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STICKERS
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BUSINESS CARDS!
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INVITATIONS!
ORDER OF SERVICE!
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The Official Publication of THE UNITED KINGDOM FLIGHT SAFETY COMMITTEE ISSN: 1355-1523 WINTER 2017

FOCUS is a quarterly subscription journal devoted to the promotion of best practises in aviation safety. It includes articles, either original or reprinted from other sources, related to safety issues throughout all areas of air transport operations. Besides providing information on safety related matters, **FOCUS** aims to promote debate and improve networking within the industry. It must be emphasised that **FOCUS** is not intended as a substitute for regulatory information or company publications and procedures.

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Front Cover Picture: The Rolls-Royce Trent XWB engine is the most efficient large aero engine flying in the world today. Assembled in the UK and Germany, it recently reached a key milestone, celebrating 1 million flying hours, while achieving record levels of reliability. With over 1,600 engines already sold it is also the fastest selling widebody engine ever.

Accountability, Responsibility and Commercial Pressures

by Dai Whittingham, Chief Executive UKFSC

With 2017 rapidly drawing to a close, it seems we are very close to yet another record year for commercial aviation safety. The traffic predictions suggest that around 4 billion people will fly in some form of air transport this year; by the end of June, only 4 people had died in CAT accidents. That is an astonishingly good safety record and something of which we can all be proud.

Unfortunately, success usually comes with a downside of one sort or another. At shop floor level, the industry is well aware of the dangers of complacency; we know we cannot afford to take our collective feet off the accelerator pedal or lives could be lost in the future. However, as we see increasing numbers of people with no direct aviation experience arriving on management boards, we need them to have a reasonable understanding of our industry-specific safety issues rather than approach matters from a purely commercial perspective as is often the case.

This is not meant to be a criticism, merely an observation that we all bring previously acquired knowledge, skills and attitudes into a new workplace along with the hope that techniques that worked in Company A will now work in Company B. If those enterprises are in the same lines or models of business, the probability is that most learned (management) behaviours will translate easily. There are also examples of successful business leaders who have on first exposure been equally successful at senior levels in the aviation sector. But this is not always the case; resource decisions can be taken in the name of cost control but at the expense of increased risk.

It is normal business to bear down on costs, at least if you plan on being successful, but there are areas where resources are required even when the contribution to the bottom line is not immediately obvious. Safety work falls clearly into this category. The same dilemma is faced in considering expenditure on a deterrent capability, be that a criminal justice system or possession of nuclear weapons. How do you prove that a deterrent works? Is the absence of the thing you seek to deter evidence enough that the deterrent is viable, or have you just been lucky? And if you can't prove that the deterrent works, how do you persuade the holder of the purse strings that you need money to buy a new widget?

An Accountable Manager (AM) is the single individual responsible to a Regulatory Authority in respect of the regulated functions carried out by an aircraft operator, an air navigation service provider, an aircraft maintenance and repair organisation or an airport operator. Crucially, they must have the executive authority necessary to control these functions and the financial resources needed to carry out the various activities. It is the organisation itself that appoints the AM; your NAA has no legal responsibility to decide on his or her suitability though it does have a responsibility to formally accept the nomination of the Key Post holders.

It is therefore perfectly possible, and lawful, to find yourself with an AM who has no experience of aviation whatsoever, which is when the role of the post-holders becomes crucial. If they cannot convince the AM of the need for spending on a safety measure, you are in difficulties, and equally so if the safety office cannot first convince the post-holder of the same need.

Risks should of course be articulated in your SMS but it will be for the AM to decide how much risk can be accepted, hopefully while heeding the advice of the post-holders. There will be safety spending required which is non-discretionary, for example on FDM programmes for aircraft over 27 metric tons, whereas other measures will be discretionary and therefore open to debate. For example, the carriage of fire containment equipment for PED lithium battery fires would seem at first sight to be a sensible precaution but this requires a judgement about the risk of such a fire – some operators might decide that the long-haul nature of their business means the risk is unacceptable, others might decide that the availability of a rapid landing for their short-haul European routes means the risk is perfectly acceptable, and some will simply consider the risk is suitably remote anyway. From a safety standpoint, we would default naturally to the safest option, but the people with the budget will not always see things the same way and we must accept that sometimes they will be right.

In September 2006, a Royal Air Force Nimrod MR2 crashed in Afghanistan after a catastrophic and uncontained in-flight fire; all 14 men on board lost their lives. During the lengthy and difficult investigation into this tragic accident it became apparent that some fundamental airworthiness risks had not been properly accounted for, and that there had been serious flaws in the procurement, manufacturing, sustainment and in-service support processes. When the scale of the problem became clear, Charles Haddon-Cave QC was appointed by MOD to conduct a full review of the system.

The Nimrod Review report published in 2009,[1] which was sub-titled "A failure of leadership, culture and priorities", led to the transformation of the MOD's risk management processes and the establishment of a Duty Holder construct that involved direct and personal responsibility and accountability for safety reaching up to the most senior (board) levels. As part of the processes established since the Review, all decisions on resourcing, organisational changes or operational policy must involve formal and recorded consideration of their potential impact on safety. Under this regime, a commercially-driven decision to (eg) stop attending external safety meetings because of the associated costs would need to be recorded in the SMS along with any mitigating measures, the acceptance of any perceived increase in safety risk, and the identity of the decision maker.

As well as holding some named individuals to account, Haddon-Cave also pointed out that those involved in airworthiness, risk management and operational safety should be 'suitably qualified and experienced personnel' (SQEP). This argument extends to safety activities in commercial air transport: if you populate your safety offices with people who lack experience and/or training, you introduce an element of corporate liability should things go wrong. Some years ago, a major supermarket in the UK was successfully prosecuted for an accident in a warehouse because the local Health & Safety officer was not SQEP; she was suitably qualified, but her experience was deemed to be inadequate because it had all been gained as a nurse in a hospital environment and not in an industrial setting. There is clear alignment here with the need for post-holders to be SQEP and for the regulator to have some means of assessing and checking this, even though there is a more flexible (if possibly unwise) approach to AM experience.

Commercial pressure has always been a feature of our industry, but the difficult economic climate of recent years has increased the focus on cost reductions, witness some of the more unusual pilot employment models that have emerged. As traffic and airport congestion has increased so too has the pressure for on-time performance, which brings its own safety risks on the human factors front.

Some comments from the 2003 Columbia accident report may resonate here. As Brigadier General Duane Deal noted: *"If reliability and safety are preached as "organizational bumper stickers", but leaders constantly emphasize keeping on schedule and saving money, workers will soon realize what is deemed important and change accordingly."* One experienced observer of the space programme also described the Shuttle workforce as *"The few, the tired" and suggested that "…a decade of downsizing and budget tightening has left NASA exploring the universe with a less experienced staff…".* Do you recognise such symptoms in your own organisations? And how does that last quote sit when you think about our regulator?

Last but not least, there has been much discussion about erroneous take-off performance calculations, the role of EFBs and the need for more reliable gross-error checks. Set that against the commercial pressure to use the maximum possible de-rate for fuel and engine life considerations, which means using more runway than necessary and reduces margins against obstacles after take-off. If getting close to the upwind end of the runway on most departures becomes the norm, how do pilots realise they don't have the required power if there has been a calculation error? What do you use as an acceleration check point?

A recent incident involving an overseas operator in Belfast featured a late rotation and collision with some lighting in the over-run. The AAIB investigation is in progress and it would be reasonable to expect that power settings will form one of the avenues of inquiry as the team seeks to understand the event. Unfortunately, key evidence from the DFDR will not be available to the investigators as it was over-written in the time between the event and it being brought to the AAIB's attention.

Preservation of data is a crucial step in the investigatory process and your OM should contain the procedures for crews to do this. It is worth remembering that it is the aircraft commander's duty to report accidents and serious incidents to the AAIB or national SIA. Whilst this responsibility is often 'upwards delegated' to company level, staff inexperience or failure to recognise the seriousness of an event can lead to problems with timely reporting. If you are in doubt, pick the phone up and call the AAIB, the team there will be very happy to offer advice on whether you need to make it a formal contact or not. This 24-hour service is available free to you on 01252 512299.

Notes

1. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/229037/1025.pdf

How to get through the day (safely) ...

by Jacky Mills, Chairman UKFSC

Being ready for what life may throw at us is a good part of the battle in making the operation a success on any trip. Preparation can consist of many different facets – some of course starting years before and others being in the moment.

Experience is probably the tool which has been embedded furthest back. The benefit of having 'seen this scenario' before is the first barrier which may mitigate the threats that have lined up to challenge us today. Of course, being prepared can also be the mind-set which, without being pessimistic, expects that things will be thrown in our path in a bid to trip us up or at least throw a little turbulence in our way. Being mentally ready to take on the various challenges sets the scene towards successful management of the day, so being ready for the 'banana skins' is a good start.

Approaching the day in chunks can make this seem much more manageable, a less daunting approach, so being ready for the challenge in the crew room, for instance, could be the first hurdle. For today I am going to issue a free pass for travel to your initial place of work – we will assume that the greater beings have allowed a trouble-free arrival. Security have smiled at your in-date Pass, you weren't, unintentionally, carrying any 'forbidden' items about your person, your food was acceptable for going airside, all is well in the world – so far. In the crew room the paperwork is all ready for you, alternates reviewed, weather in limits, initial briefing done with other team members, fuel figure passed, everything looks good. Think about it... there are all manner of hurdles which could have been waiting for you... nobody available to prepare your paperwork for you today, computer said 'No' to your log-in, printer decided to jam... And we've not even got out to the aircraft yet. Of course, these scenarios can equally be applicable if your day involves a desk, computer, meetings, phone calls, technology...

The mitigation put in place way in advance of the day in question is training – this is often cited as a significant Barrier when a Risk Assessment is drawn up for a particular activity. But how effective is this training? Is it addressing the weaknesses seen previously in the operation? Is it addressing the weaknesses of the individual which may have been identified? This is where the new ATQP programme scores many points in my book, as it can be individually designed to address potential shortfalls of both the Operation and the Individual and utilise training time to the optimum.

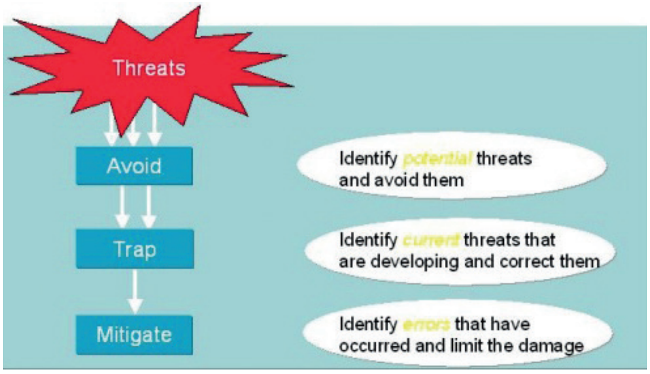
Threat and Error Management (TEM) is one option in the flight crew's toolkit which can make a big difference to how the day, or indeed night, develops. The fact that TEM is widely used and with often very good results is, in my opinion, because it inherently acknowledges that threats AND errors are part of everyday aviation operations that have to be managed by crews. Human error will happen so being ready to address this is a great start, and to accept that it may be someone else's error that brings about this scenario which could, if not addressed, result in an undesired aircraft state. The undesired state management is essential, and could represent the last opportunity to avoid the unsafe outcome and maintain safety margins. Getting down to the final barrier is to be avoided; safety systems and professionals strive to develop robust systems - the more barriers the more robust and comfortable the operation will be.

Threats can be defined as 'events or errors that occur beyond the influence of the flight crew, that increase operational complexity, and which must be managed to maintain the margins of safety'. These can be environmental – adverse meteorological conditions – terrain en route – congested airspace and therefore, congested RT communications, aircraft malfunctions, and the effect of the actions of others on the flight be it ATC, Engineers or Ground crew. These all have to be considered as they all have the potential to negatively affect the operation and reduce those margins of flight safety.

So, the first tool could be considered as the Briefing Tool. Getting specifically ready for the threat which is expected – thunderstorms en route for instance and how the flight path could be adjusted to avoid these.

Other threats occur unexpectedly; a technical malfunction that happens suddenly and with no warning. This draws on the flight crews' skills, training and experience, both technical and human skills are needed to deal with both the problem and the startle factor, and is why Memory Items from the checklist are so important. Sometimes there is just no time to 'think' - donning oxygen masks, for example, in certain scenarios has to be an immediate automatic action.

Then there are the latent threats which will not be obvious to the flight crew on the day and may only become apparent by the examination of data post flight, once all parts of the jigsaw can be considered together. These can include ergonomics, operational constraints introduced for commercial expedience, procedure design, and many others.



The ability to successfully manage any threat effectively relies on threats being anticipated to enable a response with appropriate countermeasures, in a timely manner. Threat management could be considered the first building block to managing errors and ultimately the undesired aircraft state. Threats and errors may not have a simple linkage between them but accident data has demonstrated that mismanaged threats are often linked to flight crew errors and often to the undesirable aircraft state. So threat management is clearly vital to avoid having to deal with the undesirable outcome.

The arrival at the incident usually has a very long trail of events behind it which can be pieced together with the wonderful benefit of hindsight. So threat management gives the most proactive route to maintaining good margins of safety within any operation; it addresses the safety compromising situation at the root cause position. The flight crew are the last line of defence and wherever possible, safety system developers will have put sufficient barriers in place to prevent the threat reaching them.

However, even the best designed systems cannot completely design out a lot of threats – both Environmental and Organisational – weather, ATC, airport constraints, terrain, operational – both actual and perceived – malfunctions – other personnel's errors that affect your operation. All these must be managed dynamically.

In this context, Errors can be defined as 'actions or inactions by the flight crew that lead to deviations from organisational or flight crew intentions or expectations'. If errors are not managed effectively they frequently lead to the undesired aircraft state. This reduces the margins of safety and increases the probability and likelihood of an adverse event. They can be part of an error chain or can stand alone. Switch mis-setting, incorrect mode selection, a mis-understood communication, are some examples of the starting point of the error, which if not trapped, lead to the undesirable outcome.

So simple of course... NO! More like a minefield of traps to catch us out. The effect of the error depends on the detection and response prior to the undesirable aircraft state being reached. So detection and response and the understanding of error management is as important as focusing on the causal factors. In reality it is impossible to eliminate all causes of failure and therefore, effective management is vital. Errors which are detected and rectified before the undesired aircraft state do not lead to a reduction in safety margins.

So effective error management is a great example of successful human performance, with both learning and training values. Capturing how errors are managed is at least as important as capturing the prevalence of the different types of error. Also discovering if, when and by who the errors are detected is helpful as well as the outcome of the errors. Obviously some are detected quickly and so never turn into an event, but others go undetected or may not be successfully managed.

There are many errors that can spoil the day – and often it is a combination of circumstances – the well-known 'Holes in the Swiss Cheese' which conspire to give the eventual error. For instance, handling errors – speed deviations – incorrect flap/ speed brakes – are more often than not linked to adverse weather conditions – turbulence – unexpected wind shear – for example. Procedural errors – item missed on the checklist – is most likely due to distraction of some kind, while a communication error may be linked to similar callsigns on the same frequency leading to the crew taking the wrong call.

Simple to resolve then... if only it was - but finding the links that cause the eventual error is the best avenue to building up the barriers that will stop the error ending up with undesired consequences.

The important focus for the flight crew once the error has occurred is to switch from managing the error to managing the outcome and prevent it escalating. It is easy and natural to dwell on the mistake made and get locked into error management rather than deftly moving on to mitigate any adverse event.

Countermeasures are used by flight crew every day as a matter of course – checklists – SOPs – briefings – all are an inherent part of the day designed to stop any errors getting through. Then there are the aircraft systems which are in place solely to capture errors – ACAS/TCAS and GPWS automatically warn the crew of an undesirable impending situation. These are mandated on commercial aircraft and as such taken for granted, but are a vital part of the defence toolkit.

So now that we have discussed Threats and Errors in depth will that stop them happening? Sadly not, but fore warned is undoubtedly fore armed, and if the day starts with the thought 'which banana skin is going to trip us up today and how are we going to stop it...', then I believe we all have a better chance of a safe outcome.

Fatigue Management: procedure vs practice

Fatigue management is an issue that is growing in importance with the demands and pressures of 24-hour operations and with ever-greater cost-efficiency. In this article, Nick Carpenter and Ann Bicknell discuss purposeful and tactical non-compliance with procedures for fatigue management. What lies in the gap between procedure and practice?

KEY POINTS

1. Procedures have an important place in safety-critical enterprises.
2. Humans are adaptable problem solvers trying to do their best.
3. For fatigue management, blind compliance with procedures to result in safe operations may not always ensure safe operations.

A growing challenge

On 12 February 2009, a Colgan Air Dash-8-400 crashed whilst on approach to Buffalo-Niagara Airport New York in the United States of America. Forty-five passengers, the four crew and one person on the ground died in the accident. Inappropriate inputs by both crewmembers contributed to exacerbate the stalled condition of flight 3407. The National Transportation Safety Board cited pilot fatigue as a contributing factor. The United States Federal Aviation Administration (FAA) listed 'Reducing Fatigue-Related Accidents' on its 2016 most wanted list.

The fatigue problem is linked to the economics of aviation. In the United States, deregulation of the airline industry occurred in 1978, with open skies between the EU and US arriving in 2008, eliminating service restrictions between the two trading blocks. The result is that airlines operate in an increasingly competitive environment, fuelled by the rise of Low Fare Airlines. The fall-out has included seven bankrupt airlines in Ireland, 39 in the UK and over 100 in the United States since 2000; a rate of just under one per month.

The pressure means that crews are working longer. In the first large-scale survey by the London School of Economics of pilots' perceptions of safety within the European aviation industry, 51 per cent of pilots surveyed felt that fatigue was not taken seriously by their airline, and 28 per cent of pilots felt that they had insufficient numbers of staff to carry out their work safely. The issue is reflected in the British Airline Pilots' Association campaign to raise awareness of fatigue within the industry. Concurrently, regulatory authorities are relaxing prescriptive flight time and duty limitations designed to keep pilots alert, exemplified by the FAA's new rules that exempt freighter pilots.

To try to understand this problem further, I recruited 11 medium-haul pilots to participate in semi-structured interviews and the transcribed data was thematically analysed. The pilots, all employed by a foreign carrier, conduct 'tours of duty' where they spend approximately 20 days working day and night flights (irregularly allocated), followed by a return to their country of domicile and 10 days off. As an experienced airline pilot, I was afforded candid disclosure of the current 'coping strategies' of this hard-to-reach professional sample.

I wanted to investigate how pilots attempt to cope with fatigue. It was anticipated that they would employ strategic and tactical methods.

Strategic planning typically involves lifestyle adjustments prior to duties starting. Tactical coping involves behaviours used to maintain alertness whilst on trips.

In general, pilots:

- Found sleep less restorative in company-provided hotels
- Struggled with changes from day to night duties
- Found multiple sector duties more demanding, and
- Felt that diverting was the most fatiguing operation.

Many participants instinctively used tactical techniques identified by sleep laboratories; coffee, cockpit lighting and conversation being the most popular tactical methods to maintain alertness. Some used cognitive methods including games, reading and music and a minority used physical methods such as exercise, both in the aeroplane and between flights.

Don't worry Jim, have a look at the roster!
Soon you'll become an experienced pilot, like the rest us!

Enabling non-compliance: When procedures and practice diverge

Bearing in mind aviation's heavy reliance on, and belief in, procedures, the most interesting outcome was the discovery that many of those interviewed have operated contrary to company procedures in a limited number of areas. Hollnagel et al (2014) suggested that what workers actually do at work can sometimes be very different from what managers, and those who write procedures, believe that they do. This difference between 'work-as-imagined' and 'work-as-done' only becomes apparent after something has gone wrong.

Typically, the procedure that fails has been used for a significant amount of time before being implicated in an incident. In the current context, crews are expected to remain alert in the cockpit without the use of controlled rest and are not allowed to use medication to help them to sleep between duties. Of those interviewed, almost all coordinated with their flight deck colleague to enable them to sleep in the cockpit whilst on duty. Some of them resorted to medication to enable recuperative rest between duties in contravention of current procedures. It is only through non-compliance with procedures that interviewees felt they were able to maintain their alertness at critical stages of flight: approach and landing.

What's prescribed is not necessarily what happens

For these pilots, blind compliance with procedures is not always the ideal method of delivering safe flight. This is something that we need to explore, whilst considering how to integrate 'enabling non-compliance' into safe operations as one method of optimising performance. That said, judging when it is prudent to contravene established procedures is difficult. Indeed, many would argue that this is a radical concept, but procedures have to evolve with the context in which they are used.

'Enabling non-compliance' has a dual purpose: facilitating open disclosure about frontline procedures while enabling procedure writers to adjust their work-as-imagined to the changing needs of frontline employees. This research suggested that those interviewed believe that they are capable of judging when non-compliance is prudent. The focus, then, needs to be on building flexibility into Standard Operating Procedures to close the gap behind work-as-imagined and work-as-done, whilst training crews to give them greater cognitive skills and judgmental awareness to step outside the rules when they have reached the limit of their effectiveness. Research by Robert Mauro (2016) and by Frederik Mohrmann et al (2015) suggests that resilience training should include training in decision-making and information analysis, including the use of virtual experience, strategies for decision shifts and the appropriate allocation of time to endow both competence and confidence in a non-jeopardy environment where flexibility and decision shifts are accepted.

Implicit in this change to training is the need for cultural change within organisations where simulators are used for competency training instead of only checks, and where an acceptance that stepping outside of procedures can, on occasion, be acceptable.

Of course, questions remain about risk and safety monitoring, procedure design and just culture. If work-as-done is sometimes deliberately contrary to procedures: 1. How can the company understand what is going on, and ensure that risk is adequately assessed in light with regulations and its safety management system? 2. How can procedures be adapted to be more flexible to allow for discretion around practices that aviation professionals deem to be safe and effective? 3. How will companies and national judiciaries treat pilots who purposefully contravene procedures, even when it makes sense to them to do so, if an accident occurs? These are questions that the industry will need to consider as work becomes more complex and demanding than we can imagine.

Reference:

- Hollnagel, E., Leonhardt, J., Licu, T., & Shorrock. S. (2013). *From Safety-I to Safety-II. A White Paper*. Brussels: EUROCONTROL Network Manager.
- Mauro, R. (2016, September). Affect and aeronautical decision making. *Paper presented at the meeting of the European Association of Aviation Psychology*, Cascais, Portugal.
- Mohrmann, F., Lemmers, A., & Stoop, J. (2015). Investigating flight crew recovery capabilities regarding system failures in highly automated fourth generation aircraft. *Aviation Psychology and Applied Human Factors,* 5(2), 71-82.

Further Reading

- Åkerstedt, T., & Folkard, S. (1997). The three-process model of alertness and its extension to performance, sleep latency and sleep length. *Chronobiology International,* 14(2), 115-123.
- Hartzler, B. (2014). Fatigue on the flight deck: The consequences of sleep loss and the benefits of napping. *Accident Analysis and Prevention,* 62, 309-318.

Dr. Ann Bicknell supervised the research and is the Programme Director at Ashmore Hill Management College, Warwickshire.

Nick Carpenter is a military trained and commercially experienced airline pilot flying wide body aeroplanes in Asia. His interest in flight safety has inspired him to study for both a Bachelor's and a Master's degree in Psychology and he is currently in the process of establishing a peer support network for contract pilots in Japan. The research cited formed the Dissertation for Nick's MSc.

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Hitting Offenders Where it Hurts:

Penalties for Health & Safety Offences on the Rise

by Chris Birks and Ashleigh Ovland, Holman Fenwick Willan LLP

A new Sentencing Guideline for UK health and safety offences came into force on 1 February 2016. A year and a half on, it appears that the trend is towards significantly higher fines for breaches of health and safety law.

The Court of Appeal recently upheld a £3 million fine in the manufacturing industry on the basis that it is not necessary for someone to be injured for a severe penalty to be imposed, because *"the offence lies in the creation of risk and it is that which must be punished."*

What does the Guideline say?

Courts must now act in accordance with the stated principle that fines must be *"sufficiently substantial to have a genuine economic impact"* on companies. The rationale is to bring home to management and shareholders that non-compliance with health and safety legislation will have serious financial consequences.

Importantly, when determining the appropriate penalty, the Guideline takes into account how an organisation conducts itself after the event, looking at steps taken to rectify health and safety shortcomings connected to an incident. The implication is that organisations must engage with the regulator as quickly as possible after the accident and certainly well before the sentencing hearing. Providing assistance *"beyond that which will always be expected"* will be a mitigating factor, but it is clear that the expectations are extremely high.

Before the Guideline came into effect, legislation and case law gave judges a wide discretion. There was no ceiling on fines, but neither was there any clear indication of an appropriate baseline. The position under the Guideline is now considerably more defined: it sets out a nine-step approach that tailors sentencing to the circumstances of the offence. Factors taken into account include the level of culpability, the risk of accident and the seriousness of harm. Before sentencing, the company must submit detailed financial information to the court, which will scrutinise turnover and profit margins closely in order to make sure that the impact of the penalty is appropriately severe. It is of note that the Guideline expressly states that putting an offender out of business may be *"an acceptable consequence"* in particularly bad cases.

How has Health and Safety Sentencing changed in practice?

Recent sentencing suggests that the courts are supporting the more stringent regime and even enhancing its scope. More than a dozen business received fines in excess of £1 million in 2016. Additionally, the same period saw cases brought against directors and senior managers under the Health and Safety at Work Act 1974 double compared to the previous year.

Impact on the aviation industry

The impact of the Guideline is being felt in the aviation industry as well. In March 2017 an aircraft engineering company was fined £160,000 and ordered to pay costs after pleading guilty to offences under sections 2 and 3 of the Health and Safety at Work Act. The offences were linked to the injury of an employee and an agency worker who fell approximately 15 feet while carrying out checks at the tail of an aircraft. A Health and Safety Executive (HSE) investigation found that there were insufficient systems in place for risk assessment and monitoring. A representative of the HSE said after the sentencing that *"not all risks are covered by the Aircraft Maintenance Manual and additional measures need to be introduced."*

Meanwhile, an ejector seat manufacturer was fined £800,000 and ordered to pay costs for breaching the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Three employees were said to have developed lung conditions after at least three years of exposure to metalworking fluid mist. The HSE had found that there were insufficient measures in place to limit exposure to the toxic substance.

It is clear that the comprehensive framework provided by the Guideline has made judges more comfortable about imposing severely punitive fines in the event of health and safety breaches, even ones where no harm has resulted. This upward trend in sentencing may help to bring investment in safety and training (including training on how to respond to an investigation) to the top of the aviation management agenda.

Air Canada A320 CFIT accident Halifax, Nova Scotia, 29 March 2015

by Dai Whittingham, Chief Executive UKFSC

An Air Canada A320-211 on a scheduled night flight from Toronto/Lester B. Pearson International Airport (CYYZ), Ontario, to Halifax/Stanfield International Airport (CYHZ), Nova Scotia, struck terrain around 740 feet short of the threshold, eventually coming to rest about 1900 feet past the threshold. Of the 138 occupants, 25 sustained injuries; the aircraft was damaged beyond repair.

AC624 was airborne at 2205 with the captain as pilot flying (PF) in the left seat, and the first officer in the right seat as pilot monitoring (PM); the pilots had not previously flown together but were both very experienced (11,000+ hrs). The forecast for Halifax was wind 350° true (°T) at 15 knots with gusts at 21 knots, visibility ½ statute mile (sm) in moderate snow and drifting snow, and temperature −5 °C, so the crew planned to fly the localizer (LOC) approach to Halifax Runway 05. The flight was expected to take 2 hrs 10 mins.

The crew calculated the final approach fix (FAF) crossing altitude would be 2200 feet ASL, based on the published altitude of 2000 feet plus a cold temperature correction of 200 feet. The MDA was calculated at 813 feet ASL, based on the published MDA of 740 feet ASL plus a cold temperature correction of 23 feet, plus 50 feet added to the corrected MDA, as required by Air Canada's FOM. The crew also calculated a flight path angle (FPA) based on the temperature-corrected FAF, the charted vertical descent angle of −3.08° and Air Canada's QRH for a final calculated FPA of −3.5°.

About 50 minutes into their flight, Air Canada dispatch provided weather updates and advised that a company aircraft had recently landed on Runway 05 after carrying out a missed approach due to insufficient visibility. The crew performed the go-around briefing and repeatedly reviewed the CYHZ weather conditions at CYHZ before assessing the conditions as suitable for the aircraft to land.

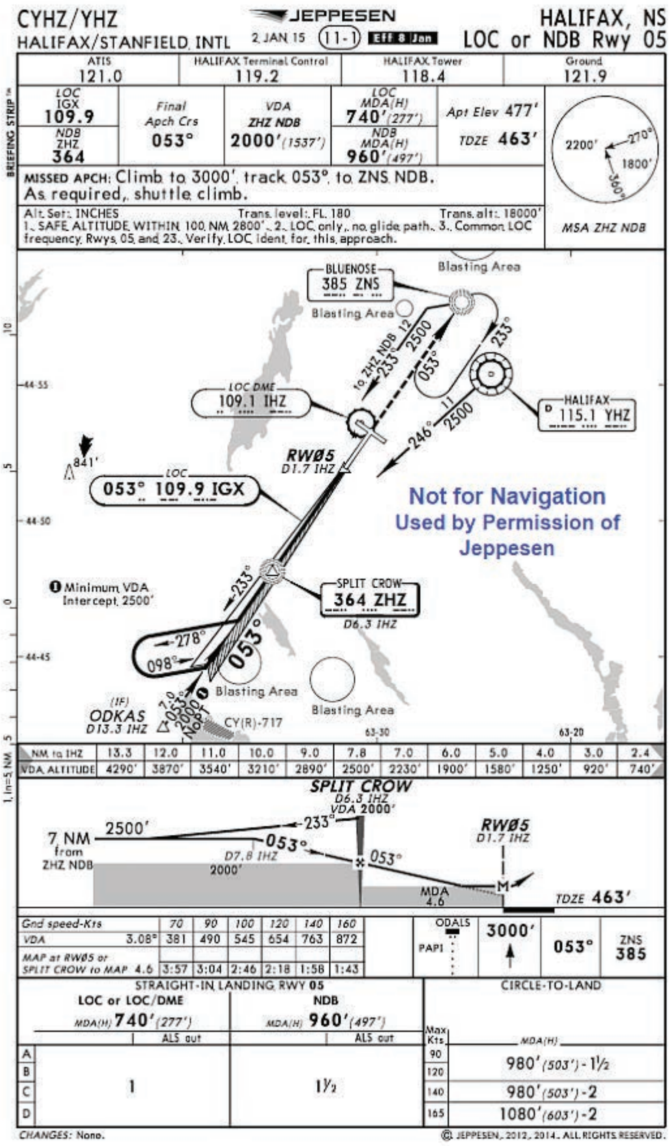
The 2300 Halifax METAR then reported visibility of ¼ sm with heavy snow. According to the Canadian Aviation Regulations (CARs) operations specification (OPS Spec) for non-precision approaches, where the published visibility minimum is 1 sm, approaches can be continued past the FAF when visibility is reported to be at or greater than ½ sm. The crew therefore decided to hold until the weather improved or fuel required them to divert to their alternate. The approach briefing covered a non-precision LOC approach to Runway 05 which would be coupled–selected, with a manual landing (i.e. LOC-coupled for lateral guidance with crew-selected vertical guidance). During the descent, the crew discussed the holding requirements and were then cleared as requested to hold at 9000 feet ASL; they had sufficient fuel to hold until 0100 on 29 March.

At 2334, the crew contacted tower for an update on the weather and runway conditions and were informed that the reported visibility was still ¼ sm and that vehicles were continuing to remove snow from the runway. Around 30 minutes later, the PF indicated that, if the weather did not improve within about the next 20 minutes, the flight would have to divert to Moncton.

At 0009, the latest METAR indicated visibility of ⅛ sm, winds of 360°M at 20 knots, gusting to 25 knots, in heavy snow and drifting snow, and vertical visibility of 300 feet. Four minutes later, the tower controller contacted AC624 to advise that the report of ⅛ sm visibility had been incorrect and that the actual visibility was ¼ sm, although he reported being able to see about ½ sm. They then received a SPECI advising visibility of ½ sm in snow/drifting snow with vertical visibility of 300 feet. Based on this improvement in visibility the crew elected to make an approach to Runway 05.

The accident

At 0016, the terminal controller cleared AC624 to the intermediate fix, ODKAS, 11.6 nautical miles (nm) from the runway, and cleared the flight to descend to 4000 feet ASL. AC624 was then cleared for the straight-in LOC approach via ODKAS and was advised that there was no change in weather and runway conditions from those previously reported.



The crew then asked the tower to confirm that the runway lights were on setting 5. The controller, who was also dealing with the snowploughs on the runway and an aircraft taxying, advised that the lights were currently on setting 4 but would be on setting 5 in time for the landing. Runway 05 has a high-intensity lighting system, which includes threshold, end, centre-line, and edge lighting, and a medium-intensity omnidirectional approach lighting system (ODALS) extending 1500 feet from the threshold. The ODALS includes 5 lights spaced approximately 300 feet apart, which flash sequentially every second (60 times per minute). Canadian high-intensity lighting systems have 5 brightness settings, ODALS have 3 settings; HIALS.

AC624 levelled off at 3400 feet ASL about 12 nm from the threshold with the autopilot (AP) on and the flight director lateral mode selected to LOC (localizer track mode), and the crew began to configure the aircraft for the descent with AP 1 and autothrust still engaged, and with landing lights off. During the LOC capture turn, the crew could see the ground when looking straight down as well as when looking off on a slight angle.

At about 8 nm from the threshold, the landing checks were completed, the aircraft levelled off at 2200 feet ASL, and the missed approach altitude was set. At about the same time, the tower controller requested that the snowploughs vacate the runway. The aircraft was fully configured for landing before the FAF.

About 2.7 nm from the FAF, the PF selected FPA mode on the Flight Control Unit; the aircraft was now being flown with the FPA selected to 0.0°. The PM began to countdown distance and at 0.3 nm from the FAF, per company SOPs, the PF rotated the V/S-FPA knob to select −3.5°. The Airbus FCTM advises that the FPA should be preset and the mode selected by pulling the V/S-FPA selector knob 0.3nm before the desired descent point to ensure a smooth transition, but this FCA preset requirement was not included in the company's AOM.

The tower controller cleared AC624 to land; the runway lights remained at setting 4, though the PM could see ground lighting. The aircraft started to descend about 0.2 nm from the FAF, crossing it at an indicated 2170 feet. As the aircraft descended, the airspeed was stable and the vertical descent speed ranged between 700 and 800 feet per minute (fpm) but the flight path diverged from the planned profile as a result of wind variations, the divergence widening throughout the approach.

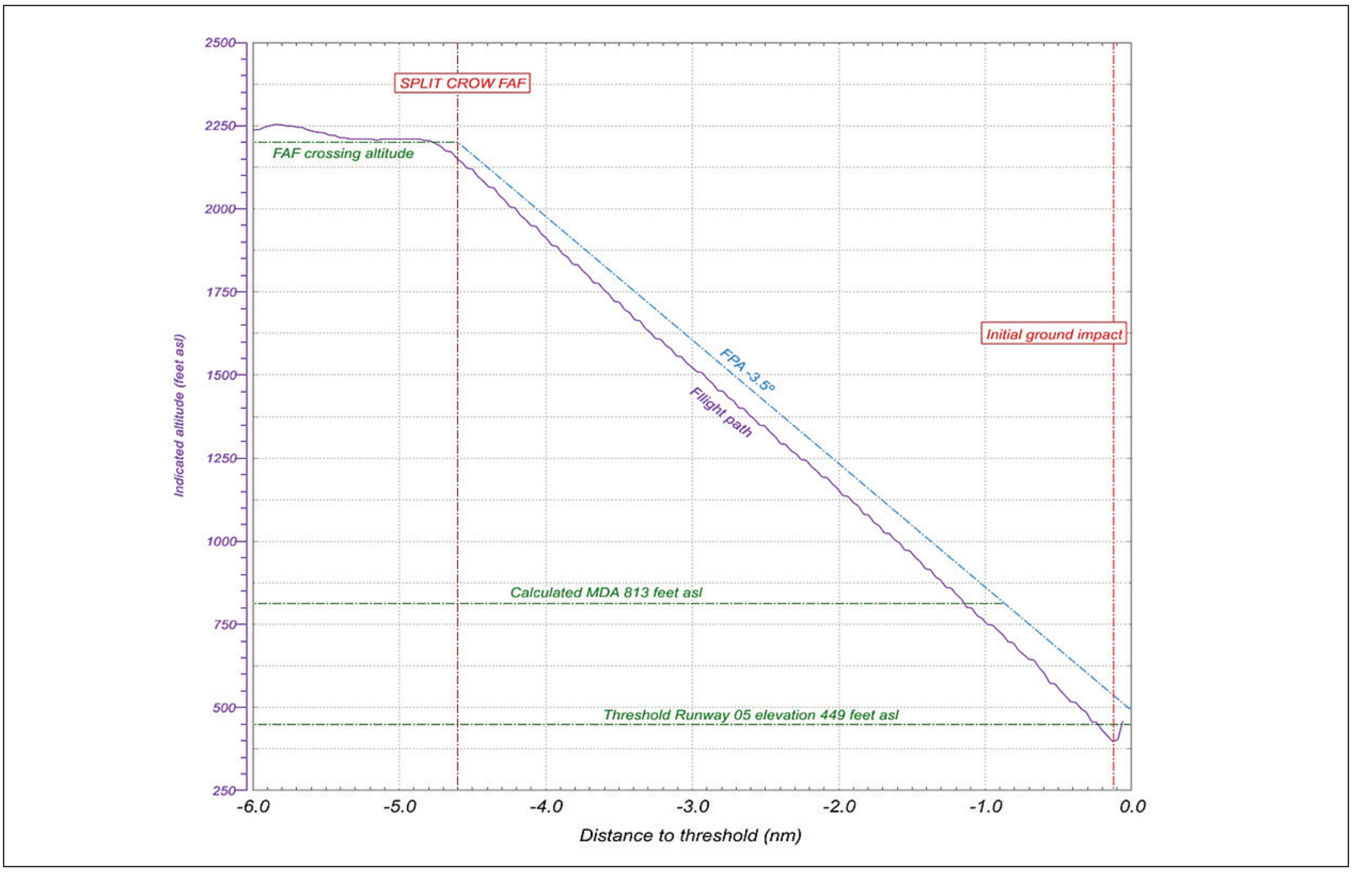


Figure 1. Flight path angle (FPA) versus aircraft flight path

Almost immediately after an automated radalt call of "400" was made, the aircraft crossed the calculated MDA at 1.2 nm from the threshold. The PM observed some approach lights and called, "Minimum, lights only," when the aircraft was about 1.0 nm from the threshold. The PF immediately called, "Landing," and began to see some approach lights. By this time, the aircraft had descended through the published MDA (740 feet ASL) but was 0.3 nm farther back than the published distance. The autopilot remained engaged as the aircraft continued descending, with no reduction in the descent rate.

When the aircraft was about 0.7 nm from the threshold, the crew agreed they could see some approach lights. At this time, the aircraft crossed over a lighted facility. At 0029:47, the landing lights were selected ON, followed in very quick succession by the PF disconnecting the autopilot, an automated call of "100," an automated call of "50," and the PM calling to pull up. The aircraft then contacted and severed the electrical power line that ran perpendicular to the runway and which supplied the airport terminal.

About 1 second before initial ground impact, the PF selected TOGA and full nose-up side-stick. One of the left mainwheel tyres hit an approach light located 861 feet from the runway threshold and at 0030:00, the aircraft's main landing gear, aft lower fuselage, and left engine cowling impacted the snow-covered ground on the embankment sloping up toward the runway. The aircraft bounced through the localiser antenna array before striking the ground twice more and then sliding along the runway, coming to a halt about 1900 feet beyond the threshold. During these movements, the aircraft completely lost electrical power; the lights inside the cabin went off and the emergency lights activated automatically.

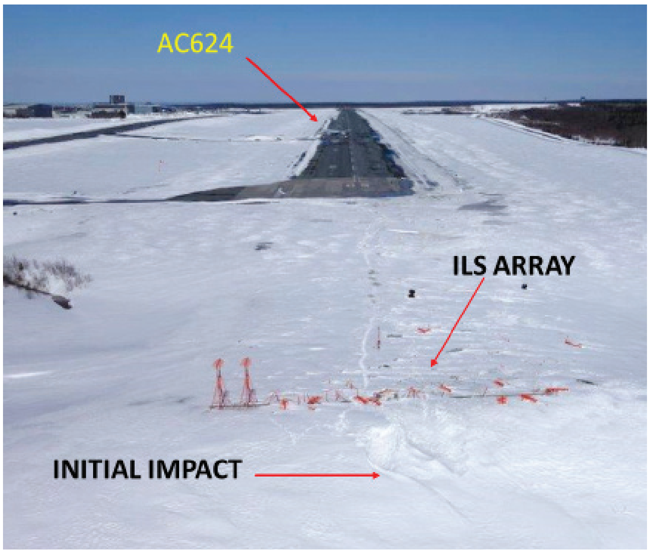


Image: TSB Canada

The aftermath

Although no evacuation order was given, passengers in rows 17 and 18 opened the 4 over-wing exits and began to leave the aircraft. The service director opened the forward left cabin (L1) door and directed the passengers to evacuate. About 2 minutes after the crash alarm was activated, while passengers were completing the evacuation, firefighters with the airport emergency response services (ERS) arrived at the accident site.

The aircraft was evacuated within 5 minutes after it came to a stop, many passengers wearing open-toed shoes, shorts, and t-shirts, and some with their carry-on baggage. Occupants with more severe injuries sat in the emergency response vehicles. 12 minutes after impact, the firefighters confirmed the evacuation was complete and requested transport to take the aircraft occupants to shelter. It was not until 50 minutes after the accident that the last passengers were brought to an indoor holding area. The METAR issued 30 minutes after the initial impact records a windspeed of 340/20G54 and an air temp of -6°C, giving a wind chill factor of -15°C to -17°C.

Of the 25 persons injured, 24 received only minor injuries; the exception was the first officer, who sustained a serious injury to his eye when his head struck the glare-shield. The injury was consistent with his having twisted in his seat during the accident sequence, caused by the failure of one side of his shoulder harness to lock correctly. A maintenance check of the seat had been performed approximately 14 days previously; the inspection schedule did not include the requirement for a pull test, although Air Canada conducted these tests anyway. However, the seat manufacturer's maintenance instructions did not specify that, to ensure no interference between the straps and the ratchet mechanism, the straps needed to be extended by 25% before the pull test; Air Canada was therefore not aware of this requirement. A test conducted without the 25% extension would not correctly identify a failure in the inertia reel system.

The analysis

The aircraft was found to be correctly certified, equipped, and maintained in accordance with existing regulations and procedures. Other than a defect-logged inoperable No 2 air pack flow indication, there were no reported of technical difficulties before flight and no indications of any during the flight, and the aircraft was within its weight and CG limits.

A primary focus of the investigation was to understand the decision making that led to the approach being continued below MDA without visual references being available to the crew that were sufficient to allow them to land safely. Unlike EASA and FAA rules, CARs does not require the OPS Spec for non-precision approaches to take account of the approach lighting system. This meant the approach could legally be flown (per Air Canada SOPs) with ½ sm visibility and 1500 ft of approach lighting, provided in this case by ODALS. By comparison, a similar approach in the USA would require an additional 900 ft of approach lighting.

The Visual Descent Angle (VDA) is published as part of the NPA procedure and is aimed at generating the correct profile for an aircraft to cross the threshold at 50 ft agl and land in the touchdown zone. As part of the system to verify the flight profile, distance/altitude tables are included in the published procedure. However, Air Canada SOPs and historical practice was that crews flying using the FPA mode were not required to monitor the profile using these tables once they were past the FAF, nor were they required to adjust the FPA. This did not accord with either the company or Airbus FCOM.

TC had reviewed the Air Canada AOM and SOPs but did not identify the discrepancy with the FCOM requirement to monitor the vertical profile when beyond the FAF.

MDA and beyond

As the crew did not monitor distance/altitude, per SOPs, they would have been unaware of the divergence from the selected FPA flightpath and would probably not have recognised that they had crossed MDA further back from the threshold than normal. The investigation considered the visual cues that might have been available with the reported ½ sm visibility in snow: when the crew had a brief discussion about acquisition of the lights, they may only have been able to see the first 2 ODALS lights (15 seconds before impact) and at 2000 ft from the threshold, when the AP was disconnected, all of the ODALS and the first 3 pairs of edge lights. Theoretical data suggested that at the 2000 ft point, as much as all ODALS and the first 19 pairs of edge lights might have been visible; had the lights been at maximum brilliance, the crew may have been able to see all ODALS and the first 3 pairs of edge lights from the calculated MDA.

Safety Actions

Air Canada made a number of changes to its manuals and processes, including removal of the 'lights only' call from the SOPs and other SOP alignments with the FOM. PM duties now involve greater emphasis on instrument monitoring when below MDA. The FOM has been revised to link approved approach minima and approach lighting requirements. Air Canada has also formally requested that Transport Canada ties the standard for approach minima to the approach lighting capability of the relevant runway and that the corrected minimum is shown on each approach plate.

In addition, airport authority took a range of actions to enhance its emergency response capability. Some equipment and facilities were upgraded and a new backup emergency operations centre was established. The airport also replaced ODALS on both runways with a simplified short-approach lighting system with runway alignment indicator lights (SSALR), coupled with high-intensity approach lights.

Primary reference and source for all graphics and photographs: TSB Canada Aviation Investigation Report A15H0002, accessed at http://www.bst-tsb.gc.ca/eng/rapports-reports/aviation/2015/a15h0002/a15h0002.asp

Note: a critique of elements of the TSB Canada report is available at http://www.picma.info/sites/default/files/images/Report%20critique%201_4.pdf

CHIRP
Air Transport FEEDBACK

Lack of Radio Discipline

Report Text: Over the last few years it has become apparent that the once well drilled R/T discipline we could expect from our flying colleagues has somewhat dropped away. The last 2 summers and this year, so far, have seen an increase in all London sectors so it is now that R/T discipline by both pilots and controllers needs to be tightened up.

I have flown on the jump seat and I realise that picking up your call sign on a busy or congested radio whilst you are carrying out your other flying duties is not always easy - likewise as a controller when I am coordinating on the phone or with a colleague we may occasionally miss calls. However, with greater regularity we are hearing cross transmissions especially when a/c are checking in which would indicate that a/c are not listening in to the frequency before making initial calls. We are also experiencing missed transmissions which are becoming increasing more frustrating. Every session there are multiple transmissions to a/c who are not maintaining a listening watch - every repeat instruction is rapidly increasing controller workload as they have to make that instruction again and wait for correct read back. I can imagine it would be quite frustrating in the cockpit if you had to make multiple repeated inputs before getting the expected response...

Obviously lapses do happen but I implore all pilots to not totally switch off attention especially when they are at cruise levels (the most likely time transmissions are missed).

Lessons Learned - I have informally inquired whether there have been any changes at the NATS radio sites that might make the transmission less audible or powerful but I have been told there have been no changes.

CHIRP Comment: The reporter's experience of missed transmissions, particularly by flight crew in the cruise, and transmissions being 'stepped on' were familiar to pilot and controller members of the Air Transport Advisory Board alike.

CHIRP is grateful to NATS for researching the issue and advising that:

- Call blocking (stepped on transmissions) has been particularly high this year – 9 events so far, against 3 the year before
- Predominantly the events are in "Area Control", followed by the LTMA
- The events have manifested themselves in the following way:
  - – Overload
  - – Level Bust
  - – Loss of separation

These types of occurrence are not reported formally unless they lead to a reportable outcome and there are many more that were not reported. Monitoring a sample of LTMA frequencies during the summer revealed that there was at least one instance of instructions having to be repeated in every 30 minute period. The reasons for this were:

- Poor English from the pilot
- No response from the pilot
- Two pilots speaking at once (2 different aircraft)
- Pilot not understanding the clearance.

While there are many reasons why a call might be stepped on, a common example was pilots not waiting for clearances to another aircraft to be read back before transmitting their own messages. This is an avoidable error that increases the workload and fatigue for controllers and causes frustration for all.

There are other factors contributing to the difficulty of using frequencies effectively:

- Distraction caused by
  - – The proper and improper use of 121.5
  - – The requirement for cabin crew to use the interphone to contact flight crew
- The use by some foreign operators of the flight deck loudspeaker rather than headsets (CHIRP will take up this issue with EASA and Eurocontrol)
- Similarity of call signs (There is a software application available from Eurocontrol to assist operators in addressing this problem)
- Undisciplined verbosity using up valuable time

How can we make the best use of the available RT frequencies? There are already technical means of preventing blocked transmissions but not many operators have introduced them. However, the introduction of Controller-Pilot Data Link Communications (CPDLC) in upper airspace, although patchy and immature in Europe, has relieved RT congestion in the sectors where it is used; Maastricht is a good example. There has been a noticeable increase in the number of aircraft equipped with CPDLC this year but there still remains an element of uncertainty about response times/timeouts etc. that can discourage its use. This can lead to an unwelcoming frequency for pilots as strings of instructions are fired off with minimal noticeable breaks. However, within UK controlled airspace, aircraft that have been transferred are normally identified to the controller. In essence changing frequency to a congested one is like taking 'an RT queue ticket' and if the frequency is too busy to "get in" the controller will know you are there and can initiate the conversation. That said, it is recognised that frequency congestion remains a problem during busy times of the day and the opportunity to make RT calls can become critical when, for example, aircraft approach a clearance limit and require further descent. Whatever the circumstances, maximising the use of CPDLC and good RT discipline by controllers and pilots alike are vital.

Descent below Designated Altitude

Report Text: We were on arrival into [an airport in the London TMA] from Belgium. While on arrival we were with London Control and given an assigned heading which took us off the assigned STAR. This is not unusual as we rarely stay on the assigned Arrivals and Departures when with London Control. I was given a descent on our present heading to FL100. I set 10000 in our altitude selector and continued an approx.1500 fpm descent. During that time my Co Captain, Pilot Monitoring, was off frequency communicating with [handling agent] in preparation for our arrival. We were issued a frequency change to a new sector and we checked in. We were next issued a turn direct to [ ] and were continuing to descend to FL100. Around FL103 the controller called and asked what we were doing. My colleague responded, going direct to [ ]. The controller said, no you were assigned FL110. Our response was to ask if he wanted us to climb. He responded no continue descent to FL90.

Lessons Learned - Well the obvious answer is to always check and double check altitude assignments. In this case ATC had several chances to catch the mistake, if it was a mistake. I repeated what I thought to be our assigned altitude to two different controllers. ATC also has the capability to see what I have in my altitude selector so it shouldn't have been a surprise that I was descending to FL100. The Arrival phase into the London Area is an extremely busy and complex time. We always need to be vigilant to maintain a high level of situational awareness. In the US, ATC has adopted much less of a "positive control" concept for arrival flow. Aircraft are metered using the arrivals which aids in reducing errors and increasing flow. It would be great to see a more effective arrival airway system in the UK.

CHIRP Comment: We are grateful for this honest account of an incident from which there are several lessons for the benefit of other pilots. In essence, a simple error was not detected or corrected by the barriers which might otherwise have prevented a level bust. The RT tapes record that the crew was instructed to descend to FL110 to be level by [ ]. This was correctly read back but FL100 was selected in the autopilot and the aircraft began to descend. The incorrect level was challenged by ATC as the aircraft was descending past FL103. No other aircraft were affected by this level bust and the controller immediately cleared the aircraft to FL90.

The erroneous selection of FL100 selected altitude was a typical and common example of a human performance error: a correct read back but an incorrect action. One of the barriers for catching this type of error is monitoring by the other pilot. Unfortunately he was speaking to the handling agent when the ATC descent clearance was issued and read back correctly by the handling pilot. Although FL100 is typically the level below which flight decks go sterile, many operators use FL200 for operations into the London TMA because the airspace is so busy and complex. If it is essential for one pilot to go off the operating frequency below FL200 and a descent is instructed while they are away, on their return they should ask ATC to confirm the altitude cleared; this is not uncommon and controllers would prefer to be asked for confirmation than risk a level bust.

Another potential barrier was the downlink of the altitude selected in the aircraft FMS. However, the controller did not detect the incorrect altitude selected by the pilot and pilots should not expect them to do so. Controllers are not mandated to check the selected altitude because it would be impractical given the amount of traffic in the TMA and the variable delay that occurs between clearing aircraft to descend and the altitude being selected. If controllers do see a discrepancy they will try to resolve it, but it is not currently practical to expect them to do so routinely. In future controllers will increasingly make use of electronic flight strips (rather than the paper ones) and these, in some situations, will alert the controller if there is a discrepancy between the cleared altitude and the Mode S indication. Unfortunately, the utility of the selected altitude function may not be compatible with RNP procedures and step-climb SIDs. Therefore, while technical solutions will be welcome and beneficial, from a human factors perspective the old adage – 'never assume, check' – comes to mind in circumstances such as occurred here.

Once again, kudos to the reporter for providing the opportunity to highlight some important lessons.

Reporting Fatigue to the Company

Report Text: I offloaded myself in the middle of a long sequence of Flight Duty Periods where every day involved multiple sectors. After checking out, I filled in the fatigue report form. I then had to call crewing, who wanted me to report back the next morning to position to [ ] to carry on with my roster (I had been due to operate there the evening before). Crewing also wanted me to call them the next morning to let them know whether or not I was still fatigued.

I did call crewing the next morning (having set my alarm to ensure I was awake in time call them with enough notice to call a standby to cover my duty) to let them know I was still exhausted. So what do our good friends in crewing do on my roster? They put me down as SICK.

The following Sunday morning, when I was well rested, I reported to continue my roster. Before flying I [had an interview to determine the circumstances and background to my reporting fatigue]. May I say that the interview did not feel like a duty of care interview, but more an interrogation into my lifestyle?

A few days later I received an email asking me to fill in a Self-Certification form for my recent sickness. [The explanation was that my absence had been recorded] as sickness as my roster met the legal requirements when it was put through [a proprietary fatigue management application].

So, not only are the company relying on computer software to decide whether or not a flight crew member is fatigued, they have also made the whole process of reporting fatigue very long-winded. Having spoken to a number of flight crew within the company, I discover that - for the sake of simplicity - flight crew are actually reporting sick rather than going through the whole fatigue reporting process.

CHIRP Comment: Reporting sick, rather than fatigued, for convenience cannot be condoned. It is reasonable for operators to investigate the factors contributing to fatigue in order to identify the elements that are their responsibility to manage. Unfortunately, susceptibility to fatigue is dependent on individual personal characteristics and circumstances and therefore a great deal of information is required. It might be a time-consuming process but it is necessary to gather the information either by a filling in a long fatigue reporting form or subsequently by interview. Fatigue modelling software is becoming increasingly sophisticated but should not be used as a sole determinant of whether a particular individual was fatigued. There needs to be a clear policy on reporting fatigue, including how and who classifies it and clear training on the use of models to support fatigue assessment. It is reasonable that the impact of the individual circumstances is considered as well but if a crew member says they were too fatigued to operate then they were and the information needs to be recorded.

Ability to Achieve a Break durng FDP

Report Text: Our Company has recently introduced a new service. There are only two crew members completing the service at the back of aircraft which can hold up to 150 passengers. The new service can now take two hours. The issue is not the new procedure itself but the problems that are arising because of it.

I became very dehydrated on a long flight as I did not eat or drink all day – 11+ hours – as we could not take a break. No rest breaks are ever achieved. I have heard this from many colleagues that this is happening on most flights.

CHIRP Comment: We have received many similar reports on this new procedure and all reporters have been encouraged to report their concerns to the Operator so that they are aware of all the issues raised. The Company has advised that they are aware of the problems that are occurring and have asked for cabin crew members to continue to report their concerns directly to the company.

EASA FTL Regulation ORO.FTL.240 states that 'During the FDP there shall be the opportunity for a meal and drink in order to avoid any detriment to a crew member's performance, especially when the FDP exceeds 6 hours'. Each operator should specify in their Operations Manual how the crew member's nutrition during FDP is ensured.

The operating SCCM is responsible for managing breaks to ensure that they are achieved, if the length of a duty permits an inflight break. However, if a crew member knows that they are entitled to a break and it seems that it will be difficult to achieve it, they should speak up and advise the SCCM so that it can be planned within the duty.

Hazardous Ice

by Richard J. Ranaudo

A 1994 crash prompted research aimed at preventing deadly encounters with freezing droplets of rain and drizzle.

On Oct. 31, 1994, an ATR 72, American Eagle Flight 4184, departed from Indianapolis for Chicago O'Hare International Airport with 64 passengers and four crewmembers. Due to traffic at O'Hare, the aircraft was held over Roselawn, Indiana, at 10,000 ft in icing conditions. The ice protection system (IPS) was functioning, and the wing flaps were partially extended. Air traffic control cleared the aircraft to 8,000 ft, and while descending, the flap overspeed warning sounded. The copilot raised the wing flaps, and the angle of attack began increasing. Suddenly, the right wing stalled, the autopilot disconnected, and the control column deflected full right. The aircraft rolled uncontrollably into a steep right bank and entered a dive. As the angle of attack decreased in the dive, aileron control was regained, but both pilots began pulling back on the control column to recover from the dive. Angle of attack increased, the right wing stalled a second time, and the control column again deflected full right. The aircraft entered a steep rolling dive from which recovery was impossible and crashed. All passengers and crew were killed.

The subsequent accident investigation determined that the probable cause was "the accretion of a ridge of ice aft of the de-icing boots, upstream of the ailerons, due to a prolonged operation of Flight 4184 in a freezing drizzle environment, well beyond the aircraft's certification envelope."[1] Contributing factors included errors by the flight crew, "insufficient recognition by airworthiness authorities and the aviation industry worldwide of freezing drizzle characteristics and their potential effect on aircraft performance and controllability," and the failure of civil aviation authorities to provide regulation for flight in icing conditions, other than the U.S. Federal Aviation Regulations (FARs) Part 25, Appendix C icing envelopes.

The Appendix C icing certification envelopes, which were developed in the 1940s by the U.S. National Advisory Committee for Aeronautics (the precursor to the National Aeronautics and Space Administration [NASA]),[2] characterize supercooled icing "cloud water droplets" in terms of their size and distribution in a cloud. After 1973, all airplanes certified for icing had to show safe operation in these conditions. Cloud water droplets are extremely small — about the size of a grain of flour.[3]

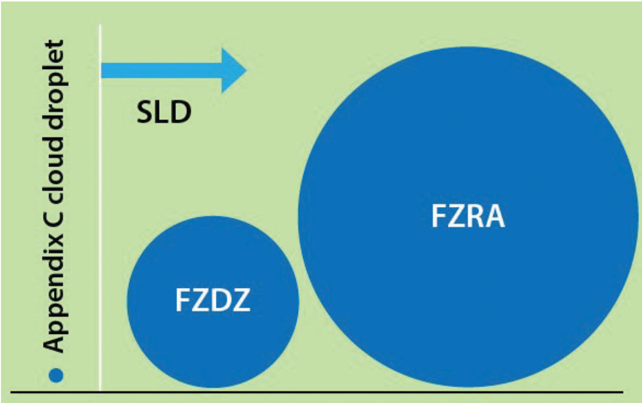


Figure 1 – Graphic Illustration of Relative Sizes of Cloud and SLD Water Droplet Diameters
FZDZ = freezing drizzle; FZRA = freezing rain; SLD = supercooled large droplet
Source: Ben C. Bernstein, Meteorologist, Leading Edge Atmospherics

But in nature, icing conditions also exist that produce much larger droplets. These are supercooled large droplets (SLD), which exist in two sub-categories: freezing drizzle droplets (FZDZ), with diameters up to 0.5mm (0.02 in), and freezing rain droplets (FZRA), which can be five times larger, or even bigger. SLD can result in ice accretions that cannot be removed by an IPS designed for Appendix C conditions due to the larger droplet inertia causing impacts aft of the IPS. Figure 1 shows an approximate graphic relationship between Appendix C cloud size water droplets and SLD droplets.[4]

Photo A — Appendix C icing on wing leading edge

Contrasting Ice Formations

Appendix C icing clouds can develop if two primary conditions exist — the presence of liquid water droplets and a subfreezing temperature. When an aircraft flies through a cloud containing these supercooled water droplets, ice can form. Photo A illustrates an Appendix C ice formation on an unprotected wing's leading edge. The black area is the area an IPS will protect in these conditions.

FZDZ and FZRA are generally formed by different mechanisms.[5] FZRA forms in what is termed a "classical" manner, and occurs when snow falls through a layer of warm (above freezing) air, turning the snow into rain. The rain continues to fall and then reaches a second sub-freezing layer below, causing the raindrops to become supercooled. If supercooled raindrops freeze when they strike a surface (such as the ground or an aircraft), they are considered to be FZRA. FZDZ, on the other hand, typically forms via the "non-classical" mechanism, when water droplets collide with each other and coalesce into larger supercooled droplets.[6] If the droplets become large enough, they can reach the drizzle size range, becoming "supercooled drizzle." If this drizzle freezes when it strikes a surface, it is FZDZ. If an aircraft flies through either condition, potentially hazardous ice formations result. Figures 2 and 3 illustrate these formation mechanisms; diagonal lines illustrate air temperature vs. altitude.[7]

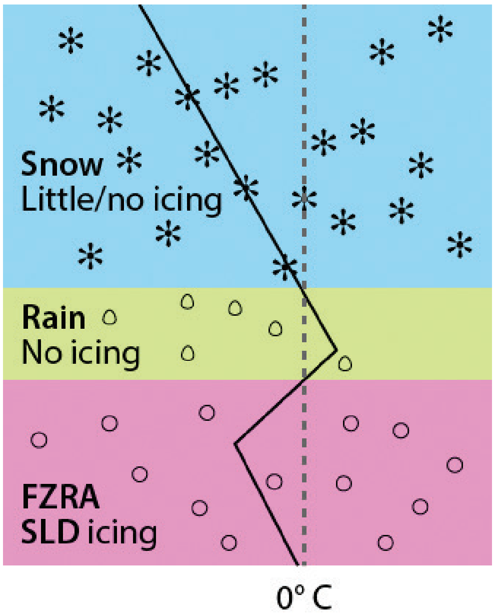


Figure 2 — FZRA Classical Formation Process
FZRA = freezing rain; SLD = supercooled large droplet
Source: Ben C. Bernstein, Meteorologist, Leading Edge Atmospherics

In Figure 2, FZRA is indicated as occurring at the surface. It is possible for rain to be indicated at the surface if the temperature beneath the lower sub-freezing layer rises above freezing. Ice pellets can be reported if the melting in the warm layer aloft is incomplete and the partially melted raindrops refreeze at the lower sub-freezing level.

FZRA can also be mixed with ice pellets, snow and/or rain, depending on the details of the vertical structure, the intensity of the precipitation and the size of the snowflakes falling from the upper layer. It is important to note that a subfreezing lower layer must be present if FZRA is to exist. Radars typically see this condition well, since the droplets are large. The condition described in Figure 2 is most often found ahead of advancing warm fronts.

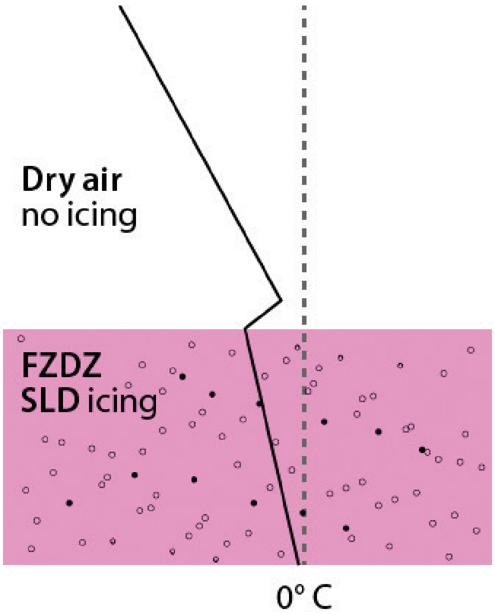


Figure 3 — FZDZ Non-Classical Formation Process
FZDZ = freezing drizzle; SLD = supercooled large droplet
Source: Ben C. Bernstein, Meteorologist, Leading Edge Atmospherics

In Figure 3, FZDZ is indicated as occurring at the surface, and the lower cloud layer (pink) consists of supercooled water droplets that are colliding, coalescing and falling toward the surface. Some drops may evaporate before reaching the ground. They also can warm to temperatures above zero, resulting in reports of drizzle at the ground. Because the drops are relatively small, radar returns tend to be relatively weak, making them difficult or impossible to see on some radar plots. In addition, they often are evident only in close proximity to the radars. Reports of FZDZ at the surface are a strong indicator of the presence of FZDZ aloft; however, many airports cannot report FZDZ due to lack of a trained observer on site and/or limitations in equipment.

Photo B — Supercooled large droplet formation on unprotected wing

Photo B illustrates an FZDZ accumulation on an unprotected wing. Note that the ice formed well beyond the area that would be protected by wing deicing pneumatic boots.

Ice protection systems have generally been designed to handle Appendix C conditions. When such a system is operated in SLD conditions, a ridge of ice sometimes forms behind the protected area, acting as a spoiler, deflecting the airflow, greatly reducing lift and decreasing the angle of attack at which stalls occur. These ridges aft of the wing boot upper surface can cause early airflow separation and uncommanded aileron deflection, as was the case in the ATR 72 accident. Photo C illustrates this condition on a NASA icing research aircraft after a FZRA encounter.

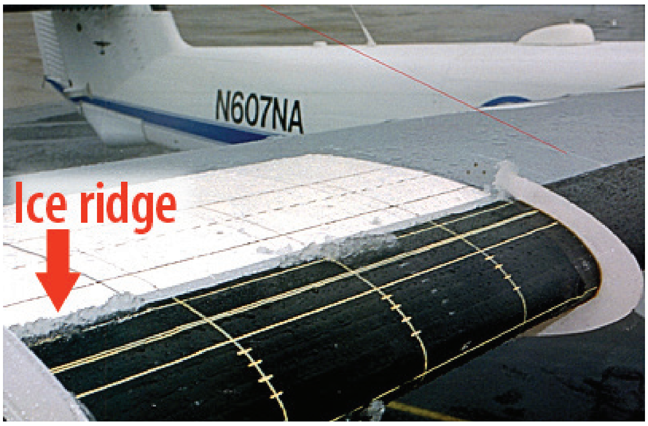


Photo C — Ice ridge on icing research aircraft from a freezing rain encounter, after much of the ice had melted and/or shed after landing

Ice formations from FZRA and FZDZ encounters can also accumulate on large non-lifting surfaces such as a propeller spinner, nose and other areas of the fuselage, greatly increasing drag and reducing aircraft climb and level flight performance. Photo D illustrates a FZRA accumulation on the nose of an aircraft.

Photo D — Freezing rain formation on the nose of an aircraft from a freezing rain encounter

Flight Research

In 1995 and 1996, the U.S. Federal Aviation Administration (FAA) sponsored in-flight icing conferences on SLD to determine if changes or modifications to existing aircraft icing certification rules were needed to improve flight safety.[8] As a result, the FAA developed a three-year plan for a joint flight research campaign with the NASA Glenn Research Center and the National Center for Atmospheric Research (NCAR). A team of specialists, including pilots, engineers and meteorologists, was assembled to conduct the research program. Three flight campaigns were conducted in the Cleveland area between 1996 and 1998. Later, additional tests were performed jointly with the National Research Council of Canada (NRC). The main objectives were to test and develop weather tools to diagnose and forecast the presence of SLD, to understand the effect of SLD on aircraft performance and to provide valuable comparison data for wind tunnel tests and numerical icing codes used for certification. To that end, NASA employed its de Havilland Canada DH-6 Twin Otter icing research aircraft, which was instrumented to measure and record icing conditions. NCAR provided meteorologists to forecast and direct the aircraft safely into SLD conditions, and the FAA provided program oversight and advocacy and served as the depository for the flight research data. In addition to the NASA/NCAR/FAA project, Environment Canada and the NRC completed similar flight projects with the NRC Convair 580 to collect and characterize the SLD atmospheric environment.[9]

Meteorological Flight Research

Ninety research flights were conducted by NASA over the three-year period, from which an extensive data base of SLD cloud conditions was made available to both domestic and international agencies for developing forecasting tools, testing standards and SLD instrumentation. Several important observations were made during the conduct of these flights, including:[10]

- In many cases, SLD encounters occurred in mixed-phase conditions where both cloud liquid water and ice crystals were present at the same time — a finding that also proved true for Appendix C icing clouds.[11]
- Cloud liquid water content in SLD conditions was less than that found in small droplet Appendix C conditions. This was likely due to the differences in the characteristics of small vs. large droplet concentrations and the fact that large drops tend to precipitate out of the clouds. Additionally, in-cloud visibility during an SLD encounter was usually better than in small droplet icing clouds.
- Small and large supercooled water droplets were commonly found to exist simultaneously within SLD clouds. In the vertical structure of these clouds, smaller droplets tended to dominate the higher portion of the cloud, while large drops tended to dominate the lower portion and were found both between cloud layers and beneath them.
- The climatological data for the past 30 years of observed freezing rain and freezing drizzle at the surface in the Cleveland area correlated well with monthly frequencies of SLD encounters during the flight research program. This is an important indicator of the value placed on these data for developing SLD forecasting tools — and to pilots who are trying to avoid these conditions.[12]

SLD Effects on Performance

NASA's standard methodology for measuring aircraft performance after an icing encounter ("Discoveries on Ice," ASW, 2/12) was employed after all meteorological data were collected and ice accretions had formed on the aircraft. Photos E and F show SLD accretions on the right wing of NASA's icing aircraft after two flights — one in FZDZ and one in FZRA. Significant increases in aircraft drag and loss of lift were measured in each condition.[12]

FZDZ resulted in a measured 41 percent reduction in maximum lift coefficient and a 33 percent increase in drag. FZRA resulted in a comparable level of lift loss, but the drag increase was double, largely due to extensive ice formations over much of the aircraft, as shown in Photo D. Notably, the performance losses measured in these two flights were unique to the SLD conditions encountered on those flights — and should not be considered representative of all SLD encounters experienced during the flight research program.[13] Regardless, these flights illustrated the potentially hazardous situation that can result from SLD encounters.

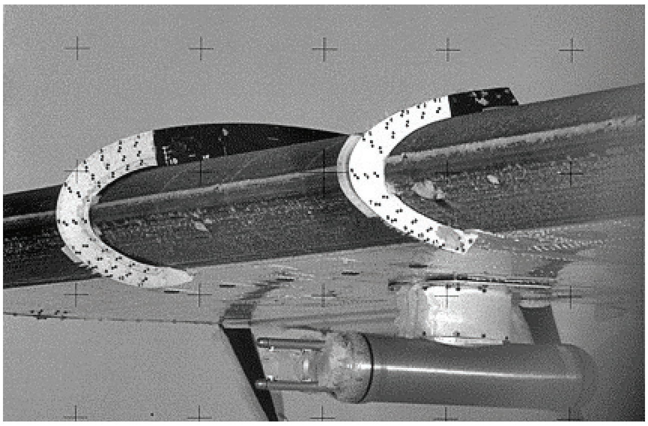


Photo E — Freezing drizzle accumulation on the wing of a NASA icing research aircraft

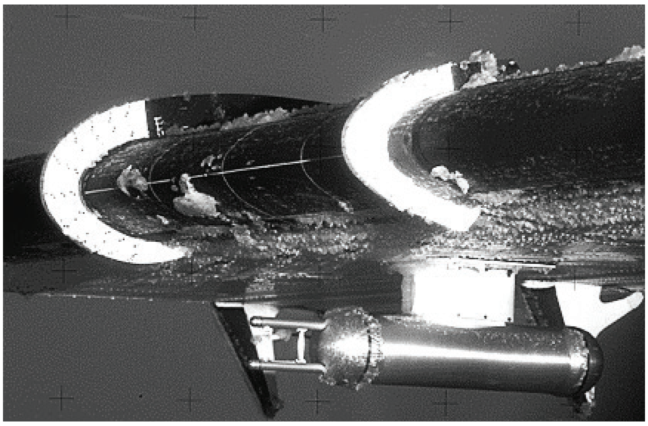


Photo F — Freezing rain accumulation on the wing of a NASA icing research aircraft

Outcomes

Thomas Ratvasky, who was the NASA lead project and flight test engineer for the SLD flight research program, said that the NASA/FAA and Canadian research flights, prompted by the ATR accident, made the aviation community more aware of the threat caused by SLD icing.

"The joint testing performed by NASA and the Environment and Climate Change Canada (formerly Atmospheric Environment Service) and the National Research Council Canada improved SLD cloud characterization, instrumentation and established international standards for data acquisition and analysis," Ratvasky said.

This icing flight data base allowed meteorologists at NCAR to use their forecasting and in-flight experience, as well as the cloud characterization data, to improve SLD weather forecasting techniques, including the development of the Current Icing Product (CIP) and Forecast Icing Product (FIP). These products, which are available free to the public, provide diagnoses and forecasts of icing conditions, including their probability, severity and the potential for SLD. The CIP and FIP products may be accessed via the Aviation Digital Data Service (ADDS) website <http://www.aviationweather.gov/icing>. This website also provides important information on how CIP/FIP products should be used.

The icing flight database was also provided to the FAA for use in developing new engineering standards related to airworthiness and means of compliance.

The U.S. National Transportation Safety Board (NTSB), in safety recommendations prompted by its investigation of the ATR accident and a subsequent accident that also involved flight in icing conditions, called on the FAA to "use a full range of icing conditions, including SLD, for icing certification testing. This would include freezing rain, freezing drizzle, and freezing mist."[14]

In 2014, the FAA issued Advisory Circular (AC) 25-28, which provides acceptable means of compliance under a new Appendix O icing condition, defining the SLD icing envelope. The same year, the FAA issued amendment 25-140 to FARs Part 25.1420, which provides for certification of transport category aircraft to operate in SLD.

"The research programs led to the development of weather diagnostic and forecast tools that currently enable aircraft to strategically avoid SLD conditions," Ratvasky said. "The research programs were also the basis for new certification standards so that new aircraft must be tested with shapes that can form in SLD encounters. Additionally, airplane flight manuals were updated to inform pilots of cues of SLD icing and procedures to mitigate the hazard if encountered. Although the ATR accident was tragic, the actions and processes that occurred since that time have reduced the likelihood of another tragic event."

Richard J. Ranaudo was a NASA research pilot for 25 years and the lead project test pilot in the icing research program for 16 years. After retiring from NASA, he spent five years as manager of Canadair flight test programs and conducted icing development and certification testing on prototype business and regional aircraft.

Acknowledgement

Thomas P. Ratvasky of NASA and Ben C. Bernstein, formerly of NCAR and now with Leading Edge Atmospherics, were central figures and technical experts in the conduct of the joint NASA/NCAR/FAA SLD flight research program. They were in large part responsible for safe and successful execution of the program.

Notes

1. NTSB. NTSB/AAR-96/02, In-Flight Icing Encounter and Loss of Control; Simmons Airlines, American Eagle Flight 4184; Roselawn, Indiana; October 31, 1994.

2. Leary, W.M. NASA SP-2002-4226, We Freeze to Please, p. 1–61.

3. Hareland, G.A. "Evaluation of Flour Particle Size Distribution by Laser Diffraction, Sieve Analysis and Near-Infrared Reflectance Spectroscopy." Journal of Cereal Science, Volume 20 (September 1994): 183–190.

4. Ben C. Bernstein, a meteorologist with Leading Edge Atmospherics, suggests that typical droplet sizes in each category are around 0.02 mm, 0.2 mm and 2 mm (0.00078 in, 0.0078 in and 0.078 in).

5. Bernstein, B.C.; Ratvasky, T.P.; Miller, D.R.; McDonough, F. NASA/TM–2000-210058, "Freezing Rain as an In-Flight Icing Hazard." June 2000.

6. Huffman, G.J.; Norman, G.A. Jr. "The Supercooled Warm Rain Process and the Specification of Freezing Precipitation." Monthly Weather Review Volume 116 (November 1988): 2172–2182.

7. Bernstein, B.C. "Icing Meteorology." Prepared for Embry Riddle University Aircraft Icing Short Course, Leading Edge Atmospherics, August 2015.

8. FAA. "FAA Inflight Aircraft Icing Research Plan." April 1997.

9. Personal communication with Ratvasky, Thomas P.

10. Miller, D.R.; Ratvasky, T.P.; Bernstein, B.; McDonough, F.; Strapp, W.J. NASA/TM–1998-206620, "NASA/FAA/NCAR Supercooled Icing Flight Research: Summary of 1996–97 Winter Flight Operations." January 1998.

11. Personal communication with Bernstein, Ben C.

12. Ratvasky, T.P., "NASA Icing Flight Research with Performance and Stability and Control Considerations." UTSI Aircraft Icing Short Course, Sept. 21, 2010.

13. Personal conversation with Ratvasky, Thomas P.

14. Hersman, Deborah A.P. Testimony before the aviation subcommittee of the Committee on Transportation and Infrastructure, U.S. House of Representatives. Washington. Feb. 24, 2010.

15. FAA. AC 25-28, Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions. Oct. 27, 2014.

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