was drawn upwards and swept violently out through a jagged hole in the port side. A moment later, the entire cabin structure was carried away.

Three rows further forward, another flight attendant, also standing in the aisle, was struck violently on the head as the flightdeck door was torn off. The third flight attendant, though bruised when thrown to the floor, crawled up and down the aisle during the emergency descent to render assistance and calm the distressed.

Fuselage damage

The aircraft was beyond repair. The structure had separated from slightly aft of the main door, rearward about 5.5 m to just forward of the leading edge of the wing, and from floor level on the port side to the starboard side windows. Below the floor on the port side, the skin had peeled off in large arrowhead-shaped gashes. Slightly to the left of the centreline, floor beams were broken, and adjacent floor beams cracked. Floor panels were displaced upwards as much as 10 cm, the displacement matching the broken beams.

A piece of cabin structure was wedged between the leading edge flap and inboard side of the starboard engine strut. The only separated piece recovered, it contained two skin repairs. Pre-existing cracks were present in some of the lap joint rivet holes.

Cables for the thrust lever and start lever systems of the port engine, routed beneath the cabin floor distortion, were broken, preventing movement of the fuel control or increase in engine power. The cables were badly corroded.

Passenger evidence

A woman who boarded at Hilo told investigators that, while entering through the main door, she noticed a small crack in the side of the fuselage. It ran through a row of rivets just aft of the door – evidently a small longitudinal crack in the upper row of rivets along a lap joint. But, believing she would only be 'humoured'

if she 'made a fuss', she made no mention of it. When the first officer made his inspection in the pre-dawn darkness, the crack had apparently not progressed sufficiently to be visible.

Aircraft history

The Boeing 737-200 was constructed 19 years earlier. Delivered to Aloha in May 1969, it had accumulated 35,496 flying hours and 89,680 flight cycles, the second highest number in the world 737 fleet. But because of the short distances of Aloha routes, the maximum cabin pressure differential of 7.5 psi was not reached on every flight, so the equivalent number of full pressurisation cycles was somewhat less.

Fail-safe design

Boeing designed the 737 for an economic life of 20 years, 51,000 flying hours and 75,000 cycles. Based on an estimate of maximum damage by fragments from an uncontained engine failure, the fuselage was capable of withstanding a 40-inch crack without suffering catastrophic failure. But no consideration was given to the joining up of adjacent cracks during extended service, or to the possibility of disbonding, and the effects of corrosion on fuselage lap joints.

A fatal accident involving the failure of a Boeing 737 fuselage occurred in August 1981, when a Taiwanese 737-200 broke up in flight as the result of an explosive decompression. The cause was attributed to 'extensive corrosion damage ... and the possible existence of undetected cracks because of the great number of pressurisation cycles of the aircraft (a total of 33,313 landings)'.

Lap joint bonding

On early model Boeing 737s, the fuselage skin lap joints were 'cold' bonded, using an epoxy-impregnated cloth to join the longitudinal edges of skin panels together. In addition, the joint was reinforced with three rows of countersunk rivets.

The cold bonding process was intended to provide structural efficiency, reduced manufacturing costs and weight reduction. Pressurisation loads were transferred through the bonded joint, rather than through the rivets, allowing the use of lighter, thinner skin panels.

The early service history of 737s revealed difficulties with this process, resulting in bonding of low durability. Boeing discontinued cold bonding in 1972, and introduced a close-fitting, surface-sealed and riveted lap joint, with increased joint thickness.

Laboratory examination

Pieces of fuselage skin sent to the National Transport Safety Bureau's (NTSB) laboratory showed evidence of extensive fatigue and corrosion. There was light to moderate corrosion generally, with severe corrosion in some places. Examination of lap joint samples revealed fatigue cracking adjacent to nearly every rivet hole.

The sample found wedged in the starboard wing contained two doubler patches, and extensive fatigue cracking was found under and between them.

Examination of the fuselage structure along the longitudinal separations pointed to an upper lap joint on the port side as the most likely source of faliure. Fatigue cracks emanated longitudinally from both sides of at least seven adjacent rivet holes in the skin, and it appeared that the primary failure had occurred when the skin pulled away in tension overload.

The damaged and distorted cabin floor on the port side, with broken and cracked floor beams, contrasting with the undisplaced starboard side floor panels, also pointed to the failure originating on the port side. As pressure in the upper fuselage lobe was released, pressure in the lower lobe was contained by the cabin floor, resulting in the floor being deflected upwards.

The possible reasons for the catastrophic failure were examined in detail. When disbonding occurs in a bonded lap joint, the pressurisation loads normally transferred through the lap joint are borne by the rows of countersunk rivets. Because of the thin skin the bonded construction permitted, the countersink for the flush rivet heads extended through the entire thickness.

The knife edges thus created produced stress concentrations with each fuselage pressurisation, leading to fatigue cracking from the rivet holes.

The damage to the accident aircraft, damage on other Boeing 737s in the Aloha fleet, and the service history of 737 lap joint disbonding, led investigators to conclude that numerous fatigue cracks in a lap joint finally linked up to cause the catastrophic failure.

Boeing visits

Boeing's Ageing Fleet Evaluation Program provided for examination of selected aircraft to assess their condition. Six months before the accident, Aloha was one of the operators chosen – it had the highest flight time and cycle aircraft in the world 737 fleet. Several had exceeded 75 per cent of their design life.

Senior Boeing executives voiced concern about corrosion and skin patches found on two 737s, recommending that the airline 'totally strip and upgrade their structures'. But a month later, when Aloha's management again met with Boeing, Boeing staff gained the impression the airline was planning to delay the structural overhauls.

Boeing then made a number of further recommendations, including a corrosion control program and complete structural inspections on at least four high-time aircraft, with detailed inspections of critical lap joints on all aircraft with more than 40,000 flight cycles.

Aloha maintenance

Several aspects of the airline's maintenance concerned the accident investigators. Flight cycles are the dominant factor in fatigue cracking, but Aloha's maintenance did not adequately consider this. Its D-check inspections were too infrequent for either detection of disbonding, or effective corrosion control. There was also a potential for the checks to be hurried to keep aircraft in service.

Time and manpower further limited inspections. Because Aloha's fleet was fully utilised in daytime operations, most of its maintenance took place at night, forcing staff to work continually under pressure, with loss of sleep and rest schedules.

Inspections of early Boeing 737 lap joints imposed considerable physical demands: first climbing scaffolding; then, carrying a bright light, making close inspections of about 1300 rivets along the upper fuselage. The inspections also required the use of safety ropes suspended from the hangar rafters. Examining the area around one rivet after another for signs of minute cracks under these circumstances was tedious to say the least – and even more difficult with aircraft skin covered by several layers of paint.

Corrosion control

When corrosion was detected, corrective action was frequently deferred, its significance to lap joint integrity and overall airworthiness unrecognised. The general condition of Aloha's fleet indicated on-going corrosion was accepted as a normal operating condition. Lack of structural understanding, high aircraft utilisation and the lack of spare aircraft, were all contributing factors.

The extent of skin repairs, and their effect on damage tolerance, was a further cause for concern. The accident aircraft had over two dozen fuselage repairs, the majority skin repairs using doubler patches. The cumulative effect could jeopardise the capacity of the structure to meet fail-safe or damage-tolerant standards.

Overall, the investigators found that Aloha's maintenance department did not possess sufficient manpower, technical knowledge, or the required organisation to ensure the continuing structural integrity of its aircraft.

Operational considerations

The startling extent of the inflight structural failure far exceeded anything for which the pilots could have been prepared. Even so, they brought the aircraft to a safe landing. Their coolness and professionalism in the face of such alarming odds spoke extremely well of their training and airmanship.

The one flight attendant who was not incapacitated also performed in a highly commendable manner in a frightening and unpredictable situation. Her action in moving about the critically damaged cabin to reassure terrified passengers and prepare them for the emergency landing was exemplary.

'The one flight attendant who was not incapacitated also performed in a highly commendable manner in a frightening and unpredictable situation.'

However, the investigators believed one aspect of the way in which the aircraft was handled was open to criticism. The pilots began a rapid descent shortly after the explosive decompression. Despite the enormous damage the 737 had sustained, the captain deployed the speed brakes and descended at between 280 and 290 knots without first checking the structural integrity of the aircraft. This certainly minimised the time during which the passengers suffered the effects of anoxia.

But it also increased the loads being imposed on the weakened structure, and exposed some unfortunate passengers to the fury of the unimaginable wind force. It also subjected the open break in the fuselage to extremely high dynamic pressure, potentially affecting the aircraft's slim margin of structural integrity. ■

Macarthur Job is an aviation writer and historian. Macarthur's services to aviation safety were recognised in November last year with his 'Lifetime Achievement' award at the 2007 National Aviation Press Club awards.

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:

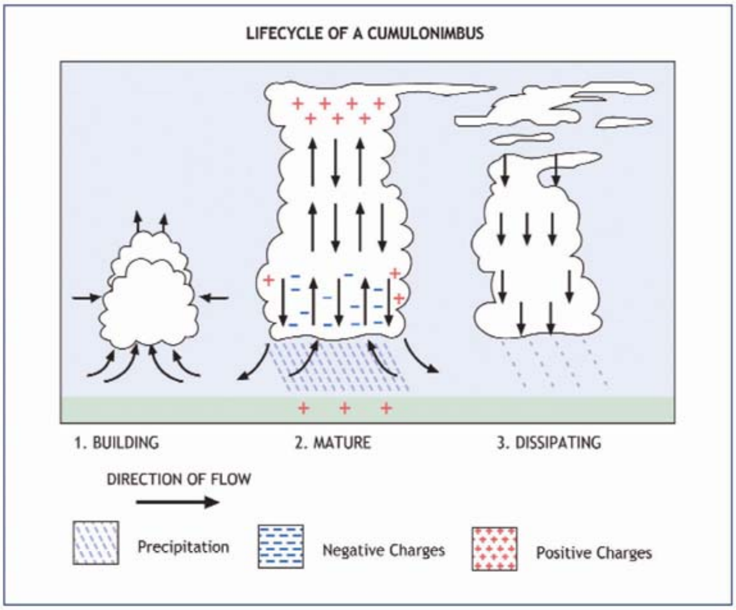
- On 5 May 2007, a Kenya Airways B737 departing Douala, Cameroon crashed shortly after take-off in a thunderstorm.
- On 16 September 2007, a One-Two-GO MD82 crashed at Phuket while attempting a go-around in heavy rain and strong crosswinds associated with a severe thunderstorm over the airport.

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



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

Hidden Cabin Fires Require Fast, Aggressive and Imporvised Response

Update recommendations by international authorities emphasize a mindset, priority-setting and methods that Cabin Crew requires if confirmed by signs of an in-flight fire – including invisible/inaccessible flames and smoke/odor from portable electronic devices.

Knowing that no two in-flight fires will be identical. Cabin crew must be prepared to discharge the first available fire extinguisher in the cabin without any hesitation.

If flames are not visible or the fire is relatively inaccessible, these general guidelines call for aggressively searching for the fire source, then discharging the fire-extinguishing agent onto the base of flames or smoldering material. These actions may required cabin crew to quickly locate hot spots (locations with abnormally high temperatures) by **feeling** along **cabin surfaces** with the **back** of the **hand**, to cautiously open storage compartments or doors, and to consider the possibility that openings may have to be punched or cut into floors, ceilings or sidewall panels.

Familiarity with the hidden areas where fire might occur on a specific aircraft type (Figure 1) enables cabin crew to accurately describe the emergency to crewmembers who are on the flight deck or in other areas of the cabin. For example, the cheek area of narrow-body aircraft and wide-body aircraft typically contains wire bundles, hydraulic lines and other electrical components. An overhead area typically contains components of the aircraft's entertainment system, wire bundles, control-surface cables, portions of the air conditioning system, the passenger emergency oxygen system and other systems.

"**Failure** or **uncommanded operation** of an aircraft component may indicate a developing **fire**." "Electrical connections and the components themselves may have been damaged by a fire in the area of the component or at any point along its power supply line. For this reason, cabin crewmembers should **report** all **failures of electrical items** to the cockpit crew. Circuit breaker(s) [CBs] tripping [activating], especially multiple [CBs] such as entertainment systems, coffee makers, etc. may be an indication of damage occurring in a hidden area common to the affected components.

"**Odor**... may be one of your **first indications** of an **impending fire. Never ignore** a strange odor; you need to identify its source as soon as possible. Smoke coming from vents or seams between interior panels, especially from the ceiling area, is a sure sign of a problem, and you should take immediate action to determine the source. Hot spots on the floor, sidewall, ceiling or other panels should be immediately investigated."

Awareness of known fire causes can help the cabin crew to respond. The following causes of hidden fires, which may be subtle compared with a readily visible fires, were cited:

- Wiring failures, electrical component failures and faulty circuit protection have occurred. "A majority of hidden in-flight fires are the result of electrical arcs along wire bundles,"
- Lightning strikes very infrequently have ignited an in-flight fire. "In these instances, faulty or contaminated insulation material contributed to the fire," and,
- High-temperature bleed-air leaks (i.e., in aircraft with environmental control systems that use air

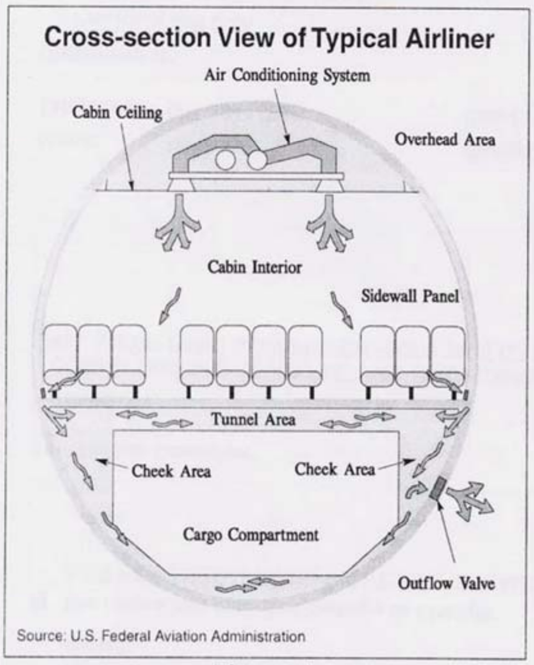


Figure 1

compressed by the engine) have caused in-flight fires and structural damage. "A failure of any of these [pneumatic] supply lines, if left unchecked, can cause high temperatures in the surrounding area and damage to the aircraft's equipment, wiring and associated components."

Resource fulness and persistence in accessing hidden areas within the aircraft can be essential to quickly extinguish an in-flight fire.

"A carbonated beverage may be used as a fire extinguisher by shaking up the can or bottle, opening the top and spraying the contents at the base of the fire.

"For example, a fire located behind a panel or within a cupboard area in the lavatory probably would not be successfully extinguished by discharging a fire extinguisher into die lavatory without first opening the cupboard or gaining access to the area behind the panel where the fire is located." "Depending on the volume of [an] overhead area, discharging a fire extinguisher randomly without attacking the base of the flames or smoldering material probably would have no effect on the fire."

Cutting or punching a hole in an aircraft cabin wall, ceiling or floor panel is appropriate if this is the only way to gain access to the fire.

"In this situation, the risk of damaging equipment behind the paneling and the possibility of creating a bigger problem must be weighed against the catastrophic potential of in-flight fires left unattended."

Improvised tools and methods to pull open, pry apart or otherwise separate sidewall panels to access a hidden fire could include the following:

- The manual-release, tool designed to open the overhead oxygen-mask compartments (if equipped);
- Galley equipment such as the handle of a casserole pan, ice tongs or metal cutlery;
- Walking canes and similar rigid items;
- Access points unique to an aircraft type or cabin configuration, such as cabin-ceiling speaker covers.

Ideally, consideration of resources will encompass unconventional fire fighting aids and fire-extinguishing methods.

"For example, non-alcoholic beverages such as coffee, soda, juice or water may be poured onto a fire." "A carbonated beverage may be used as a fire extinguisher by shaking up the can or bottle, opening the top and spraying the contents at the base of the fire. Additionally, wet blankets or pillows may be used as smothering devices to help extinguish a fire and prevent reignition." "If you suspect a fire in a lavatory, you should immediately notify another crewmember, get the closest fire extinguisher and check the door for heat." "Cautiously and slowly open the lavatory door. If the base of the flames or the source of the fire cannot be readily identified, do not discharge the agent with the intent of suffocating the smoke. This is not an effective way lo fight a fire and would only waste valuable extinguishing agent when the source or base of the fire is not accessible."

The crewmember who finds signs of fire — typically a cabin crew — can act as the firefighter. A second crewmember can act as the communicator, immediately notifying flight deck crewmembers and continually relaying the location, source and severity of the fire (e.g., that the fire is under control, spreading, contained or extinguished), the number of fire extinguishers discharged, smoke conditions and specific actions taken to extinguish the fire. "The communicator also makes announcements to inform and calm the passengers." Another crewmember can act as the runner, providing fire fighting support, such as obtaining supplies, relocating passengers, distributing towels for passengers to cover their noses and mouths to filter smoke, and removing oxygen bottles away from the fire area.

Courtesy FSF Publication

Unlocking the Potential of a Safety Management System (SMS)

SMS has been described informally as a structure of systems to identify, describe, communicate, control, eliminate and track risks. Some proponents also visualize an SMS as a "roof" or "umbrella" overarching the many existing safety programs of a typical airline.

The SMS also has been called "the first major effort to bring structure to safety programs in a standardized way" and a "course toward a degree of self-regulation."

SMS for airlines includes the following:

- "A safety policy on which the system is based;
- "A process for setting goals for the improvement of aviation safety and for measuring the attainment of those goals;
- "A process for identifying hazards to aviation safety and for evaluating and managing the associated risks;
- "A process for ensuring that personnel are trained and competent to perform their duties;
- "A process for the internal reporting and analyzing of hazards, incidents and accidents and for taking corrective actions to prevent their recurrence;
- "A document containing all SMS processes and a process for making personnel aware of their responsibilities with respect to them;
- "A process for conducting periodic reviews or audits of the SMS and reviews or audits for cause [i.e., for a specific reason] of the SMS; and,
- "Any additional requirements for the SMS that are prescribed under these regulations."
- "A safety management plan that includes the safety policy that the accountable executive has approved and communicated to all employees; the roles and responsibilities of personnel assigned duties under the quality assurance program …; performance goals and a means of measuring the attainment of those goals; a policy for the internal reporting of a hazard, an incident or an accident, including the conditions under which immunity from disciplinary action will be granted; and a review of the SMS to determine its effectiveness;
- "Procedures for reporting a hazard, an incident or an accident to the appropriate manager;
- "Procedures for the collection of data relating to hazards, incidents and accidents;
- "Procedures for analyzing data … during an audit … and for taking corrective actions;
- "An audit system …;
- "Training requirements for the operations manager, the maintenance manager and personnel assigned duties under the SMS; and,
- "Procedures for making progress reports to the accountable executive at intervals determined by the accountable executive and other reports as needed in urgent cases."

"The aim is to break down communication barriers between different areas of an organization and to establish links between such areas of responsibility as marketing, maintenance and operations to facilitate the recognition that a decision in any part has an impact on all other parts and may create an unintended safety hazard." "Currently, safety is the responsibility of a safety officer who reports to management but who is ultimately not responsible for safety performance. With the introduction of SMS, the focus will be at the systems level [where] inspectors will assess the effectiveness of an SMS within an organization.

Therefore, SMS adds a layer of safety. Some air operators have already begun implementing these systems and have had positive results."

Among these operators, Transport Canada cited Air Transat, which voluntarily initiated an SMS in 2002 and has shown economic benefits exceeding costs. Transport Canada said that the same results are expected for other airlines.

"SMS involves a [transfer] of some of the responsibility for safety issues from the regulator to the individual organization." The regulator oversees the effectiveness of the SMS and withdraws from a day-to-day involvement in the companies it regulates. The day-to-day issues are discovered, analyzed and corrected internally, with minimal intervention from Regulator."

The safety program comprises "an integrated set of regulations and activities aimed at improving safety." An SMS is defined as "a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures."

An implementation procedures guide provides a checklist for airlines to compare their existing overall management of safety programs to the required SMS elements. Moreover, the SMS assessment guide used by civil aviation delegated officers contains sample questions and SMS-scoring criteria.

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When the changes take effect, civil aviation authorities in contracting states would require aircraft operators (and the other types of aviation organizations) to implement a state-approved SMS. The standards require that the SMS:

- "Identifies actual and potential safety hazards;
- "Ensures that remedial action necessary to maintain an acceptable level of safety is implemented; and,
- "Provides for continuous monitoring and regular assessment of the safety level achieved."

Moreover, the standards require that "an approved SMS shall clearly define lines of safety accountability throughout the operator's organization, including a direct accountability for safety on the part of senior management."

In the draft manual, ICAO said that integrated application of an SMS — embedding proactive safety processes throughout airline management — represents the best overall method of improving existing countermeasures against unsafe acts or conditions.

SMS for airlines complements a broader strategy in which all contracting states must focus in an aggressive and coordinated manner on eliminating "systemic deficiencies" in the global air transport system.

ICAO believes that airlines can experience benefits from an SMS comparable to the benefits experienced by Air Transat, which had a 72 percent decrease in irregular operating costs (saving more than US$1 million per month, compared with the period prior to SMS implementation), while improving employee morale, reducing incidents and increasing overall awareness of operations.
The framework for implementing an SMS involves the following conceptual shifts:

- From prescriptive regulations to performance based regulations;
- From highly specialized and technically trained inspectors with significant resource requirements to system auditors and analysts who focus on areas of greatest risk; and,
- From an aviation industry that responds to regulatory requirements to an industry that becomes a partner in safety with civil aviation authorities.

Under conventional reactive strategies for preventing accidents, "constant catching up is required to match human inventiveness for new types of errors."

"Traditionally, safety has been about avoiding costs. Current thinking and research show that safety, efficiency and productivity are positively linked. … An SMS involves constant and aggressive seeking of risk information through hazard/incident reporting systems for identifying latent unsafe conditions, safety surveys to elicit feedback from front-line personnel, flight data analysis for identifying operational exceedances and confirming normal operating procedures, [and] operational inspections and operational audits to identify vulnerable areas.

In summary, the proposed SARPs for ICAO Annex 6 are expected to influence how civil aviation authorities practice safety-risk management and how the implementation of an SMS by the accountable executive of an airline builds unprecedented synergy from current and future safety efforts. Meanwhile, the rapidly expanding literature of civil aviation authorities and safety specialists in several countries provides a clearer picture of the future for airlines that have an SMS and examples of SMS implementation that airline senior managers can compare with their oversight of companywide risk-management activities.

Courtesy FSF Publication

Investigation briefs

Rejected takeoff

At 1350 EST on 19 March 2006, an Airbus A330-303 aircraft, registered VH-QPB, commenced takeoff, on runway 19 at Brisbane Airport, Qld, on a scheduled passenger service to Singapore. The pilot in command (PIC) was the pilot not flying (PNF) and the copilot was the pilot flying (PF) for the sector. Visual meteorological conditions prevailed at Brisbane.

During the take-off roll, the flight crew noticed a significant discrepancy between the PF and PNF's airspeed indications. In particular, the PNFs airspeed indication was 70 kts while the PFs airspeed indication was 110 kts. In response, the PIC assumed control of the aircraft and rejected the takeoff. During the rejected takeoff (RTO), the PIC was satisfied that sufficient runway length remained for the application of a more gradual braking rate. The PIC initially attempted to manually disconnect the autobrakes via brake pedal deflection but that attempt was not successful. The PIC then elected to press the autobrake 'Max-push button selector switch' (P/BSW) to disconnect the autobrakes. By that time, the aircraft's speed had reduced to approximately 20 kts. The time interval between the RTO and the deactivation of the autobrake was about 20 seconds.

Shortly after vacating the runway, the flight crew noted increased brake temperatures and selected the brake cooling fans ON. During the taxi, the brake temperatures continued to rise and become excessive. The fusible plugs on six of the eight main landing gear wheels melted and the respective tyres deflated. There were no injuries to the crew or passengers.

A post-flight engineering inspection of the aircraft found what appeared to be wasp-related debris in the PIC's pitot probe and the operator determined that the contamination was a probable contributory factor in the incident.

The operator and airport owner undertook a number of safety actions to minimize the risk of future wasp activity at Brisbane Airport.

A promising drive towards resilience

It was mid 2005, when pursuing enhanced passenger care and IOSA compliance; PIA started reviewing its spring back mechanism to the disastrous accidents. At that point of time, though various departmental procedures and checklists were there to fill the gap, a coordinated sort of response to the major accidents was almost non-existent. In view of the sensitivity of the matter, and considering the facts that an organized response is inevitable in negating the negative aspects of a disastrous accident; Management formulated a committee of three Sr. Vice Presidents to study the subject in detail and devise an appropriate course of actions. This was also the reflection of the airline's commitment to timely humanitarian assistance to the victims and their families facing an aircraft accident. Furthermore, ERP is an emerging discipline in the airlines and as of today is not a matter of choice but an IATA / IOSA Requirement. Airline reputation could be at stake with grave repercussions and astronomical financial damages in the absence of an effective ERP. That's why ERP is said to be the Insurance Plan.

Sensibly availing an IATA Scholarship, one officer was also sent to its Geneva Center for attending Airline Emergency Planning & Response Management (AEP&RM) Course. The course was qualified by PIA Man with Distinction. Afterwards, deliberations of the team led to the Issuance of an Interim Emergency Response Plan, Selection of Simulator Building as the place for establishing the Emergency Response Centre (ERC) and formation of ERC and Field Teams. Awareness programs and training sessions were launched for the team members at Head Office and Stations.

Emergency Response Manual is considered to be the basic document that drives a coordinated response to the eventualities. Writing a manual was the first uphill task of the series. This was strategized in a manner where Coordinators from core departments were distributed with the IATA Guidance Material and Checklists for reviewing and tailoring to fit onto PIA needs. Help of Flight Operations Department was sought to utilize one of their Flight Engineers to work with the team for compiling the manual. Thorough deliberations and a series of meetings were made with the departments and ultimately a 400^{+} page document was

Particpants of an ERP Station Coordinators Course

ERP Volunteers reconciling the Passenger Data during an Exercise

brought up as first ever comprehensive Emergency Response Manual of National Flag Carrier. It contained guidelines on handling various emergencies and checklists distributed in chapters and sections. The manual has also been placed on PIA Intranet. By then it is being regularly updated and amended to the needs of the day.

Station Emergency Plans are an extension of Emergency Response Manual and are prepared in line with the specific needs of the individual stations. Such plans have been prepared as per the feed-back of various stations with the exception of a few, where such a plan is being finalized. These plans are also available on PIA Intranet.

Emergency Response Centre (ERC) is a nerve centre where all required key executives of the airlines are assembled immediately after an accident and start supporting the accident station from the base. Field Team also reports here and is dispatched to the site in Go Aircraft within three hours of the information. An Interim ERC has been established in the Simulator Building where an operations room, media response room and out bond call centre have been housed. This centre has been equipped with direct communication lines, base station with talkies, computers, four television sets with recording facility, display boards etc.

A state of the art ERC has been planned on the first floor of Corporate Safety & Quality Assurance Building and the construction is about to start.

Kit Items are required to be provided to the Field Team members and a quantity of recommended items has been procured. These include Personal Protective Equipment, Torches, Generators, Stationery, Investigation Assistance Items, Still & Video Cameras, 5 Thuraya Satellite Phones, 50 Cell Phones etc.

Train the Trainers was another important activity in ensuring the effective execution of the written procedures. Beside the IATA AEP&RM Course as mentioned above, PIA called learned trainers from abroad and got a good number of its team in Emergency Response and Humanitarian & Family Assistance. These included renowned professionals like George Galliker of Aviation Safety Consultants (ASC) Canada, Sandra Swords Wilby of Emirates and Dr. Gisella Kellinger of Psychotrauma Institute Switzerland. In addition PIA Tem Members from ERP & Information Technology conducted study visits to Crisis Management Centres of Emirates, Etihad and Qatar Airways, Blake Emergency Services UK and SOS UK. Attending International Events Like IATA ERP Working Group Meetings, Emirates Incident Command Course and Call Centre Exercise and Avian Influenza Workshop further built the capacity of PIA ERP Team.

Induction of Family Assistance & Support Team (FAST) Volunteers is another important segment of overall Emergency Response Plan of an airline. PIA took this activity very seriously and


ERP Volunteers reconciling the Passenger Data during an Exercise

in the light of IOSA Guidelines and Best Industry Practices a good number of Volunteers have been enrolled from all the departments of the airline. These highly motivated personnel have been trained in mainly Family Assistance & Humanitarian Support Tasks. Besides managing ERC activities and rendering first aid to injured and rescuing the trapped ones are their other areas of exposure.

Training the Team Members & Volunteers is one of the major activities undertaken by the ERP Team Members. Awareness courses were started right from the beginning of the project in 2005 and the training figure is touching 4000 participants by now. Courses yet conducted include the sessions for Sr. Executives, District & Station Managers, ERC & Field Team Members, Station Coordinators, Public Health Emergency Team Members, Rescue Team Members, Emergency Call Centre Team Members etc. Besides domestic stations, Dubai, Saudi Arabia, and UK have been covered by now.

ERP Volunteers Filling-in the Passenger Record Cards during an Exercise

Exercises help in indoctrinating confidence and testing gained knowledge by the individuals. In the first phase a good number of teaching exercises wherein errors are corrected on the spot have been conducted. Taking advantage of the full scale commotion, at some stations PIA Emergency Exercise was dovetailed with CAA Airport Emergency Exercises. After covering all major domestic stations the activity has been started at international stations and considering the operational importance, Manchester was the first of the series where a Table Top Exercise of the Station Team was conducted in August 2008. Snap Exercises have also been conducted during the course.

Fokker Accident of July 2006 was a real test of the airlines' capabilities to encounter a major emergency. Development of ERC Facilities, Manual, Procedures, Training and Exercises proved to have worked effectively towards enhancing the awareness at management and employees level and led to an organized response to this tragic event. Various teams such as ERC Team, Go Team and Family Assistance Team came into action within the prescribed time limits at three stations viz Karachi, Lahore & Faisalabad. Media Communication was effective and families of the victims were flown to the accident station from various parts of the world and were appropriately assisted in meeting the tragedy.

ERP Volunteers augmenting the rescue effors during an Exercise

Mutual Support and Emergency Call Centre Agreements have also been signed with the Emirates Airlines and as per these agreements PIA Teams will be available to Emirates in case their aircraft faces a major accident in Pakistan and similarly Emirates Team will be available to PIA in case of an emergency in UAE or Muscat. Emirates Emergency Call Centre has got the capabilities of handling thousands of calls from the victim families and will be available to PIA at the hour of need.

Support Agreements with Blake Emergency Services UK has also been done by the PIA and as per agreement Blake will be providing professional assistance and technical support in case of a major emergency in different parts of the world and particularly in the west.

Incident Management Software/Application greatly helps in effective handling of the situation. This includes Automated Emergency Callout, Team Data & Roster Management, Victim Condition and Family Members Call Record and merger of both these information for automated call back list etc. While the project to have an appropriate Incident Management Software / Application is being accomplished with the help of PIA Information Technology Department some basics have been achieved in the shape of automated Emergency Notification through SMS and under finalization Passenger Record Cards and Passenger Information Forms. Substantial progress in this vital area is expected in next few months.

Some of the Field Team Kit Items on display during a training session

Leaflets, Banners and Booklets work nice in keeping the people aware of their role in different situations. A good number of leaflets and banners have been prepared accordingly for team members in English & Urdu. Furthermore, a comprehensive booklet on Emergency Response is under printing and will soon be available to team members and volunteers.

Dedicated PIA ERP Team is working with zeal and zest and keeps on updating the procedures, checklists and contact details with the help of different PIA Departments and Stations. These motivated personnel are professionally conducting training courses for various team members and efficiently interacting with the Volunteers to keep the airlines' preparedness in meeting emergencies to an effective level. Besides commendations from the IOSA Auditors, Management has also appropriately rewarded them for their untiring efforts. Renowned members of International ERP Community have given wonderful comments on the quality and pace of PIA progress into this discipline. The team is poised to work hard for continuously improving the PIA Emergency Response Plan.

Dry *and* High

Dehydration causes an insidious degradation of pilot performance that must not be lighty regraded.

BY LINDA WERFELMAN

Excessive loss of water from the human body can lead to dehydration, marked by fatigue and a deterioration of mental and physical performance that can have serious consequences for pilots.

Pilots with health problems, including intestinal viruses or food poisoning, and pilots of small airplanes and helicopters without air conditioning and/or with large, heat-intensifying windshields — especially those operating on hot days — may be most susceptible to the ill effect of dehydration. However, pilots of air carrier aircraft are not immune.

For example, the first officer of a Boeing 737-700 said, in a report submitted to the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS), that she had become ill in July 2004 during a flight from Nashville, Tennes.

In her report, the first officer said that the night before the flight, she had been sick with nausea, vomiting and diarrhea, which she assumed to be associated with food poisoning, but that she felt "physically fit to fly" when she reported for duty. During cruise, she experienced repeated bouts of nausea and complied with the captains eventual instructions to leave the cockpit to rest in the cabin while he diverted the airplane to an en route airport for landing. Emergency medical services personnel met the airplane, examined the first officer and determined that her nausea was not a sign of serious illness and her lingering weakness was caused by dehydration.

Dehydration occurs when water consumption is inadequate or when the human body loses an excessive amount of water — through heavy perspiration, exposure to hot weather, fever, vomiting or diarrhea, use of diuretics to increase urine excretion, and some diseases. The low humidity in pressurized air carrier aircraft also is a contributing factor. In addition, alcoholic beverages such as those consumed a day before a flight — and caffeine have diuretic effects.

Water accounts for about two-thirds of body weight and is an essential component of the human body, needed for replicating cells, moving nutrients and waste products, and regulating body temperature. The kidneys excrete between 1.0 pt (0.5 L) and several gallons (1.0 gal equals 3.8 L) daily — a typical amount is 3.0 to 4.0 pt (1.4 to 1.9 L); in addition, varying amounts of water are lost to perspiration.

To stay healthy, an individual must consume enough water to offset these losses. For years, typical recommendations have called for drinking 2.0 qt (1.9 L) of water daily, although some medical specialists question the rationale for that recommendation (see "Recommendations for Preventing Dehydration").

An editorial in the April 2008 *Journal of the American Society of Nephrology* said that the origin of the recommendation is unknown but that different studies have made a variety of claims about the supposed benefits of drinking water, ranging from improving kidney function and aiding weight loss to preventing headache.

"There is no clear evidence of benefit from drinking increased amounts of water," the editorial said. "We concede there is also no clear evidence of lack of benefit. In fact, there is simply a lack of evidence in general."

Nevertheless, aeromedical specialists say that failing to drink an adequate amount of water can result in an increased susceptibility to fatigue.

For example, the U.S. National Transportation Safety Board (NTSB) discussed dehydration and fatigue in its final report on the crash of a Bell 206B during a sightseeing flight on the Hawaiian island of Kauai on Sept. 24, 2004. The pilot and all four passengers were killed in the crash, which also destroyed the helicopter. The NTSB report said that the operator's schedule included no breaks for pilots, who typically ate lunch in their helicopters and remained at the controls for up to eight hours, and that the staging area had no restroom facilities.

"The lack of scheduled breaks, the short turn-around times between flights and the unavailability of private restroom facilities probably discouraged consumption of food and liquids during the workday because there was little opportunity to go to the bathroom," the report said. "This increased the risk of dehydration and other physiological problems, which could have degraded performance."

As a result of its investigation, the NTSB issued nine safety recommendations, including two involving development and enforcement of operational practices to provide for rest breaks for the pilots of sightseeing helicopters.

Quay Snyder, president and CEO of Virtual Flight Surgeons, an aeromedical consult-ing group, said that dehydration is "a definite contributing factor" not only to fatigue but also to the formation of kidney stones — stonelike masses that form in the urinary tract and can cause severe pain. Medical specialists attribute their formation to a concentration of mineral salts in the urine or to the absence from the urine of substances that inhibit formation of the stones.

Although smaller kidney stones may be asymptomatic, larger ones can cause abdominal pain, nausea and vomiting, fever and blood in the urine. Recurrent kidney stones can result in loss of medical certification.

Formation of kidney stones generally can be prevented simply by drinking enough water, Snyder said.

Recommendations for Preventing Dehydration

The following are recommendations for preventing dehydration and other heat-related problems:

- Drink about 2.0 qt (1.9 L) of water every 24 hours, although the exact amount varies widely. Drink before you become thirsty, and drink from a container that allows you to measure daily water consumption;
- Limit consumption of alcohol and caffeine. Both are diuretics, which increase the excretion of urine;
- Monitor work and recreational activities, and stop what you are doing if you feel light-headed or dizzy. Exercise can result in water loss that is difficult to overcome quickly;
- Be aware of your physical condition, especially if you have recently been ill; and,
- Remember that your body's adjustment to a major change in weather, such as the sudden onset of hot weather, can take one to two weeks.

--LW

He said that some flight crewmembers might have intentionally reduced their fluid intake since the terrorist attacks of Sept. II, 2001 — and the subsequent adoption of an elaborate set of requirements for pilots who leave the flight deck, even for a visit to a lavatory.

"It's a bad idea for health reasons," Snyder said, noting "at least a perception" that more pilots have been calling his office about kidney stones in recent years than in the period before September 2001. "But its perhaps a convenient idea for the flight crew."

Snyder and other aeromedical specialists recommend that pilots drink fluids — but not caffeinated fluids — "on a regular basis" throughout their flights. Although some specify a precise amount of liquid that should be consumed, Snyder does not. Instead, he says that it should be enough to keep their urineclear and light in color. Sometimes the amount may be less than 2 qt; other times it may be more.

"I believe in what 1m saying," Snyder said. "As a glider pilot, I consume 170 to 200 oz [5 to 6 L]."

Similar quantities are not necessary for air carrier pilots, who do not operate in the hot, sunny environments typical of gliders, he said.

Similar advice comes from Rogers V. Shaw III, team coordinator of the Airman Education Program of the U.S. Federal Aviation Administration Civil Aerospace Medical Institute Aerospace Medical Education Division, who said that a primary consideration is for pilots to continually be aware of their physical condition.

"Most folks will become thirsty with a 1.5-quart [1.4-liter] deficit, or a loss of 2 percent of total body weight," Shaw said. "This level of dehydration triggers the thirst mechanism. The problem, though, is that the thirst mechanism arrives too late and is turned off too easily. A small amount of fluid in the mouth will turn this mechanism off, and the replacement of needed body fluid [will be] delayed."

Medical authorities say that symptoms ac-cumulate as the body continues to lose water (Table 1). After a deficit of about 3.0 qt (2.8 L), symptoms may include fatigue, nausea and emotional instability.

Transport Canada (TC) calls this "a very dangerous level for pilots, as this is where your faculties start to become affected, but you may not be aware of the deteriorated performance."

One TC publication described experiments involving U.S. Army helicopter pilots and said that the pilots' self-reporting of problems related to dehydration was inaccurate, even at the early stages of dehydration, and pilots who felt no adverse effects had "clear, objective difficulty with cognitive tests."

A 4.0-qt (3.8-L) deficit can result in clumsiness, headache and elevated temperature. After loss of a little more than 12.7 qt (12.0 L), death is imminent.

Water vs. Sports Drinks

Under normal circumstances, medical authorities suggest that water is usually the best drink for a pilot to consume, although there is a place for rehydration drinks, including so-called sports drinks, that have been formulated not only to replenish lost fluids but also to restore the proper concentration of electrolytes — dissolved minerals such as sodium and potassium — in the blood. The electrolytes are electrically charged molecules that are key to many essential bodily functions.

"I don't believe there is any harm in sports drinks, et cetera, as long as individuals don't drink excessive quantities, but they are of little additional benefit for a pilot who has a normal, balanced diet," said Dr. Anthony Evans, chief of the International Civil Aviation Organization Aviation Medicine Section.

Rehydration drinks maybe required if pilots undergo significant or prolonged heat stress, he said.

Heat-Related Illnesses

In some situations, such as prolonged exposure to very hot temperatures in a cockpit that is not air conditioned, dehydration can progress to a heat-related illness, such as heat cramps —characterized by muscle cramps, profuse sweating, fatigue and thirst. Treatment typically includes drinking a sports drink or other fluid containing electrolytes and moving to a cooler spot.

Without such treatment, heat cramps can develop into heat exhaustion, with symptoms including headache, dizziness, nausea and dark urine. Without treatment — again, drinking a fluid containing electrolytes and moving to a cooler spot — the result can be heatstroke, a life-threatening condition in which the body temperature climbs to 104 degrees F (40 degrees C) or higher. Heatstroke can lead to shock or organ damage.

Treatment for heatstroke is more aggressive than treatment for less serious forms of heat-related illness and may include immersion in cold water or wrapping the victim in a cooling blanket and placing ice packs at the neck and other areas of the body. The goal is to quickly reduce the body temperature to normal in order to limit damage to the brain and other vital organs.

Symptoms Dehydration

Amount of Water Lost	Symptoms
1.5 L (1.6 qt)	Thirst
3.0 L (3.2 qt)	Sluggishness, fatigue, nausea, emotional instability
4.0 L (4.2 qt)	Clumsiness, headache, elevated body temperature, elevated pulse, elevated respiratory rate
5.0 L (5.3 qt)	Dizziness, slurred speech, weakness, confusion
6.0 L (6.3 qt)	Delirium, swollen tongue, circulatory problems, decreased blood volume, kidney failure
9.0 L (9.5 qt)	Inability to swallow, painful urination, cracked skin
12.0 L (12.7 qt)	Imminent death

Source: Maldment, Graeme. "Chapter 15: Thermal Physiology." In Aviation Medicine, Third Edition, edited by Ernst

HUMOR

P = The problem logged by the pilot.
S = The solution logged by the mechanic.

P: Left inside main tire almost needs replacement.
S: Almost replaced left inside main tire.

P: Test flight OK, except auto-land very rough.
S: Auto-land not installed on this aircraft.

P: No. 2 propeller seeping prop fluid.
S: No. 2 propeller seepage normal. Nos. 1, 3 and 4 propellers lack normal seepage.

P: Something loose in cockpit.
S: Something tightened in cockpit.

P: Dead bugs on windshield.
S: Live bugs on backorder.

P: Autopilot in "altitude-hold" mode produces a 200-fpm descent.
S: Cannot reproduce problem on ground.

P: Evidence of leak on right main landing gear.
S: Evidence removed.

P: DME volume unbelievably loud.
S: DME volume set to more believable level.

P: Friction locks cause throttle levers to stick.
S: That's what they're there for!

P: Transponder inoperative.
S: Transponder always inoperative in OFF mode.

P: The T/C ball seemed stuck in the middle during my last turn.
S: Congratulations! You've just made your first coordinated turn.

P: Suspected crack in windscreen.
S: Suspect you're right.

P: Number 3 engine missing.
S: Engine found on right wing after brief search.

P: Aircraft handles funny.
S: Aircraft warned to straighten up, fly right, and be serious.

P: Radar hums.
S: Reprogrammed radar with words.

P: Mouse in cockpit.
S: Cat installed.

P: Radio switches stick
S: Peanut butter no longer served to flight crew

P: Screaming sound in cabin at start-up
S: Company accountant deplaned

P: Funny smell in cockpit
S: Pilot told to change cologne

P: Aircraft 2,400 lbs over max weight
S: Aircraft put on diet of 92 octane

P: #3 engine knocks at idle
S: #3 engine let in for a few beers

P: #3 engine runs like it's sick
S: #3 engine diagnosed with hangover

P: Brakes howl on application
S: Don't step on 'em so hard!

P: Radio sounds like a squealing pig
S: Removed pig from radio. BBQ behind hangar tomorrow

P: Whole aircraft smells like BBQ
S: Ground Checks OK

P: First class cabin floor has a squeak
S: Co-pilot told not to play with toddler toys in cabin anymore

P: Electrical governor is broke
S: Paid off governor's debt to Jimmy "The Fish" Galvano

A not-so-innocent bump on the head

BY DR DAVID FITZGERALD

Getting a bump on the head is not an uncommon occurrence for pilots. Wing struts, propellers, pitot tubes, hangar doors etc, are culprits which seem to jump out at you when you are not looking. Luckily enough, apart from causing an outburst of certain four-letter words and some localised pain on the noggin, most bumps on the head go without significant disability.

However, this is not always the case. More severe head injuries can result in significant ongoing health risks and impairment. Of particular concern for flying is the potential for significant cognitive impairment, and the high risk of post-traumatic epilepsy.

There is strong evidence that the risk of post-traumatic epilepsy (PTE) after head injury is significant, and the risk lasts up to even 20 years post injury . Post traumatic seizures are thought to be due to damage to the brain, generated both from the physical damage itself, as well as iron deposition from blood following injury. Unfortunately, blood released into the brain substance after head injury can remain there and cause problems for a long time.

The good news is that while the risk may be prolonged, it drops – approximately 80 per cent of individuals with PTE will have their first seizure within the first 12 months post injury, and more than 90 per cent by the end of the second year. It is CASA practice that aircrew have a period of grounding of at least two to five years after significant head injury.

The bad news is that 15–20 per cent of patients may still be at risk of having their first seizure after two years post injury. The incidence of seizures increases significantly for penetrating brain injuries; for injuries leading to blood in the brain substance (e.g. brain contusions

and subdural haematomas); for prolonged amnesia post injury; for injuries requiring surgical intervention; and in cases of depressed skull fracture. Injuries with these findings are likely to be associated with a longer period of medical certificate suspension.

A review of CASA's aviation medicine database reveals a total of 120 head injuries. Of these, 61 were minor, or some time in the past, and were given a pass assessment. Twenty-six individuals were failed.

Thirty-three required a delay in their certification, until the risk of seizure had reduced; and of these, 23 eventually returned to flying. Some did not return for recertification.

Head injury remains a significant cause for failing or cancellation of a medical certificate, particularly in young, otherwise healthy, pilots.

Statistics show that the incidence of PTE is highest among young adults, as they are more prone to head injury. Alcohol-related falls, assaults and motor vehicle accidents are common causes in this group, and the results can be devastating for a career in aviation.

For any head injury which is more than a simple uncomplicated bump on the head, CASA requires certificate holders to cease exercising the privileges of their licence and be reviewed by their DAME, particularly if:

- any hospital observation is required
- there is any associated amnesia
- there is more than momentary loss of consciousness
- there are any abnormalities shown on CT or MRI scans
- there are any ongoing symptoms, such as headache or confusion.

CASA uses a case-by-case approach. However, for more severe injuries a minimum grounding of two to five years would be the norm.

Head injury is a common preventable cause for loss of licence, particularly in young certificate holders. Prevention is the best way to avoid losing your licence.

Head injury is related to:

- motor vehicle accidents – buckle up! And wear your helmet on your motorcycle. Leave travelling at 200 kt for the air!
- assaults and falls, particularly those related to alcohol. Moderate your alcohol intake when out and about, and leave the car at home if you're drinking.
- sports – don't go in head first!
- work hazards – observe occupational health and safety practices; stop and think!

If you use your brain first, you'll continue to be able to use it to fly! ▪

– Dr David Fitzgerald is a medical officer with CASA.

Brain injury case studies

Case study 1

A 33-year-old private pilot was struck by a car. At the scene, he was found to be poorly responsive to the ambulance officers, and had multiple orthopaedic injuries.

In hospital he was found to have brain contusions in his right temporal lobe, left frontal and parietal lobes and cerebellum; an extradural haematoma, and an extensive skull fracture. He underwent neurosurgery and extensive rehabilitation, during which he demonstrated ongoing periods of confusion and delusions.

He also became depressed and was started on antidepressants. Neuropsychological testing revealed severe cognitive deficits.

Four years later he went to his DAME for his aviation medical. He still had difficulties with speed of psychomotor performance, poor visual attention and tracking, poor mental flexibility and significant impairment in his memory and problem-solving abilities. Given his severe head injuries, his neurologist noted the risk of a post-traumatic seizure was still very high, even though he had been seizure-free for four years. Given his cognitive problems, a lot of which would impair him significantly in flying, and his seizure risk, CASA denied his application for a medical certificate.

Case study 2

A 21-year-old, Class 1 certificate holder was assaulted on his way home. He was kicked in the head and fell to the ground. His eyes rolled back and he suffered urinary incontinence. He was taken to hospital, but elected not to wait in the emergency department. For the next three days he had a slight headache and felt unsteady. He saw his GP who ordered a CT (computerised axial tomography) scan, which showed a haemorrhage in his right frontal lobe.

He saw his DAME some six months later. An MRI (magnetic resonance imaging) scan one year post-incident continued to show areas of blood from the injury. On the basis of the retained blood on the scan, his neurologist assessed his ongoing risk of post-traumatic seizure as high, and advised him not to continue to pursue his aviation training. CASA subsequently cancelled his medical certificates. ▪

Final ATSB inestigation report on Boeing 737-476 in-flight engine malfunction

On 25 August 2005, while on a scheduled flight from Brisbane, Qld, to Sydney, NSW, a Boeing 737-476 aircraft, registration VH-TJX, experienced an in-flight engine malfunction approximately 6 km SSE of Sydney Airport.

While on approach to runway 34R with the landing gear extended, the flight crew heard unusual 'popping' noises from the left side of the aircraft. The crew initially suspected a defect with the landing gear and commenced a missed approach.

When both engine power levers were advanced, the left engine did not respond. The pilot-in-command (PIC) then reduced the left engine power to idle, retracted the landing gear and climbed the aircraft to approximately 2,000 ft. The crew advised air traffic control of a possible engine problem.

The PIC advised the copilot to leave the left engine at idle and that a single engine landing would be conducted. The appropriate one-engine inoperative checklists were referenced and the aircraft was prepared for landing. At 07:37 EST a single-engine approach and landing on Sydney runway 34R was completed.

Upon landing, Aviation Rescue and Fire Fighting (ARFF) personnel performed an external visual inspection of the left engine area and advised the crew that there were no signs of a fire. The aircraft taxied to the gate without further incident. There were no injuries.

An inspection of the left engine by the operator's engineering personnel revealed damage within the high pressure compressor (HPC). The left engine, a General Electric CFM56-3C1, was subsequently removed and disassembled at the operator's maintenance facility. The teardown revealed that a single dowel pin had come loose from its installed position within stage-three of the HPC and was ingested by the downstream rotating hardware, resulting in damage to the HPC rotor and stator components.

Further examination of the HPC stator components revealed that the dowel pin had come loose due to excessive clearance and recession of the stage-three stator shroud anti-rotation pins.

As a result of this occurrence, the engine manufacturer, General Electric, initiated a number of safety actions that included a redesign of the HPC anti-rotation pin. The manufacturer also released an alert Service Bulletin CFM56-3 S/B 72-1091 to all operators and maintainers of CFM56-3 engines that recommended the introduction of the new pin design into existing engines.

Safety issue

The manufacturer's engine shop manual contained no guidance or instruction to engine maintenance personnel of CFM56-3 engines to dimensionally inspect stator shroud anti-rotation pins from new or during reinstallation of the pins from overhaul.

Action taken by General Electric

As a result of this occurrence, the engine manufacturer, General Electric, advised that they had taken a number of safety actions. In regard to the CFM56-3C1 engine fitted to the Boeing 737 fleet, the manufacturer:

consulted with the supplier of the CFM56-3 stator shrouds to determine whether a quality problem existed during the stator shroud manufacturing process

added an inspection requirement to the current CFM56-3 engine shop manual to verify the stator shroud anti-rotation pin height during piece part inspection

modified the engine shop manual to include a stator shroud anti-rotation pin height check whenever a new pin was reinstalled into a stator shroud that was being returned to service from overhaul

redesigned the anti-rotation pin and field released the new part into the CFM56-3 fleet in July 2007

released a service bulletin (CFM56-3 S/B 72-1091) in December 2007 to all operators and maintenance personnel of CFM56-3 engines to alert that the stator shroud anti-rotation pin design had changed, and recommended that the old design pins be replaced with the redesigned part into existing engines.

Response to In-flight Dangerous-goods Incidents

The cabin crew must be prepared for accident/incident in which prohibited items brought into the cabin create risks of injury or damage that could compromise the safety of any flight.

ICAO defines dangerous goods as "articles or substances which are capable of posing a risk to health, safety, property or the environment.

"The first indication of a potential [dangerous-goods] incident could be a passenger becoming concerned about an item in their cabin baggage which is leaking or giving off fumes (this can happen because of the reduced pressure); or a passenger seen using an item which is not permitted in the cabin."

The Emergency Response Guidance was designed for in-flight dangerous-goods accident/incidents – not those that occur while the aircraft is on the ground – on the assumption that aircraft rescue and fire fighting personnel and/or other hazmat specialists typically would respond on the ground.

"One of the biggest problems faced by operators is passengers who take, or try to take, on an aircraft items of dangerous goods to which they are not entitled." There is the potential for an incident to occur in flight, with disastrous results; and there have been such events in the past. The primary consideration in any [dangerous-goods] incident should be to preserve the ability of the crew to fly the aircraft. The other considerations are: to safeguard all other persons on board from the effects of any fumes or liquid from leaking packages of dangerous goods; to protect the aircraft structure as far as possible from damage; and to control the potential for the dangerous goods to cause any further harmful effect."

Techniques for Using Polyethylene Bags, Gloves Protect Hands

- "[Obtain portable breathing equipment, eye protection and oven gloves or fire-resistant gloves [from the cockpit] at least two large polyethylene waste-bin bags; and, at least three smaller polyethylene bags, such as those used for duty-

free [sales] or bar sales or, if none [are] available, airsickness bags;

- "Pick up the item [with gloves covered by small polyethylene bags] and place it in a polyethylene bag. Ensure [that] the receptacle containing the dangerous goods is kept upright or the area of leakage is at the top;
- "Using paper towels, newspaper, etc., [as appropriate for the substance to] mop up the spillage… Place the soiled towels, etc. in another polyethylene bag;
- "Place the gloves and bags used to protect the hands either in a separate small polyethylene bag or with the soiled [paper] towels;
- "If extra bags are not available, place the [paper] towels, gloves etc. in the same bag as the [dangerous goods] item; [and,]
- "Expel excess air from the bags and close [them tightly so as to be secure but not so tight that pressure equalization cannot take place."

Basic Principles Apply to Dangerous-goods

The International Civil Aviation Organization has recommended the following guiding principles for a cabin crew responding to a suspected in-flight dangerous-goods incident:

- Notify the captain, coordinate actions with the flight crew and keep the flight crew informed about cabin crew intentions and results of actions taken;
- Identify the specific dangerous-goods item involved and ensure that the captain has complete and accurate facts;
- Fight any fire that occurs using standard procedures;
- Assess potential consequences, such as a hazardous chemical reaction, before applying water to a spilled dangerous-goods item or if fumes are present;
- Relocate passengers away from the affected area;
- Don portable breathing equipment when fumes are present and protect the face with a smoke hood or gas-tight smoke mask;
- Cover the hands with fire-resistant gloves/oven mitts (covered by a polyethylene bag if the gloves/mitts otherwise would absorb liquid);
- Provide wet towels or cloths to passengers with instructions on how to cover the nose and mouth to breathe filtered air;
- Do not provide therapeutic oxygen or activate drop-down oxygen-mask systems because contaminated air would be breathed with the low flow of oxygen;
- If appropriate under the circumstances, place the dangerous-goods item in polyethylene bags and securely stow the polyethylene bags in a location selected for safety (such as the farthest lavatory from the flight deck). If bags are not available use airsickness bags;
- Handle seat cushions and seat covers that have been in contact with the dangerous-goods substance with the same precautions as when handling the dangerous goods;
- Use polyethylene bags, other plastic bags and blankets to cover the carpet/floor where a dangerous-goods substance leaked or spilled;
- Before landing, check regularly the status of the stowed dangerous-goods item and aircraft furnishings that were contaminated;
- After landing, notify responding ground personnel about the dangerous-goods item, all known facts about the item and where the item was stowed; and
- Ensure that details about the dangerous-goods incident are entered in the aircraft-maintenance log for aircraft maintenance required because of the dangerous-good incident.