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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: First flight of the A330 FSTA. Airbus Military 2010©

Past Aviation accidents – Have we picked all the 'Low hanging fruit'?

by Rich Jones, Chief Executive UKFSC

As 2010 draws to a close, it would be timely to reflect on the past year in commercial aviation safety. In overall terms, the number of accidents involving western built aircraft has continued to climb gently since its nadir in 2006. According to FSF figures, there have been 17 serious commercial airline jet accidents so far this year. More detailed analysis reveals that 14 of these occurred during the approach and landing phase and five significant runway excursion incidents. In addition, there have been two loss of control and two controlled flight into terrain accidents. Although the number of turbo prop accidents has, unusually, been less than those in the jet fleets; it has been, all in all, an average year!

As we continue to seek the holy grail which will start to push the accident statistics off the stubborn but gently undulating plateau of the past 7 years or more, and reflected upon this year's approach and landing accidents and major runway excursions, I was reminded of the premise of a presentation given at the International Aviation Safety Seminar in 2009 by Robert Mackintosh. His theme was 'Is the low hanging fruit really all gone?' In essence, he posed the following questions:

- Does our current accident history reflect missed opportunities?
- Do we sometimes suffer from the effect of collective amnesia?

We all support safety data collection for proactive and predictive measures. HOWEVER, much can also be learned from the past since study of aviation accident history continues to offer the easily obtainable "low hanging fruit" for future accident prevention.

Applying this to Runway Excursions, Robert went on to postulate that there is a vast amount of professional guidance on approach and landing accidents, including runway excursions, readily and freely available for every airline operator, large of small, affiliated or independent. The 2010 Flight Safety Foundation ALAR and the IATA Runway Excursion Risk Reduction toolkits are both full of invaluable advice and information from which any commercial pilot, young or old, could benefit.

In a nutshell, a stabilised approach from a sterile cockpit environment, with the option and expectation of a no blame go-around, with main gear contact in the designated touchdown point will result in an uneventful arrival!

Unknowingly but uncannily, Robert then went on in his 2009 presentation to apply safety lessons from the past to another 2010 accident statistic, that of Loss of Control.

Many flight crews will recall the adage 'whatever else happens, fly the aeroplane first' from their early training experience. It remains sound advice. It applies in transport aircraft operations during any abnormal situation such as loss of thrust, runaway trim, autopilot deviations or flight control computer deviations. The number one task is to "maintain aircraft control". The situation may be a very significant challenge immediately at lift off or when required to hand fly an aircraft in the corner of the performance envelope at FL390. However, with sufficient aerodynamic knowledge and competent training, flight crews must be able to deal with these situations and bring them to a successful conclusion on a regular basis.

But these lessons from the past are not the exclusive territory of the flight deck. Top management must set the culture; the training departments must address the known historical risks and deficiencies as well as those that are newly emerging; the chief pilot and quality control engineer must set the professional tone. And those at the sharp end, aircrew, ground engineers and support staff, must derive full benefit from knowledge of prior events, understand the rationale behind SOP compliance and modify their performance to minimize the known risks and thereby avoid the unfortunate experience of others.

In conclusion, there remains significant value to everyone in the industry in continuing to exploit "low hanging fruit" of past accidents and to reiterate principles to meet today's safety challenges.

Do we need pilots?

by Capt. Tony Wride, Monarch Airlines

Every so often I hear something that makes me laugh out loud because it's such a good joke. I had a similar reaction recently when I heard a novel idea which suggested that a commercial aircraft could be flown by a single pilot and that a cabin crew member could be trained to land the aircraft if the lone pilot was incapacitated! A sort of Standby pilot! Without wishing to suggest that cabin crew couldn't be trained to land an aircraft, I do wonder if those floating this concept actually understand what is involved in flying a modern commercial aircraft, particularly when things go wrong or when faced with challenging weather scenarios.

The comment that for the majority of the time the aircraft flies itself and the pilots read the papers may be close to the truth but this fails to take into account the important, high risk, times like take-off and landing or dealing with system failures. Maybe those promoting the single pilot proposition should try landing a B737 into a minor airport in poor weather with minimal navigation aids on one engine to appreciate why we need highly trained professional pilots.

Pilots are trained to deal with all sorts of scenarios and keep the aircraft, with its 'low fare' paying passengers, safe. To a pilot, safety is the primary focus not profit which is how it should always be despite the financial pressures placed on the aviation industry. Part of the safe operation of an aircraft relies on the TWO pilots working as a team and cross checking each other, so having a single pilot would remove this vital safeguard. Unfortunately we humans are fallible and we do make **"mistucks"!** A single pilot with no one monitoring their actions would seriously jeopardise safety.

Dealing with the unexpected is also something that pilots train for or if not trained are generally good at doing. The quick actions of the crew of the B737 that ingested a large number of birds into both engines on short finals to an airport in Italy prevented a fatal crash. The Hudson River incident is another example of a crew dealing with the unexpected and saving the lives of the passengers. I wonder how a partially trained 'standby' pilot would have coped? Recently the pilots of a Qantas A380 had to deal with a major, uncontained, engine failure that damaged the wing and caused a fuel leak. The pilots, plural, worked as a team to deal with the difficult failure and safely landed the aircraft back in Singapore. Could a single pilot have done the same?

Another aspect is that of carrying enough fuel so that the 'standby' pilot could get to an airport where they could use the automatics to help land. Add in a hydraulic failure, engine fire, decompression, electrical failure, or any number of challenging 'problems' that pilots are trained to deal with and the proposition gets even more riskier!

Having discussed the proposal and hopefully proved that it would be an unsafe concept I'm going to take a leap into the future and suggest that perhaps at some point it could become a reality and could even go further by having no pilots flying a commercial airliner!

At a recent BALPA 'Emerging Technologies' symposium I listened to a series of presentations that got me thinking. The first was by an Airbus test pilot who showed some of the automatic features developed for the A380 and being developed for the A350. He made the comment that these improvements were designed to assist the pilots, plural, and improve safety. Next came a couple of presentations on UAVs, Unmanned Aerial Vehicles, that showed how they were controlled from the ground and the 'smart' software being developed for them. Basically the UAVs are controlled by a base station operative/pilot who can be some distance away provided the datalink can be maintained. Take this technology on a few years and you could have a commercial aircraft being controlled remotely via a datalink! In fact what you could do is get the aircraft airborne and then hand it over to ATC who would be able to give the aircraft instructions which the automatics would then follow. On arrival at the airport the Approach controller would simply tell the aircraft to prepare for landing and set it up for final approach! The ground movement might be interesting especially trying to get an automatic ramp vehicle avoidance system to work.

The only problem with the unmanned aircraft is the unexpected failure or the severe weather situation previously mentioned. However, as computer technology advances, are we that far away from the Cyberdyne T1001 pilot (nicknamed Arnie Sullenberger) who keeps saying "I'll be back" and is programmed to deal with any emergency situation! Could we ever produce a computer that is as flexible as a human and able to deal with the 'curved ball'?

What makes a good pilot is a degree of aptitude, coupled with good training and an ever increasing experience level to enable them to deal with the unexpected. If all of that can be programmed into a machine then maybe the 'expensive' pilots will become a thing of the past and the proponents of the single pilot concept will turn out to be prophets!

In the early days of Commercial air travel the cockpit had a large team, (2 pilots, a Flight Engineer, a Navigator, and maybe even a Radio Operator). As technology progressed the numbers have gradually decreased to get to where we are now with just the two pilots and lots of computers. Could that number get any lower? To maintain an acceptable level of safety I believe that, for now, 2 is the lowest number that should be on the flight deck. In 20 years, who knows?

Contaminated and Closed

Will U.K. airports be ready for another winter onslaught?

by David Thomas

Last winter's unusually heavy snowfall caused major disruptions at most U.K. airports. Many scheduled airlines were obliged to cancel services, while charter airlines continued to fly, albeit with substantial delays. The financial implications for the airline and airport operators are still difficult to gauge. However, with the benefit of hindsight, could the current U.K. practices regarding operations with contaminated runways be improved?

The U.K. Civil Aviation Authority (CAA) currently complies with International Civil Aviation Organization (ICAO) recommendations that operations on contaminated runways should be the exception and not the norm. U.K. airports have a "back to black" policy, which means that contaminated runways must be cleared and then treated with deicing/anti-icing fluid to prevent further contamination. However, this may not always be practical; tactical decisions on runway closure are not taken lightly and are difficult to predict. Traditionally, our benign winters and maritime airflow have rarely put this policy to the test.

Uncertainty

So, what information can pilots rely on when making decisions about operating on runways that are not dry? Currently, U.K. Civil Aviation Publications (CAP) 493, *Manual of Air Traffic Services*, states that braking action reports must be issued in plain language for compacted snow and ice – for example, as "good," "medium" or "poor." This is derived

Table 1

Runway Friction Measurements		
Measured or Calculated Coefficient of Friction	**Estimated Braking Action**	**MOTNE METAR Code**
0.40 and above	Good	95
0.39 - 0.36	Medium/Good	94
0.35 - 0.30	Medium	93
0.29 - 0.26	Medium/Poor	92
0.25 and below	Poor	91
If for any reason the reading is considered unreliable	–	99

MOTNE = Meteorological Operational Telecommunication Network Europe; METAR = aviation routine weather report
Source: U.K. Civil Aviation Publication 493

from a matrix based on friction measuring devices first developed in 1959 by the Nordic countries and later adopted by ICAO (Table 1).[1] CAP 493 also says that friction measuring devices can produce inaccurate readings in conditions of slush and thin deposits of wet snow – a phenomenon highlighted by an operators' bulletin issued by the U.K. CAA in 2006.[2]

It has been known for some years that readings by friction measuring devices do not necessarily reflect the braking performance of a modern airliner and that the devices can produce differing results. The Norwegian Accident Investigation Board has found that measurements can vary by 0.10 with dry contaminants and by 0.20 with wet contaminants. These issues are currently being addressed by research committees formed by ICAO, the European Aviation Safety Agency, the. U.S. Federal Aviation Administration (FAA) and others.

So, where do we stand with regard to braking action reports if the runway is contaminated with something other than compacted snow or ice? The answer lies in CAP 493: "In conditions of slush or thin deposits of wet snow, friction measuring devices can produce inaccurate readings. [Therefore,] no plain language estimates of braking action derived from those readings shall be passed to pilots' Does this matter if the airport always clears the runway surface? The answer is yes. There can be a period of uncertainty from the time the runway begins to become contaminated to the time the airport decides to close it. Likewise, when the runway is reopened, it probably will be wet with deicing/anti-icing fluid, which should equate to a braking action of "good" However, under certain narrow temperature-dew point splits at or below freezing, ice can form when the deicing/ anti-icing fluid starts to break down, which may reduce the braking action to "poor" In these scenarios, the crew will have to make an assessment of the likely runway braking action without any meaningful data. Snow notice to airmen (SNOWTAM) code 9" and European aviation routine weather report (METAR) codes "//" and "99" indicate that runway friction measurements are "unreliable".

Consequently, should we ask the regulator to rewrite CAP 493 to allow braking reports to be passed to pilots under all conditions? The Norwegian CAA already has done this by adapting the ICAO recommendations to the Norwegian winter climate. This has enabled the Norwegian airport operator Avinor to develop a reporting matrix for its own environmental conditions. Airport personnel are trained to make an assessment based on a visual inspection of the runway to measure the contaminant, friction measurements (which cannot be solely relied upon), current weather conditions and runway maintenance activities such as treatment with deicing/anti-icing fluid, sand, etc. After the results of the assessment are interpreted using the matrix, a braking action report is produced for pilots. This has not solved the problem completely; Norway still has runway excursions. However, Avinor continues to develop tools to deal with this complex subject, the most recent being the Integrated Runway Information System, a computer program that will aid airport personnel in assessing the runway state and braking action, based on automatic meteorological measurements.

Across the Pond

On the other side of the ocean, the philosophy with regard to braking action reports differs between the FAA and Transport Canada (TC). The FAA recognizes the difficulty of assessing the surface condition of contaminated runways and reporting the information to pilots. It also acknowledges that the data provided by friction measuring devices do not necessarily represent aircraft braking performance. Consequently, the FAA recently recommended that airport operators no longer provide Mu readings (measured friction coefficients) to pilots. It believes that pilot weather reports (PIREPs) are an invaluable source of information for pilots and should be used in support of runway condition reports. After the Chicago Midway runway excursion in 2005 Air Safety World the FAA set up a workshop on runway condition reporting. Participants developed a table that correlates braking action reports with estimated runway surface conditions

Table 2

Braking Action Correlations*

Breaking Action		Estimated Correlations		ICAO
Term	**Definition**	**Runway Surface Condition**	**Code**	**Mu**
Good	Braking deceleration is normal for the wheel braking effort applied. Directional control is normal.	Water depth of 1/8 in or less Dry snow less than 3/4 in depth Compacted snow with OAT at or below -15°c	5	40 and above
Good to Medium		–	4	39-36
Medium (Fair)	Braking deceleration is noticeably reduced for the wheel braking effort applied. Directional control may be slightly reduced.	Dry snow 3/4 in or greater in depth Sanded snow Sanded ice Compacted snow with OAT above -15°c	3	35-30
Medium to Poor		–	2	29-26
Poor	Braking deceleration is significantly reduced for the wheel braking effort applied. Potential for hydroplaning exists. Directional control may be significantly reduced.	Wet snow Slush Water depth more than 1/8 in Ice (not melting)	1	25-21
Nil	Braking deceleration is minimal to non-existent for the wheel braking effort applied. Directional control may be uncertain. **Note:** *Taxi, takeoff and landing operations in nil conditions are prohibited.*	Ice (melting) Wet ice	–	20 and below

ICAO = International Civil Aviation Organization; OAT = outside air temperature
*The correlations are estimates, only. Mu valves – reported runway friction coefficients – can vary significantly

Source: Boeing Commercial Airplanes

(Table 2). The table has been provided to pilots by Boeing and is now used by a number of U.K. airlines.

TC has eliminated some of the issues caused by conflicting readings from friction measuring devices by using only decelerometers. The measurements conform to Canadian Runway Friction Index (CRFI) values comprising mostly fractions from 0 to 1, with 1 being theoretically equivalent to maximum friction on a dry runway. Although TC has considerable confidence in this system, some contaminants, including slush and loose snow, remain outside the system's capabilities. The Transportation Safety Board of Canada (TSB) forwarded an aviation safety advisory to TC after a runway excursion in 2002.[3] As a result of the recommendations made in the advisory, TC now highlights the limitations of runway surface condition reports and CRFI reports; particularly when ambient temperatures are near freezing.

Contaminated runway operations will always be the exception in the United Kingdom due to our climate, and clearing should be the first option. However, when operating under SNOWTAM code 9 or METAR codes // or 99, crews should be provided with a similar level of safety from the airport operator as would be expected under normal conditions. This is something British crews are likely to receive when operating at airfields with traditionally harsher winters. Unless the regulator changes its policy on when braking action reports can be issued, airport operators are unlikely to invest in new tools to help assess braking action. The easy option is to continue with the status quo and hope last winter was one in a million. However, if it was not and next winter we have a serious runway excursion, who will be accountable?

David Thomas is a captain for Thomas Cook Airlines. This article originally was published by the British Airline Pilots Association in its bimonthly journal, "The Log."

Notes

1. Friction measuring devices include continuous friction measuring equipment and spot measuring equipment (decelerometers).
2. U.K. CAA. Flight Operations Division Communication (FODCOM) 19/2006, Winter Operations. Oct. 30, 2006.
3. TSB Aviation Investigation Report A02A0038. Runway Excursion: Air Canada Regional Airlines (Jazz) Fokker F-26 MK1000, C-FCRK, Saint John, New Brunswick, 27 March 2002.

The Author has been involved in the Winter Information Group at the CAA. The CAA have now issued additional information on Winter Operations in section 14 of NOTAL 2010/09 and section 1.2 of FOD 27/2010.

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Back to basics? – A commentary on the management of Airworthiness

by Neil Richardson – Senior Consultant - Baines Simmons Ltd

The modern day challenges faced by the aviation industry are plenty; many focus on the performance of human beings in complex systems. Appropriate behaviour of personnel is key to contributing to systemic safety, but this requires a clear understanding of not only Human Factors, but also the basic concepts of, and relationships between, Airworthiness and Maintenance. In a world where non-compliance with rules and standards is still a major issue, how many of these unsafe acts can be attributed to insufficient knowledge of how the system within which they work was designed to operate?

This paper examines whether a gap exists between the Maintenance Programme and the Maintenance Organisation's output, i.e. between Airworthiness (Part M) and Maintenance (Part 145). It proposes that the foundations upon which the concepts of Airworthiness are built seem to have been lost (or never fully implemented) and questions whether there is a need for industry to go "back to basics" in terms of the knowledge and understanding of the two functions.

Where are the problems?

Problems resulting from misunderstanding the relationships within the approval system vary, are numerous, and exist at all levels within organisations. From the Part M organisation not supplying correct information to the Maintenance Organisation in time or at all, to the technical records staff seeing their role as 'just a clerk', to the maintenance technician feeling that the data limits are a guide only and that a deviation can be justified based upon experience. Such mindsets can be argued to result from insufficient awareness of how the system is designed to operate.

The European Commission Regulation 2042/2003 provides clear lines of responsibility for those organisations involved in Managing Continuing Airworthiness (Annex I (Part M)) and those involved in Maintenance (Annex II (Part145)) yet the relationship between these requirements is often lost in translation. The Operator's Continuing Airworthiness Management Organisation (CAMO) is responsible for ensuring that a contract is in place between such organisations and this key document should then play a pivotal role in how the maintenance activity is performed. It is common however, for the contract to focus mainly on commercial, rather than "technical", aspects, and in some cases, loss of a contract is used as a bargaining tool or threat, rather than setting out how each party will contribute to the overall objective of ensuring airworthiness.

Without the correct focus on the basic understanding of the system as a whole, unfounded myths and beliefs will prevail, exacerbated by inappropriate operator behaviours that are not in line with the contract or regulation. In the event of unforeseen circumstances, these unwanted behaviours can leave the operator and maintenance organisation exposed.

What is meant by "Airworthiness"?

The terms "airworthy" and "airworthiness" are used throughout ICAO, EU and national standards; however none of these provides a definition of what is meant by them. For the purposes of this paper, we shall assume the following, developed from a UK Ministry of Defence definition:

"Airworthiness is the ability of an aircraft or other airborne equipment or system to operate without significant hazard to flight and cabin crew, ground crew, passengers, cargo or mail (where relevant) or to the general public and property over which such airborne systems are flown."

So what does that look like from a regulatory perspective? Part M specifies the elements that contribute to Airworthiness and, as illustrated, Airworthiness is more than just maintenance.

Certain elements of Airworthiness are either accomplished directly or influenced by the performance of maintenance, yet in some cases these stand in isolation and lose their connection with the greater airworthiness management system.

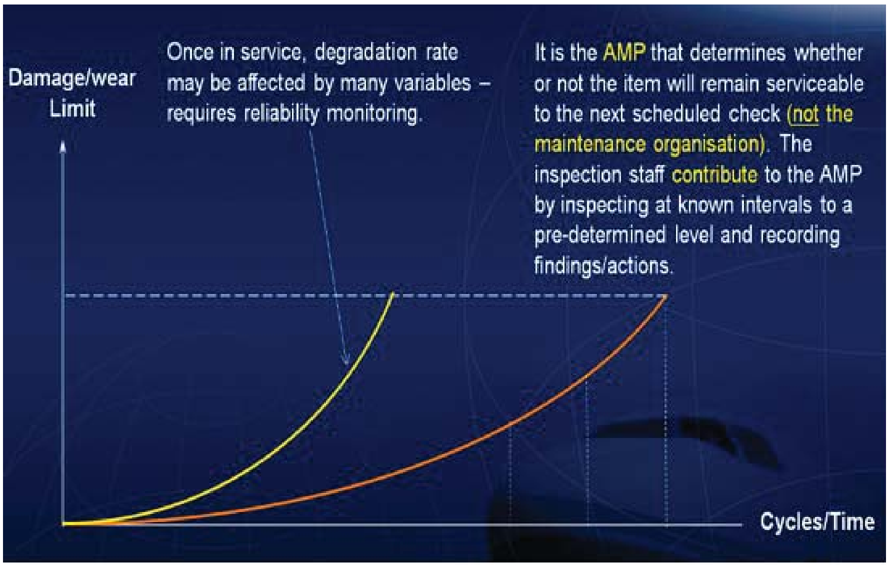
The overall responsibility for ensuring these elements are accomplished lies with the CAMO. The Maintenance activities that contribute to Airworthiness must be performed by Approved Maintenance Organisations. It must therefore be clear and unambiguous what is required of those organisations – something provided for by the contract.

What is meant by "Maintenance"?

This sounds like a simple question to answer, however the objectives of maintenance are varied. For example, scheduled maintenance serves to:

- confirm realisation of the inherent safety and reliability levels of the aircraft (as determined by design);

- restore safety and reliability to their inherent levels should deterioration occur;
- obtain information required for re-design in light of system inadequacies;
- and accomplish this at a minimum total cost.



The link between the two functions is the Maintenance Programme; a Part M requirement, which should reflect the needs of the operator's aircraft as driven by data collected via the reliability programme. The Maintenance Organisation performs the required Maintenance tasks as determined by the Programme and contracted by the operator.

That is the concept of the system in a nutshell. It is still a common belief amongst maintenance staff, however, that it is they that are solely responsible for the Airworthiness of the aircraft. This is often reinforced and perpetuated by technical representatives who manage the interface between the CAMO and the Maintenance Organisation, many of whom have a Maintenance, rather than an Airworthiness, background.

How does Maintenance affect Airworthiness?

Experience has shown that many maintenance personnel still feel that it is appropriate to make a judgement on an item: for example not changing a component that is just out of limits based upon previous experience or, conversely, changing an item close to limits even though its degradation since last inspection may be zero. The former example, to some, may be

seen as qualified, experienced staff using engineering judgement and that is what they are paid for. The latter may raise eyebrows and of course best practice would dictate that it is brought to the operator's attention to decide on a course of action after reviewing the records. Given the principles of Airworthiness, however, it would be very difficult for an inspector within a Maintenance organisation, who at the time of inspection sees only a snapshot and not the full Airworthiness picture, to satisfactorily make an accurate judgement on whether an item would remain serviceable until the next planned inspection. Such a judgement would require knowledge of the specific degradation rate and the failure modes and effects of the item. Having the 'next due date' on the work card would not be sufficient information from which a judgement can be made; data such as utilisation, operational profile, environmental considerations, wear rates, and so forth would all need to be considered; which is something that can only be achieved through the CAMO (assuming effective Part M management). Such data are fed into the Maintenance Programme and whether an item will remain serviceable to the next check will be determined by the Maintenance Programme.

The inspector's contribution is to inspect at a known interval, to a pre-determined inspection standard and compare any findings the limits defined in applicable maintenance data, for example, the Aircraft Maintenance Manual. The inspection intensity (distance and inspection aids) and conditions (lighting, access and cleanliness) will effectively dictate the threshold for reportable defects. These criteria are carefully selected, based on the design criteria, critically of each item and maintenance and operational economics. Inspection staff must not be permitted to deviate from such limits, unless authorised through a company procedure, involving the CAMO.

The tragic accident involving an Alaska Airlines' MD-83 in January 2000 revealed many failings, including failure to consider degradation rates effectively. The subsequent investigation by the National Transportation Safety Board determined that inadequate maintenance and insufficient lubrication led to excessive wear and catastrophic in-flight failure of the threads of horizontal stabiliser trim system jackscrew assembly's acme nut. What was not considered at the time by the Maintenance Organisation was the fact that historic maintenance on the affected item

was sub-standard and in conjunction with other failures (some the fault of the operator), the degradation rate was increasing. The two worlds came together on that day and the outcome was catastrophic.

Why do these problems exist?

The world of perceived or real commercial pressure, as we know, does lead to some well-intentioned yet potentially unsafe acts being committed. Yet, the question of how many of these acts are due to insufficient basic knowledge of "the system", remains unanswered. A recently overheard conversation in a restaurant between two maintenance technicians prompted a discussion that began to explore that question. To summarise the debate, one of the technicians was encouraging the other to consider becoming certifying staff. 'I would not know what to look for' stated the less experienced technician. The response was alarming: 'You soon pick it up – you know what to look for and what you can get away with'. The conversation continued and revealed more examples of maintenance staff making judgements, based on experience, yet clearly well beyond the limits of the applicable maintenance data. In this case, rivets as per the drawing, were not available, so the certifier decided, whilst eating his dinner, that he would fit 'alternatives'. This behaviour clearly begins to move the degradation curve away from that expected, making future 'judgements' potentially lethal.

So, was this being unprofessional? Some would argue yes, but in mitigation, how many other technicians in the organisation would have acted in the same manner? Did the Maintenance Organisation fail the technician by not providing the right parts? It would appear from the conversation that this was indeed the case. Would the customer have reacted inappropriately if the technician had behaved assertively and not agreed to certify the task? Recent experience indicates that this is not unheard of. How much was down to the operator, the Maintenance Organisation, and/or the Technician not understanding the basic principles of Airworthiness? A rhetorical question.

Many issues that are seen today, it may be argued, could be linked back to this gap in our knowledge. Further examples:

- The classic sign off 'SATIS', which means little to the CAMO when trying to determine degradation rates (as opposed to recording measured dimensions, tolerances, and so forth),
- Considering "greasing" as a mundane task, rather than one preventing a failure mode of, possibly, a safety critical item,
- Provision of parts direct to the technician from the operator, thereby bypassing the goods-in process,
- Pressure put upon maintenance staff to not 'look too hard' or 'snag' too much.

All of these 'minor' transgressions ultimately lead to a change in the degradation rates or the economic basis of the Maintenance Programme. Reliability, based upon analysis of data and maintenance findings, should detect trends and yet if defects are being 'let go', then the validity of the data is flawed, undermining the trends, and the effectiveness of the overall Maintenance Programme. Quite simply, the system assumes (i.e. is predicated upon) the Maintenance Organisation fulfils its responsibilities; that is, to the contract and to the standard. If the operator requires a different standard to be applied this must be reflected in its Maintenance Programme, thus putting the responsibility in the right place.

Bring into the equation the organisations that manage lease hand-backs on behalf of the operator and the need to understand the basics becomes even more evident. The recent event over Clacton involving a 737 on a post-maintenance check flight appears to highlight this need adequately. During the hydraulic power off test, which was required due to elevator tab adjustments having been performed, the aircraft entered an unexpected descent, achieving at one stage a descent rate of 21,000ft per minute. Whilst the final report has yet to be issued, the interim report suggests that the interface between the CAMO and Maintenance Organisation, which appears to have been managed by a third party (the lease hand-back organisation), could have been handled more effectively. Would a more comprehensive understanding of the principles of "the system", by the personnel and organisations involved, have influenced behaviour and therefore the outcome?

In conclusion – How can we close this gap?

Many options appear open to industry, for example the aircraft maintenance licence requirements of Part 66 could be enhanced to include an 'Airworthiness' module that explores the approval system, the concepts of Airworthiness, the responsibilities and how these are achieved. Similarly, degree courses could include the very same to capture people entering the industry via the academic route. For existing members of industry, Maintenance Organisations and CAMOs could include such a module in their induction training and certifying staff could be captured either through continuation training or at authorisation issue/renewal. The AMC/Guidance Material for Part M could be developed to highlight the fact that the technical representative fulfils a Continuing Airworthiness function and any maintenance bias needs to be tempered.

Hence it would appear that there is plenty of room for manoeuvre to be able to bridge this gap between Airworthiness and Maintenance, and the personnel/organisations involved.

Footnote

It would be hoped that an effective error management programme would identify such issues within organisations, yet the requirements for this are currently only applicable to Maintenance Organisations, rather than CAMOs. But that's another debate.

Pilot Fatigue – fatigue and flight operations

by Dr Samuel Strauss

Fatigue is a threat to aviation safety because of the impairments in alertness and performance it creates. "Fatigue" is defined as "a non-pathologic state resulting in a decreased ability to maintain function or workload due to mental or physical stress.

"The term used to describe a range of experiences from sleepy, or tired, to exhausted. There are two major physiological phenomena that have been demonstrated to create fatigue: sleep loss and circadian rhythm disruption.

Fatigue is a normal response to many conditions common to flight operations because of sleep loss, shift work, and long duty cycles. It has significant physiological and performance consequences because it is essential that all flight crew members remain alert and contribute to flight safety by their actions, observations and communications. The only effective treatment for fatigue is adequate sleep[1].

In a National Transportation Safety Board (NTSB) safety study of US major carrier accidents involving flight crew from 1978 to 1990, one finding directly addressed the concern about fatigue. It stated: "Half the captains for whom data were available had been awake for more than 12 hours prior to their accidents. Half the first officers had been awake for more than 11 hours. Crews comprising captains and first officers whose time since awake was above the median for their crew position made more errors overall, and significantly more procedural and tactical decision errors."[2]

An example of fatigue as a probable cause of a US commercial aircraft accident occurred on August 18th, 1993 in Guantanamo Bay, Cuba involving a DC-8. Impact forces and post-accident fire destroyed the aeroplane, and the three flight crew members sustained serious injuries. Visual meteorological conditions prevailed, and an instrument flight rules plan had been filed.

The following is the NTSB summary report:

"The aeroplane collided with terrain approximately 1/4 miles from he approach end of the runway after the Captain lost control of the aeroplane. Flight crew had experienced a disruption of circadian rhythms and sleep loss; had been on duty about 18 hours and had flown approximately 9 hours. Captain did not recognise deteriorating flight path and airspeed conditions due to preoccupation with locating strobe light on ground. Strobe light, used as visual reference during approach. Inoperative; crew not advised. Repeated callouts by flight engineer stating slow airspeed conditions went unheeded by the Captain.

The Captain initiated turn from base leg to final at airspeed below calculated VREF of 147 kts, and less than 1000 ft from the shoreline, and he allowed bank angles in excess of 50 degrees to develop. Stall warning stick shaker activated 7 seconds prior to impact, 5 seconds before aeroplane reached stall speed. No evidence to indicate Captain attempted to take proper corrective action at the onset of stick shaker. Operator's management structure and philosophy were insufficient to maintain vigilant oversight and control of the rapidly expanding airline operation.

Probable Cause

The impaired judgement, decision-making, and flying abilities of the Captain and flight crew due to the effect of fatigue; the Captain's failure to properly assess the conditions for landing and maintaining vigilant situational awareness of the aeroplane while manoeuvring onto final approach; his failure to prevent the loss of airspeed and avoid a stall while in a steep bank turn; and his failure to execute immediate action to recover from a stall.

Additional factors contributing to the cause were inadequacy of the flight and duty time regulations applied to 14 CFR, part 121, supplemental air carrier, international operations, and the circumstances that resulted in the extended flight/duty hours and fatigue of the flight crew members. Also contributing were the inadequate crew resource management training and the inadequate training and guidance by the airline, to the flight crew for operations at special airports, such as Guantanamo Bay; and the Navy's failure to provide a system that would assure that the local tower controller was aware of the in operative strobe light so as to provide the flight crew such information"
(NTSB report AAR-94/04, adopted 5/10/94)

When the sleep patterns of this flight crew were analysed, it was found that the entire crew suffered from cumulative sleep loss. They worked under an extended period of continuous wakefulness, and slept at times opposite to their normal circadian sleep patterns. The accident occurred in the afternoon, at the time of their maximum physiological sleepiness[2].

Sleep and sleep loss

Sleep is a vital physiological function. Like food and water, sleep is necessary for survival. Sleepiness results when sleep loss occurs. Like hunger and thirst, sleepiness is the brain's signal that sleep is needed. "Sleep loss" describes the phenomenon of getting less sleep than is needed for maximal waking performance and alertness.

If an individual normally needs 8 hours of sleep to feel completely alert, and gets only 6 hours of sleep, 2 hours of sleep loss has been incurred. Sleep loss over successive days accumulates into a "sleep debt." If the individual needing 8 hours of sleep gets only 6 hours a night for 4 nights in a row, an 8 hours sleep debt has been accumulated. The negative effects of one night of sleep loss are compounded by subsequent sleep loss. Sleep loss and the resultant sleepiness can degrade most aspects of human performance. In the laboratory, it has been demonstrated that losing as little as 2 hours of sleep can negatively affect alertness and performance. Performance effects include: degraded judgment, situation awareness, decision-making, and memory; slowed reaction time; lack of concentration; fixation; and worsened mood.

Other effects are decreased work efficiency, degraded crew coordination, reduced motivation, decreased vigilance, and increased variability of work performance. The brain is programmed for two periods of maximal sleepiness every 24 hours from about 3-5 am and 3-5 pm [3].

Symptoms and effects of fatigue

Conditions which contribute to fatigue include the time since awake, the amount of time doing the task, sleep debt, and circadian rhythm disruption. As fatigue progresses it is responsible for increased errors of omission, followed by errors of commission, and micro-sleeps. "Microsleeps" is characterized by involuntary sleep lapses lasting from a few seconds to a few minutes [3].

For obvious reasons, errors or "short absences" can have significant hazardous consequences in the aviation environment.

Many of the unique characteristics of the flight deck environment make pilots particularly susceptible to fatigue. Contributing aircraft environmental factors include movement restriction, variable airflow, low barometric pressure and humidity, noise, and vibration.

In commercial aircraft, hands on flying has been mostly replaced by greater demands on the flight crew to perform vigilant monitoring of multiple flight systems. Research has demonstrated that monotonous vigilance tasks decreased alertness by 80% in one hour [4].

Fatigue and sleepiness may be less evident to a pilot due to stimuli such as noise, physical activity, caffeine, nicotine, thirst, hunger, excitement, and interesting conversation.

Sleep-deprived pilots may not notice sleepiness or other fatigue symptoms during preflight and departure flight operations. However once underway and established on altitude and heading, sleepiness and other fatigue symptoms tend to manifest themselves.

When extreme, fatigue can cause uncontrolled and involuntary shutdown of the brain. That is, regardless of motivation, professionalism, or training, an individual who is extremely sleepy can lapse into sleep at any time, despite the potential consequences of inattention. Transportation incidents and accidents, such as the one cited above provide dramatic examples of this fact.

This phenomenon is often referred to as "boredom fatigue"

Circadian rhythms

"Circadian rhythms" are physiological and behavioural processes, such as sleep/wake, digestion, hormone secretion, and activity, that oscillate on a 25 hour basis. Each rhythm has a peak and a low point during every day/night cycle. Time cues, called "zeitgebers," keep the circadian "clock" set to the appropriate time of day. Common zeitgebers include daylight, meals and work/rest schedules. If the circadian clock is moved to a different schedule, for example when crossing time zones or changing from a day work shift to a night shift, the resulting "sleep phase shift" requires a certain amount of time to adjust to the new schedule. This amount of time depends on the number of hours the schedule is shifted, and the direction of the shift. During this transition, the circadian rhythm disruption or "jet lag" can produce effects similar to those of sleep loss.

Transmeridian flights in excess of three time zones can result in significant circadian rhythm disruption. When flying in a westerly direction the pilot's day is lengthened. When flying east, against the direction of the sun, the pilot's day is shortened. Thus the physiological time and local time can vary by several hours. Symptoms of jet lag are usually worse when flying from west to east as the day is artificially shortened. It takes about one day for every time zone crossed to recover from jet lag.

When circadian disruption and sleep loss occur together, the adverse effects of each are compounded[3].

Crew rest and flying duties

Scheduling of adequate crew rest needs to take several important factors into consideration. These include time since awake, time on task, type of tasks, extensions of normal duty periods, and cumulative duty times[3].

The "time since awake" is the starting point for fatigue to build. This can be prolonged prior to flying due to the effects of jet lag, early awakening due to disturbances in the sleep environment, the extra time needed to get up check out of a hotel and travel to the airport for flight check in, and delays in getting started preflight procedures including for mechanical problems or weather delays. "Time on task" is the time required to preflight and fly. This is the time from check-in to block-in plus fifteen minutes on the last flight of the day.

The "type of tasks" depend on the crew position, type of aircraft, and the nature of the flights. Extensions of normal duty periods can occur from events, which prolong the flight longer than scheduled. Such events include delays for en route weather, rerouting due to traffic or, more rarely, diversions. Research on duty period duration suggests that duty periods greater than twelve hours are associated with a higher risk of errors[3].

In determining maximum limits for extended duty periods, consideration needs to be given to all factors which contribute to fatigue including the numbers of legs in the day's flight plan, whether jet lag is a factor in the crew duty day, and the time since awake.

"Cumulative duty times" are most fatiguing when there are consecutive flying days with minimal or near minimal crew rest periods.

This can result in sleep debt, which requires additional time to overcome[3].

A brief review of US Federal Aviation Administration (FAA) flight time and rest rules for scheduled domestic commercial carriers (US Code Title 14, part 121.471) are as follows:

Crewmember total flying time maximum of:

- 1000 hours in any calendar year
- 100 hours in any calendar month
- 30 hours in any 7 consecutive days
- 8 hours between required rest periods
- Rest for scheduled flight during the 24 hours preceding the completion of any flight segment:
- 9 consecutive of hours rest for less than 8 hours scheduled flight time
- 10 hours rest for 8 hours or more, but less than 9 hours scheduled flight time
- 11 hours rest for 9 hours or more scheduled flight time

Read the entire section for exceptions[18].

The flight crew duty day starts with check-in, and is considered concluded at block-in plus 15 minutes for that day's final flight. Rest periods are times when the crewmember is not scheduled for flying duty. These are not periods of restful sleep. Adequate restful sleep, however, must be achievable during these rest periods. In addition to FAA regulations, company rules and practices also influence crew scheduling and rest issues. Company contracts with pilots, scheduling practices for bids and reserve, and productivity demands all play a part in the balance between work requirements and crew rest.

Restful sleep requirements

There is considerable variability in individual sleep needs. Some individuals do well with 6 hours sleep per night, yet others need 9 or 10 hours sleep. However, most adults require 8 hours of restful sleep to stay out of sleep debt. With aging there is usually a significant decline in habitual daily sleep due to increased nighttime awakenings. Therefore, in older individuals decreased quality of nighttime sleep can result in increased daytime fatigue, sleepiness, dozing and napping[5][6]. Napping seems to compensate for the loss of quality sleep during nighttime hours, but the need for a mid-day nap may not be compatible with flight duty demands on short haul flights[3]. Research has demonstrated that pre-planned cockpit rest has improved in-flight sustained attention and psychomotor response speed[7]. Some international airlines have created policies allowing pilots to nap during long haul flights at times of low workloads. Thus far, the US Federal Aviation Regulations have not made reference to planned in-flight crew rest.

Complete recovery from significant sleep debt may not occur after a single sleep period. Usually 2 nights of recovery are required. Eight to 10 hours of recovery sleep per sleep period may be required for most people to achieve effective levels of alertness and performance[8]. Obtaining the required sleep time under layover conditions depends on the length of the off duty rest period. Off duty time must be adequate to allow for at least 8 hours of restful sleep per night in order to recover from sleep debt, and therefore the potentially hazardous effects of flying while fatigued.

Warning signs of fatigue

When flight crewmembers find themselves flying when fatigued several warning signals should alert them of a dangerous situation. These include:

- Eyes going in and out of focus
- Head bobs involuntarily
- Persistent yawning
- Wandering or poorly organized thoughts
- Spotty near term memory
- Missed or erroneous performance of routine procedures
- Degradation of control accuracy[19]

Countermeasures

Research has shown that several countermeasures for fatigue are effective in improving alertness and performance. Long naps, 3-4 hours, can significantly restore alertness for 12-15 hours. Short or "power" naps of 10-30 minutes can help restore alertness for 3-4 hours. Allow 15-20 minutes after awakening to become fully alert before assuming aircrew duties[7, 12, 17].

Other countermeasures include:

- Eat high protein meals (avoid high fat and high carbohydrate foods)
- Drink plenty of fluids especially water
- Caffeine can help counteract noticeable fatigue symptoms if awake for 18 hours or less
- Rotate flight tasks and converse with other crewmembers
- Keep the flight deck temperature cool
- Move / stretch in the seat, and periodically get up to walk around the aircraft if possible
- Gradually shift times for sleep, meals, and exercise to adjust to a new time zone[19]

A word about sleep inducing medications

None of the non-prescription sleep preparations, including Sominex®, Tylenol PM®, and Excedrin PM®, are allowed by the FAA for flight deck use, and require waiting 12-24 hours from last dose to flight duty. Prescription medications such as Sonata®, Halcion® and Restoril® are not approved for airmen. Those pilots taking Ambian®, another prescription medication, must wait 24-48 hours after the last dose before flying[18].

Dietary supplements, such as melatonin, reportedly help reduce sleep problems. The FAA generally allows airmen to use these supplements if they do not suffer side effects from them. However, the UK CAA are more restrictive, so check with your regulator first.

However, claims about dietary supplements' benefits in treating insomnia and jet lag often are overstated. Some individuals have significant side effects from these "natural" supplements[18].

Conclusion and recommendations

Pilot fatigue has been shown to be a hazard in commercial flight operations. Many factors contribute to fatigue in the commercial aviation environment. Circadian rhythm disruption, prolonged work schedules, inadequate crew rest, and inadequate restful sleep contribute to the potential for pilot fatigue.

When the regulations regarding "rest" are compared to identified requirements for "restful sleep," one can see that adequate restorative rest may not occur. Reviews of federal research activities, hours of service / rest regulations, and airline company scheduling policies are needed to correct existing systemic problems. Enhanced pilot training is also needed to prevent fatigue, and to recognize it when it occurs so that effective countermeasures can be employed[1]. Doing so will help insure that pilots fly adequately rested and alert thereby improving flying safety.

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MCRM Discoveries

By Anne Isaacs, NATS

This document is a collection of issues that have been 'discovered' throughout the first season of the Multi-Crew Resource Management [MCRM] workshops. Since December 2008, 25 workshops have been run by NATS that have been attended by over 170 controllers and 135 pilots. The controllers were from Swanwick (AC and TC) and pilots attended from 32 airlines from the UK, Europe and the United States.

During every workshop there was extensive debate with regard to communication issues and the influence of situation awareness on both professional groups. As a result, both professional groups 'discovered' several things about each other that we believe are worth sharing with all controllers and pilots, not just the attendees of the workshops.

This document records the majority of these 'discoveries' that we hope will help everyone in aviation in the UK and beyond.

The main issues have been grouped together into four sections:

- Communication
- Emergencies
- Weather issues
- Workload issues

There have also been significant activities that have been developed from the MCRM workshops, which include:

- The production of a call-sign confusion resolution tool for airlines
- The identification of R/T signal difficulties in the TC area [which has been remedied]
- The production of a weather avoidance module for controller emergency training
- The production of an emergency quick reference checklist for controllers [also known as a QRH]
- The production of a Level Bust risk factors checklist for pilots and controllers

- The creation of a 'scratch-pad' activity concerned with American carriers, the results of which will hopefully decrease the difficulties faced when these airlines enter UK airspace

COMMUNICATION

Pilot Discoveries

- Pilots often report they cannot get on the frequency. The solution is to wait and be assured that the controllers have them on the radar and will contact them when required.

  Controllers appreciate that some frequencies and times of the day are extremely difficult – they advise that it is very helpful to do the following.

  Don't just announce "Hello London"

  Don't press the transmit switch until you are ready to send your message

Do call 'BLOCKED' so the controller is aware there is a message which has not been received

- Controllers require full information on first contact which always includes your call sign, not complying with this takes up more time on frequency for both parties
- When controllers ask you to 'expedite' they mean follow the instruction with your best climb/descent/speed
- 121.5/Guard frequency seems to be overused by some flight crews. Pilots can request a discrete frequency if required

Controller Discoveries

- The R/T in parts of TC is of poor quality in terms of reception. This has been reported as 'controllers having their heads in a bucket'. The reason for this is that the radio transmission signal in the TC north and east area is split to enhance coverage. However there are areas where the transmission overlaps and this causes the poor reception.

  The solution was to eliminate one radio signal, alternately with the other, meaning there would be only one radio signal used at any one time, although there would always be two sources available should they be required.

- Iberia and Air Portugal report that their pilots will add '0' before the heading, below FL100, i.e. 90 would be 090, this may confuse some controllers

- American carriers report that they routinely DO NOT wear headsets above FL180 – a scratch pad activity is underway and 3 of the American carriers are collaborating with this work
- When controllers require pilots to 'expedite' pilots would rather you gave them the actual rate of climb/descent i.e. 2,000 or 3,000 feet a minute

Joint Issues

- If either party asks for instructions to be repeated, always ensure that the instructions are repeated verbatim
- All clearances should be read back CORRECTLY and COMPLETELY
- There should not be more than 3 pieces of information transmitted at one time
- Always use numbers as written/spoken i.e. 5,7,2,2 not fifty seven, twenty two
- Call sign confusion remains a problem for both pilots and controllers – always report these issues – NATS has just published a tool to assist airlines to 'de-conflict' their call signs prior to publishing their schedules
- Statistically Controllers have more errors in the first 20 minutes on position and Pilots have more errors in the first and last 15 minutes of a flight
- Both Controllers and Pilots working through the night and working early morning duties are fatigued and therefore may need more consideration – the major risk here is that both groups can be equally sleep deprived

EMERGENCIES

Pilot Discoveries

- For Controllers their priority is:
  - Co-ordinate
  - Communicate
  - Calculate
- Controllers do not routinely use Quick Reference Checklists/Handbooks in emergencies
- Although Controllers will probably have more emergencies in their shift cycle than you, they remain uncertain if they are not given what they perceive as essential information – remember from the above bullet points their priorities can be different from yours – they have many aircraft to move out of your way, which means increased co-ordination with other colleagues
- Selecting 7700 helps controllers to identify aircraft who need 'special attention' or have an emergency. Controllers will treat all 7700 squawks as needing priority and arrange their traffic accordingly. The 7700 squawk is also 'seen' on radar by all controllers throughout the UK.
- Controllers expect pilots to announce "PAN PAN" for special attention regardless of the outcome. Controllers expect pilots to announce "MAYDAY MAYDAY" when requiring immediate support. Both 'PAN' and 'MAYDAY' announcements carry almost equal attention and the controllers will allocate a dedicated controller to you if required

Controller Discoveries

- For Pilots their priority is:
  - Aviate
  - Navigate
  - Communicate
- Quick Reference Checklists/Handbooks for emergencies are very useful and are used by pilots extensively – you now have such checklists in the Ops. rooms

Many airlines use an emergency acronym with all their crews to help simplify the emergency situation. The acronym they use is **NITS** – this represents:

N - **Nature** of problem
I - **Intention**
T - **Time needed** – to sort out the issue
S - **Special Instructions** – such as ambulance request/fire service support

Controllers may use this acronym to simplify an emergency situation

- At all times but particularly in an emergency, pilots prefer to be given distance information in miles, not distance in time
- Pilots have advised that they find it very helpful to add "when able" after giving an instruction in an emergency
- MAYDAY and PAN does not necessarily mean immediate landing or nearest airfield

EMERGENCIES

Pilot Discoveries

- Pilots who require an ambulance must announce a 'PAN' and it is helpful to use the phrase " I need..."
- If pilots require to be placed out of sequence or want 'free airspace' to sort out a problem – ASK, controllers will do as much as possible to re-arrange their traffic

Controller Discoveries

- Pilots advise that in most unusual or emergency situations they prefer to be given airspace to sort themselves out. The only exception is in an explosive decompression or smoke/fire in the flight deck or cabin

Joint Issues

- At all times, but particularly in an emergency, the 'world view' of the two parties differs (see the first bullet points on the previous page). This clearly dictates the priorities of the two parties and therefore the reason these situations can be difficult to manage
- The phrase 'PAN' is rarely used or acknowledged in Europe
- If either party should hear an Emergency Locator Transmittor, it should be reported immediately. Every ELT report is investigated and will be reported back to the reportee as soon as practicable. There are two ELT factories in the UK which often 'ping' without knowledge.

- In emergencies or 'go-around' situations, which require an immediate climb/descent, each airline will expect a slightly different instruction. Some airlines prefer a straight ahead climb/descent and some prefer a turning descent. What the Airlines require and what Controllers expect they want are often completely different.

WEATHER ISSUES

Pilot Discoveries

- Pilots may not realise that controllers do not have weather radar displayed on their screens, in the UK – this prevents them from anticipating weather avoidance and in some cases asking your advice about the weather conditions
- In weather avoidance situations, controllers will usually use time to maintain a heading change
- When you have avoided the weather, announce this to the controller so they can re-plan your route and their other traffic

Controller Discoveries

- Pilots appreciate knowing if there is a delay – it will assist their situation awareness
- Every aircraft type has a slightly different weather radar display and every pilot/airline will behave slightly differently in similar weather conditions
- In weather avoidance situations, pilots like to be given the distance to run on a heading change
- When pilots want to turn to avoid weather, announce how much turn and for how long in miles
- If you take an aircraft off a SID, pilots appreciate being told when and why

Joint Issues

- In a weather diversion, fuel can be critical for the Pilots. However Controllers take some time to arrange co-ordination for the diversions with colleagues. Therefore in poor/bad weather Pilots should be aware there may be several diversions being arranged simultaneously and they may find controllers are very busy.

WORKLOAD ISSUES

Pilot Discoveries

- Controllers workload increases in the following situations:
  - Emergencies
  - Weather avoidance situations
  - Unusual requests
  - Non-standard flight requests
  - Splitting or collapsing/bandboxing a sector
  - Change of procedures
  - Change in technology
  - When training is in progress
  - When visitors are on the sector
- Flight Levels – Heavy charter airlines sometimes have difficulty making their assigned levels, Controllers would appreciate being informed of this issue

Controller Discoveries

- Pilots' workload increases in the following situations:
  - Take-off and landing
  - Poor or bad weather
  - Emergencies
  - Last minute changes in navigation instructions
  - System failures
  - Unexpected instructions from Controllers
  - When training/examination is in progress
  - When visitors are on the flight-deck
- Routeings – Pilots can have difficulty accepting 'short-cut' routeings, particularly in large highly automated aircraft and when pilots are training
- In the vicinity of an airfield – Pilots appreciate the information "miles to touchdown" and in cloud add "the airfield is in your xxx o'clock position"

Joint Issues

- All controllers and Pilots try to do their best to assist each other, but obviously the context of the working environment can change, often rapidly. Be aware if Controllers lose their patience with flight crews they can have a break almost immediately – flight crews may have to fly on in distress/angry for up to 11 hours.
- ATSOCAS - these new rules can be difficult to understand, particularly for foreign Pilots. Although Pilots appreciate direct routeing - both groups should be aware that there is some airspace when a direct routeing will place a Pilot outside controlled airspace i.e direct to Mayfield from France at night and direct to the centre fix on Runway 26 at Bristol.

For more information regarding the MCRM workshops please contact: Anne Isaac at anne.isaac@nats.co.uk or Carole Quinton at carole.quinton@nats.co.uk

'In the unlikely event...'

by Pat Malone

Most of us spend more time in the cabin of an aircraft than at the stick - and we can take responsibility for safety there, too. PAT MALONE reports

Above: Air accidents are incredibly rare, but you can't take safety for granted

The line between life and death in an air crash often seems arbitrary, dependent largely on the luck of the draw. Most people, I suspect, feel like helpless bystanders when they climb into an airliner, at the mercy of fortune and wholly in the hands of others. Nothing could be further from the truth; experience of air accidents, and research among those who survived when others did not, shows that passengers can do a great deal to stack the odds in their favour, and an extraordinary safety course run by British Airways aims to teach people how best to save themselves when the worst comes to the worst.

At Cranebank, on the fringe of Heathrow, BA has a massive hangar containing the best part of a Boeing 747 mock-up, a shortened 737 fuselage and a number of platforms from which are hung escape slides, all for the training of cabin crew who, we sometimes forget, are not there to top off one's Martini; their primary purpose is to deal with emergencies - they just fill in time between disasters serving drinks. BA is offering a brief taste of their training to organised groups of passengers, and I went along with fellow members of the Helicopter Club of Great Britain.

The course was designed in response to requests from companies like BP, who spend a lot of money with BA and have a lot of expensive and highly-trained frequent fliers they're reluctant to lose. An accident is so extremely unlikely that everyone's virtually certain to be wasting their time... one of our lead trainers, Andy Clubb, said he had trained 3,200 pilots and 14,000 cabin crew, and he'd never even met anyone who's had to do it for real. The last time the overwing exits on a British Airways aircraft were used in anger was 24 years ago. But if survival is a case of stacking the odds in your favour wherever possible, this is an easy win. It's certainly a fascinating experience, and provides food for thought for days afterwards.

Never has a safety briefing had a more attentive audience

We had a high-powered team of instructors, including Geoff Fearon, 34 years in BA, 15 as Flight Engineer on 747s, now specialising in ground training on the 737 and Airbus family; Nick Jones, 38 years with BA, 15 as a flight engineer on the 747, now training on the 777 and 747; Andy Clubb, cabin crew with BA for 20 years and a very good communicator; First Officer Aogan Kearney, ten years a BA pilot having started as a cadet from school, now in the right seat of a 747; and Steve Denyer manager, with 25 years of experience in training, who produced most of the training material. In five hours we were bombarded with a huge amount of useful information, and 'I never thought of that' moments came thick and fast. I've distilled things in a vague chronological order - imagine you're getting on a passenger jet; this is what you do to give yourself the best possible chance of living a long and happy life.

First, as you walk up the aisle you need to count the number of rows to your seat, so you can feel your way back to the door in darkness and thick smoke. Stay close to the exit if you wish, or choose to sit by an over-wing exit. Where best to sit to maximise your chances of survival? We've all heard stories of people in the back surviving when all others perished, but there's no science to it. In the BA Manchester 737 crash in 1985, most of the 55 dead were at the rear. "While it's true that no aircraft ever reversed into a mountain," said Andy Clubb, "there's little to choose in where you sit. First Class might be considered a crumple zone for economy; beyond that, it's moot. The centre of the fuselage is strongest. You've got the wing spars, the engine pylons, the undercarriage supports. We can't advise you." Wherever you sit, figure out where the nearest exits are and how best to get to them, like the flight attendant says.

Stuff your bag overhead, climb in and fasten your seat belt. Then unfasten it, and fasten it again. Why do the cabin crew show you how to fasten the seatbelt, holding it up and clicking it into place? Surely every idiot knows that! Well, ask yourself how come so many corpses are found in seats, belts still fastened, their fingers torn and broken along with the trouser material at their sides, and indeed, their flesh gouged at the thigh? Because when panic, disorientation and sensory deprivation hit, they dived for the seat belt in their cars! 'Muscle memory' takes over. So try your belt buckle a few times, to instil a more appropriate 'muscle memory' in your arm. It might save a good pair of trousers.

Check that the buckle abuts the soft part of your stomach - there's less to damage around there - and double-check that the belt isn't twisted. Properly used, the belt is a good restraint; side-on, it's a blade to chop you in two in the event of an extreme deceleration.

Why no three-point harness? People don't like them, there's nothing to anchor them to, and it would prevent you adopting the brace position, in which you place your heels against the bar under your seat and get your head down onto

The ovenving exit doors weigh 40 lbs and must be thrown out of the aircraft

Instant IMC inside the cabin simulator as the evacuation drill begins

your knees, with your hands over your head for protection. If you remain upright in a crash, your head will whiplash down and bounce off the floor, your legs will fly forwards and your shins will smash against the seat in front, dislocating your hips and rendering you immobile. Heels against the bar means your lower legs are angled slightly backwards so in a deceleration, there's a down-force that keeps them from lashing forward.

Save a hand

When you put your hands over your head in the brace position, put your stronger one underneath your weaker one. In a crash there's going to be a lot of stuff flying about, and it matters less if your weaker hand gets mashed and broken by debris - you've still got your better one for undoing the seat belt and other tricky work. If you're so tall that the seat in front prevents you from getting your head right down on your knees, don't worry; there's a lot of padding there, and the seat will restrict movement.

Seats are stressed to 16g, up from 9g on older aircraft. For best results we really ought to be facing the tail, the configuration adopted in many military aircraft. The seat structure would then give maximum protection. But passengers feel uneasy being dragged backwards into the sky, and the movement in their peripheral vision makes them feel queasy.

Watch the safety briefing every time. Your lifejacket under your seat, they say. Is it? Passengers steal thousands of these things they're checked every day, but if some light-fingered joker has liberated yours from the previous flight, the time not to find out is when you're up to your chin in brine. In the Hudson River ditching, the skill of the pilots saved the day; had it been left to the passengers to save themselves after a more violent impact, few would be alive today. Of the 155 on board, only 25 had watched the safety brief, and after the ditching, only seven of them took their own lifejackets!

Mostly, lifejackets come in handy overruns or short landings - so of the world's major airfields are close to the water. If by misfortune your lifejacket inflates inside the aircraft, either through confusion or because you snag the lanyard, you can deflate it by pushing on the valve in the manual inflation tube - it's just like the valve in a tyre. Once you're outside, four or five big puffs will blow it up again. On many occassions people have died in aircraft because their lifejackets pinned them to the ceiling when the water came in. Tie the straps around your waist in a double bow, so you can untie it quickly if you've inadvertently tied yourself to your seat. It happens.

Decompression is the most common incident a passenger is likely to experience – as Andy Clubb said, "either from Bruce Willis running amok with a machine gun or some other factor." He outlined what the passenger would experience in an explosive decompression - ear and abdominal pain among other things - and Aogan Kearney explained how the pilots would get down into breathable air at anything up to 10,000 fpm.

At cruise altitudes you'd have about 15 seconds of useful consciousness, so it's important that you get your oxygen mask on immediately. The natural passenger reaction when the 'rubber jungle' comes down is to whip out mobile phones and take a picture, it seems. The team explained how the normal pressurisation system works - bleed air off the bypass fan - how oxygen is made or stored, and how much there is (not much).

The way out

Now, those emergency exits. In order for an aircraft to be certificated, it must be demonstrated that it can be evacuated in 90 seconds with half the exits unusable. The A380 has been emptied of 880 people in just 74 seconds, but not in a real-world evacuation scenario. Having demonstrated that a Boeing 737 could be evacuated in the requisite time in test circumstances, organisers of a second test offered $20 to the first 20 people off the plane. Not a soul escaped the aircraft - they all got jammed in the doors trying desperately to win the money. That's more like what it would be like in an accident. It is clear that there is no room for gentlemanly conduct. Don't stand on ceremony, stand on somebody's head. You want to be first in the aisle, and first at the exit, so you need to be first to undo your seatbelt - see 'muscle memory' above. Not only will you save yourself, but people who are panicking will see someone who looks like he knows what he is doing, and will follow.

Check the exit before flight to see how it works. There will be a full explanation on the laminated safety card, which you'll also study closely. There is no real standardisation in how these exits work, although design is moving in that direction. If you're sitting next to an overwing exit, figure out which hand you'll use to do what; you'll need not only to pull the door out, but you'll have to throw it out through the hole. You can't open it when the aircraft is pressurised - at normal cruise of about 8 psi there's about two tonnes of pressure on it. The door weighs 40 lbs, and you'll probably have to lean back as you pull it in or it'll clout you on the head. Virtually the last thing the flight crew do when they get the final wind-check from the tower before take-off is to figure out at which angle they'd stop the aircraft on the runway in the event of an engine fire to ensure that the wind carried the flames away from the fuselage - one of the lessons of Manchester. The two things the fellow next to the overwing exit must remember to do before opening the door are first, to release his seatbelt, and second, to check outside for fire. No point jumping out of the frying pan...

In terms of getting out, you're much better off at the main doors, which are several times the size, easier to operate, and will probably have been opened by trained people. In tests, eight people get out of a main door for every one who gets out over the wing. The flaps will have been lowered to 40 degrees to act as a slide off the wing. Engineer Nick Jones took us through the door-opening procedure, which is very simple unless you're in a panic. The handle rotates through 180 degrees - but then one edge of door on the simulator swings slightly in towards the passengers before the whole shooting match moves out of the way, so if you just push on it, you'll be disappointed .

The lights are dimmed on take-off and landing to help eyes adjust to the semidarkness you'd experience in a power failure; going directly from bright light to darkness would reduce your ability to respond. In an emergency, chances are that smoke will obscure the exit signs, and anything you can do to improve your awareness of where the exits are will count in your favour. Understand this your disorientation will be so complete, your brain function so slow, that simple tasks will become almost impossible. Who knows what pitch or roll angle the floor will be at? Decide now that if it becomes necessary, you're going to follow the white floor-level lighting along the aisle towards an exit. On most aircraft, there's a red light on the floor at the exit, added as a result of the experiences of a chap who survived the Manchester crash - fully six minutes after the accident he was crawling along the floor, and he noticed a tiny glimmer of light off to the side... he rolled to it, and fell out of an exit. He was the last man out.

Above: an A380 has been cleared of 880 people in 74 seconds in test conditions
Above Right: on the escape slides, it's important to hit the ground running

So, into the sim. The aircraft started to vibrate as though taxiing. The recorded voice of the captain made the usual noises, and there was a feeling of acceleration as the back of the cabin dropped away... but as we began to 'climb' smoke began to appear from beneath one of the seats at the front. All of a sudden things got very tense, the tone of the announcements changed to one of harsh compulsion. "This is the Captain. This is an emergency. Brace! Brace!"

The cabin crew, strapped in behind us, took up the chorus: "Brace, brace! Brace, brace!" And they kept shouting it, at the top of their voices. The cabin began to fill with smoke non-lethal, and smelling of vanilla. At some point, alerted by an evacuation alarm I don't remember hearing, the instruction changed. "Unfasten your seatbelt! Come this way!" The rush for the exits was far too polite - in the real world, just forget everything else and go! At Manchester, a women turned back from the door to get her handbag, working frantically against the flow of passengers. She died in the fire. The continuous shouting of "Brace, brace!" was obvious in retrospect- if they stopped, we'd all sit up and look around to see why. And they didn't just tell us to evacuate; we got piecemeal instruction we could understand, like "unfasten your seat belt" and "come this way".

On to the escape slides. These were not added to aircraft until 1971, and weren't designed integrally to the door until much later. We began by sitting at the top of the slide and pushing gently off and graduated to jumping on. No drama - but it's important to sit forward, because you want to hit the ground running lest a cascade of falling passengers crush you. In a real emergency you'd have someone else's boot in your face on the way down, and you'd land on hard tarmac rather than rubber matting.

Unlikely though an air accident is, I feel much more confident getting into an airliner now. One always feels trepidatious being strapped down in a tube with somebody else at the stick, but this course makes you realise you're far more than just a passive victim; you have a significant degree of control over your destiny. I'm reluctant to say, "Bring it on!" but I can't remember an afternoon as well spent.

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Chilling Out In The Sim – The Need For Icing Training

Loss of control due to airframe icing is still one of the biggest problems in air transportation. Guest author, Dr. Nihad E. Daidzic suggests that realistic flight simulation could be the best tool for comprehensive pilot training of icing hazards.

Unlike thunderstorms, which are visually apparent and thus a relatively straight-forward task to forecast and avoid, icing can be sneaky, silent killer.

A major challenge today is providing realistic, in-depth icing-hazard training for pilots. That includes not only better theoretical education on icing and associated risks, but also realistic flight simulation to practice typical ice encounters, counter-measures and control recoveries. As a result, a set of best practices for icing avoidance and recoveries could be defined and implemented worldwide.

According to FAA, ice is usually reported by pilots as: trace, light, moderate or severe. This is a somewhat subjective classification as it is based on the effect icing has on an aircraft and not necessarily on the actual size and density distribution of supercooled droplets. Severe icing conditions for a general aviation light plane might be reported as light icing conditions by a large jetliner. No de-icing equipment is designed for, or able to cope with, severe icing conditions for any extended period. Indeed severe icing implies that de-icing equipment cannot handle the rate of ice accumulation and any prolonged exposure to it would spell disaster.

There are about 2,000 known shapes/forms of ice crystals. In aviation ice is classified as rime, clear (glaze) and mixed: ice. Mixed ice consists of the mixture of glaze, rime ice, entrapped air bubbles, etc., and is particularly dangerous due to rough surface and protruded shapes. Rime ice consists of small, supercooled droplets and occurs mostly at lower temperatures (-20° to -40°C). Its rough; surface increases friction coefficient significantly, but rime ice is brittle and can break easily, which is not necessarily a good thing as that may result in asymmetric aerodynamic forces and loss of control. Clear or glaze ice is created by supercooled large droplets (SLD) in air temperatures ranging from -10° to 0° and is usually encountered in thunderstorms or freezing rain (or drizzle): with incredible rates of accumulation.

Phenomena

Three plimary adverse phenomena work against a pilot in icing conditions. Two of them lead to reduced performance while the third, and the most dangerous, could lead to loss of aircraft stability and controll ability.

The weight of ice sticking to the airframe increases the stalling speed by the square root of the load increase and compresses the flight envelope, leading to reduced maneuverability margin. In most cases, however, this effect alone can often be neglected. Even an unbelievable 20% weight increase, due to ice accretion, will raise the stalling speed by "only" 10% which is not so critical, since the airplane is usually lighter during cruise, approach, and landing In addition, increased weight will also require a higher thrust setting for the same airspeed.

Ice accretion on airfoil surfaces, airframe and other parts of the airplane will lead to increased parasitic drag. Normally ice is more or less porous, which will increase the surface friction coefficient directly and affect the boundary layer development and thicknesses, thus affecting the form drag too. The increased wall shear stress will destroy the low-drag advantage of advanced laminar and supercritical airfoils. This in turn reduces the airlane's speed at the constant thrust setting (Fig 1).

In effect the increased low-speed buffet airspeed and decreased maximum airspeed narrows the flight envelope, bringing an airplane closer to an "edge of the envelope" and creating yet another "coffin-corner", where the margin between stalling speed and maximum flying speed becomes ever smaller. For example, a 20% increase in parasitic drag coefficient results in about 9% decrease in cruising airspeed for the same thrust setting - about 20-30kn for a typical turboprop aircraft.

Ice accretion, however, can create much more parasitic drag than that. A not impossible 40% increase in parasitic coefficient of drag due to ice would result in something like a 20% decrease in cruise airspeed for the same thrust. Now that is really significant.

Simultaneously, ice can also negatively affect the thrust generating engine and/or propulsive efficiency, leading to even slower cruise airspeeds. The longer an airplane stays in icing conditions and the higher the liquid water content (LWC) of the atmosphere, the faster the ice will accumulate and the less time a pilot has for action.

Performance

Unfortunately it is not only the airplane's performance that suffers, aircraft stability and control endure as well. The most dangerous side of airplane icing is that exotic ice accretion on the leading edges of a wing (ice-horns) and/or ridges built some distance away from the leading edge on the upper (suction) airfoil surfaces, will cause premature boundary-layer separation and often uncommanded roll accompanied by aerodynamic stall. This all would occur at lower angles-of-attack and higher airspeeds compared to clean wing (Fig. 2).

In fact, leading-edge horns of ice can significantly reduce the wing's maximum coefficient of lift causing a 20% or more increase in stalling airspeed.

The "runback" ice that often forms from SLDs, which are water droplets in a thermodynamically meta-stable state that will freeze upon contact with the soli surface, will "creep" back from the wing's leading edge and form streaks of frozen ice, ridges, and "feathers" somewhere within the first quarter of the wing chord. That is exactly at the locations responsible for generation of most of the lift force.

Also runback ice could cause abrupt boundary-layer separation, local changes in flow patterns, the formation of recirculation "bubble", and turbulent wakes at the place where the ailerons (or flaps) are normally located. This will cause flow disruption and result in unwanted roll upset.

As we know from basic fixed-wing aerodynamics, stalling speed has to increase to offset the reduction of the maximum lift coefficient, leaving a severely restricted flight envelope for a pilot to deal with. In addition, maximum coefficient of lift achieved at lower stalling angles of attack will decrease and will

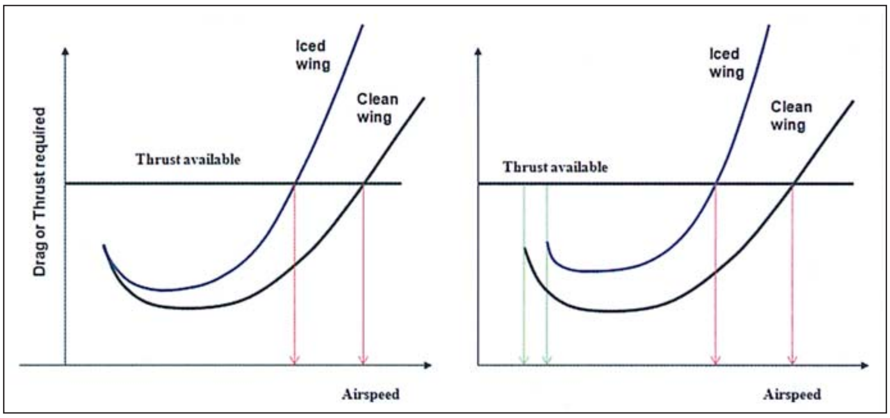

FIG.1 The effect ice accretion has on airplane drag (or thrust required) due to increase in parasitic drag only (left side). Increased weight and decreased coefficient-of-lift will result in even more inferior drag curve with accompanied higher stalling speed and slower maximum airspeeds (right diagram).

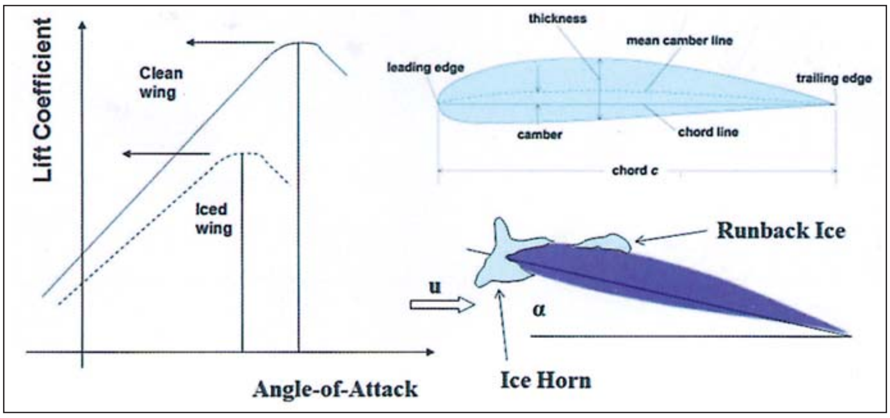

FIG. 2: The effect ice accretion has on the coefficient of 11ft and sta111ng angle-of-attack for a typical airfoil. Also sketched is an airfoil with leading-edge ice homs and runback ice (slightly exaggerated for better visual effects).

often result in a steep decline of lift characteristics in a post-stall region, increasing the chance of unrecoverable spin entry once stall occurs.

The conditions under which most transport category airplanes are certified are explained using, for example, FAR 91.527, FAR 135.227, and FAR 25 Appendix C. Droplets of median volume diameter (MVD) 40 um (micrometers one micrometer is one-thousandth of a millimetre) are used for certification in quasi-continuous (17.4nm horizontal distance) icing conditions, while for intermittent maximum icing (2.6nm horizontal extent), droplets of up to 50um are allowed. Everything above that is regarded as SLD and the certification does not deal with it. However, SLDs (drizzle or rain) can be as large as 500um and even bigger (up to 3-4mm). For comparison, typical cloud droplets are 10-20um diameter. Accordingly, single representative SLD will have a diameter 50 times larger. Interestingly the amount (volume) of liquid, i.e., ice, that will freeze on the airframe, from one such SLD will be equivalent to 125,000 tiny cloud droplets. Accordingly one typical SLD (500um) will be equivalent to about 1,000 largest supercooled droplets allowed in FAR 25 icing certification (50 um).

To make matters worse, there is something called "tail-plane icing" in which the tail elevator/stabilizer accumulates ice, loses ability to keep the airplane level, and the nose drops down, often following a sudden forward yoke/stick pulse. This usually happens at slower airspeeds, in approach configurations (when flaps are extended), all when the horizontal stabilizer has to deliver more downward force. In airplanes without hydraulically boosted controls, due to developed wake on the lower suction surface of the horizontal stabilizer, the elevator could snatch downward, pushing the airplane's nose over. This is also the regime where the center of pressure on the main wing moves downstream and away from the airplane's centre of gravity, thus increasing the main wing destabilizing pitching moment. Any tailplane stall would thus result in a sudden downward jerk. If not handled adequately the airplane could easily end up in a vertical nose-down attitude.

Experiments

Researchers at NASA Glenn Research Center (GRC) performed extensive flight experiments using their own Canadian-built De Havilland DHC-6 "Twin Otter" modified for icing flight research. According to NASA GRC, the only way to recover from tail-plane ice is to immediately pull back on the stick, which is completely opposite to how one would recover from main wing stall. The author doubts that such recovery maneuver would always be successful for every airplane type.

But, regardless, how is the pilot to know that nose drop was caused by tailplane ice and not by a more familiar aerodynamic stall requiring forward yoke/stick push? This is a similar catch-22 scenario to a high-altitude jet flying on the edge of its aerodynamic ceiling, where the merging low-speed buffet (aerodynamic stall) and high-speed buffet (transonic Mach effects) create dreaded "coffin corner", where you are damned if you pull and damned if you push.

The difference between the mainwing ice and the tail-plane ice is very subtle, and the best way to learn the difference would be to conduct quality training in a flight simulator using accurate icing flight models. Realistic flight simulation could be the best tool for comprehensive pilot training of icing hazards.

Task

Designing realistic icing flight models for a particular aircraft type, however, is not easy. Simulation of nonlinear unsteady aerodynamics, post-stall large angles of attack and/or sideslips is compounded by many uncertainties as to the accuracy of the results. Adding ice effects further complicates matters.

Extensive wind tunnel tests on scaled aircraft models have to be performed followed by time-consuming and expensive computational fluid dynamics (CFD) analysis. An icing wind tunnel at NASA GRC (and others worldwide) has been used to measure accumulated ice shapes on various airfoils at different icing conditions. Models of ice shapes have been designed based on wind tunnel and flight test research, and then used for experimental and computational simulation. Such ice-mimicking shapes (made of different materials) have then been attached at various locations on the wing and/or tail airfoils simulating ice-horns and/or runback ice to measure aerodynamic properties.

NASA GRC and other academic and research institutions worldwide, are working diligently on aircraft icing problems. Many powerful computer programs, based on Large-eddy or Reynolds-Averaged Navier-Stokes (RANS) CFDs to simulate turbulent flow around growing or already formed ice obstacles, were developed to predict flow on different parts of ice-laden airframes. However, such computational and experimental analysis does not run in real time and cannot be used for flight simulation directly. Rather, the measured changes in aerodynamic forces and moments are recorded, analyzed, and used to augment existing dynamic models of clean airframes.

The derived six-DOF aircraft dynamics incorporating icing dynamics, with associated coefficients of lift, drag, pitching moment and other important integral aerodynamic parameters at various angles of attack and/or sideslip, could be employed in existing and future FFS and AATD flight models. NASA GRC has already designed an icing simulator, which essentially has the built in icing model based on the DHC-6 flight model.

In addition to these efforts, progress has been achieved in ice detection and protection using Kalman-filtering and neural networks. Nevertheless, none of these activities alone will provide 100% safety from icing danger. New technologies will reduce the risk of icing accident, but never eliminate them.

In the end, faced with the icing hazard, basic airmanship, and competent, educated crews are the best insurance against accident.

Loss of control (LOC) caused by ice accretion is an order of magnitude more difficult to predict and recover from than LOC of clean wing alone. Ice comes in so many shapes and forms and it accumulates on different parts of an airplane at different rates, which affects stability, maneuverability and controllability in so many, often unpredictable, ways.

Realistic flight simulation, however, will expose pilots to icing LOC that they never thought possible and educate them in how best to avoid potential disaster. A pilot who experiences degrading performance, control, and stability, and then recovers control of an ice-laden aircraft in flight simulation will develop more respect and competency towards icing hazards. So typical in most actual icing accidents are bewildered crews being surprised by a sudden loss of control. We owe it to our flying public to show the highest level of competence, skill and professionalism.

When faced with icing danger it is important not to wait until that often invisible point of no return is passed. In order not to become a "test pilot" during a scheduled flight, training in flight simulators featuring realistic icing effects is the best countermeasure. Actual flight tests in icing conditions are better left to wind-tunnel experiments and professional flight research crews operating specially equipped airplanes in very controlled conditions.

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Reducing the Threat of Laser Illuminations

by Peter A. Derenski, Techinncal Fellow, Human Systems Integration

Laser illumination of commercial airplanes is a growing threat to operational safety, and the number of incidents is increasing. The U.S. Federal Aviation Administration (FAA) laser-incident database contains more than 3,200 reports of incidents since 2004 and provides information on the locations, altitudes, colour of light, and phases of flight that show the most activity. By knowing how the laser affects the eye and following recommended procedures, pilots can reduce this safety threat.

Flight crew exposure to strong laser light source can result in flash blindness and afterimages

A growing threat to air transportation safety involves laser pointers directed at commercial airplanes by people near flight routes and airports. Because laser light can distract flight crews and damage eyes, the commercial aviation industry needs to be aware of the threat posed by laser illumination, the protective technologies available and their effects on flight deck.

Lighting, and the recommended defensive procedures for pilots to follow. This article describes typical laser incidents, discusses laser properties and effects on eyesight, and provides recommendations for mitigating the effects of laser illumination.

Laser illumination incidents

Lasers are a source of collimated, monochromatic, coherent light that can travel long distances with very little loss of intensity. This coherent property is what allows a laser to maintain a narrow, highpowered beam over long distances. Lasers are available in a variety of colors, intensities, and power outputs. Green lasers, which have become increasingly more affordable, have been reported in more than 90 percent of the documented laser incidents.

There was a time when the only lasers pilots needed to worry about came from Las Vegas hotels or a light show at one of the Disney properties (see fig. 1). But small laser pointers have been available to the public for quite some time, and their number is increasing as they become more affordable.

Since Advisory Circular 70-2 on *Reporting of Laser Illumination of Aircraft* was published by the FAA in late 2004, more than 3,200 laser incidents have been reported within the United States, along with hundreds more internationally. A laser illumination incident begins quite suddenly as the flight deck is filled with a bright light. The glare makes it difficult to concentrate on the flight instruments and can remove the crew's visual references with the runway environment, making pilots unsure of their position relative to the runway and the ground. According to the FAA incident database, 50 percent of reported incidents occurred at 5.000 feet or below and usually during evening hours. Some incidents have been reported during cruise at much higher altitudes. The western Pacific region of the United States has had the greatest number of reports, with the highest number of incidents occurring in the San Jose and Los Angeles areas.

Figure 1: Professional laser light show
Until recently, the expense of lasers had limited their use to professional shows, but lower prices on handheld laser pointers have made this type of device widely available. (Photo courtesy of Dr. Leon McLin.)

Under the USA PATRIOT Act, it is a federal offense to interfere with the safe operation of an airplane and that includes the flight crews. Recently an individual was sentenced to two and a half years in prison for directing a laser at an airplane near the John Wayne Airport in Los Angeles.

Incidents are occurring not only in the United States but internationally as well. Reports of laser incidents have come from Australia, Canada, England, Germany, and Ireland. In one incident at Sydney, Australia, in March 2008, a number of people armed with lasers and cell phones performed what was described as a "coordinated attack" on landing airplanes. Some airplanes landed, others executed missed approaches, and others diverted to other airports. During this incident, air traffic controllers were forced to change the active runway to get airplanes away from the laser pointers.

The effect of laser light on eyesight

How a laser affects the eye depends on the wavelength of the laser, the power level, and the duration of the exposure. The optics of the human eye can take available light and multiply it 100,000 times, allowing people to see on dark, moonless nights. That dark adaptation can be lost in the presence of a strong light source and can take several minutes to readapt.

The human eye sensitivity peaks in the green range and perceives green 30 times brighter than red. When comparing a green and a red laser of equal power output, the green one will appear much brighter than the red.

Visible light lasers (380 to 750 nanometers) enter the optical system and are magnified and focused on the back of the eye (retina), making the retina the target of the laser energy. The eye's natural defense for bright visible light is the blink response, which can take effect within a quarter of a second.

Nonvisible light can be in the wavelength range of ultraviolet (200 to 380 nanometers), near infrared (750 to 1,400 nanometers), or mid to far infrared (1,400 nanometers to 1 millimeter). Nonvisible lasers also enter the optical system and affect the eye, but they are not visible and present a different challenge: the blink response only works with visible light, so there is no natural protection for the eye when outside the visible spectrum. Near infrared light has the same effect on the retina as visible light, but cannot be seen. Ultraviolet and mid- to far-infrared wavelengths affect the cornea and lens and can cause corneal clouding or cataracts.

With visible light (380 to 750 nanometers), a range of effects can occur during and after a visible laser exposure. Starting from the mildest form, lasers can cause glare—an interference that inhibits the viewer from seeing details in the visual scene due to excess brightness. At lower power levels or long distances from the source, this can simply be a distraction (see fig. 2). At stronger levels or closer to the source, the high brightness can preclude a viewer from seeing outside landmarks and references and can affect pilots' ability to clearly see an instrument panel directly in front of them (see figs. 3 and 4).

Exposure to a strong laser light source can result in flash blindness and afterimages. In flash blindness, exposure to a very bright light source can deprive pilots of vision for a period of time ranging from a few seconds to a few minutes. This can be followed by afterimages, such as the yellow and purple dots seen after a flash photo. Again, these afterimages will disappear in time.

The number of laser incidents involving commercial airplanes continues to increase every year. The best way for flight crews to protect themselves is being aware of the problem and by following proper procedures if affected by laser light.

In the most serious exposures to lasers, the lens of the eye concentrates the light themselves in a situation involving laser energy on the retina and can actually burn light in the cockpit should consider taking the retinal tissue. The human eye can these steps: compensate for small area retinal burns by looking around them, but large area retinal burns can mean permanent loss of vision for the affected area.

Protection from visible laser lights

There are two primary ways flight crews can protect themselves from the effects of laser lights.

Protective glasses. A variety of safety glasses are available that can protect the wearer from green laser energy; however, airlines should

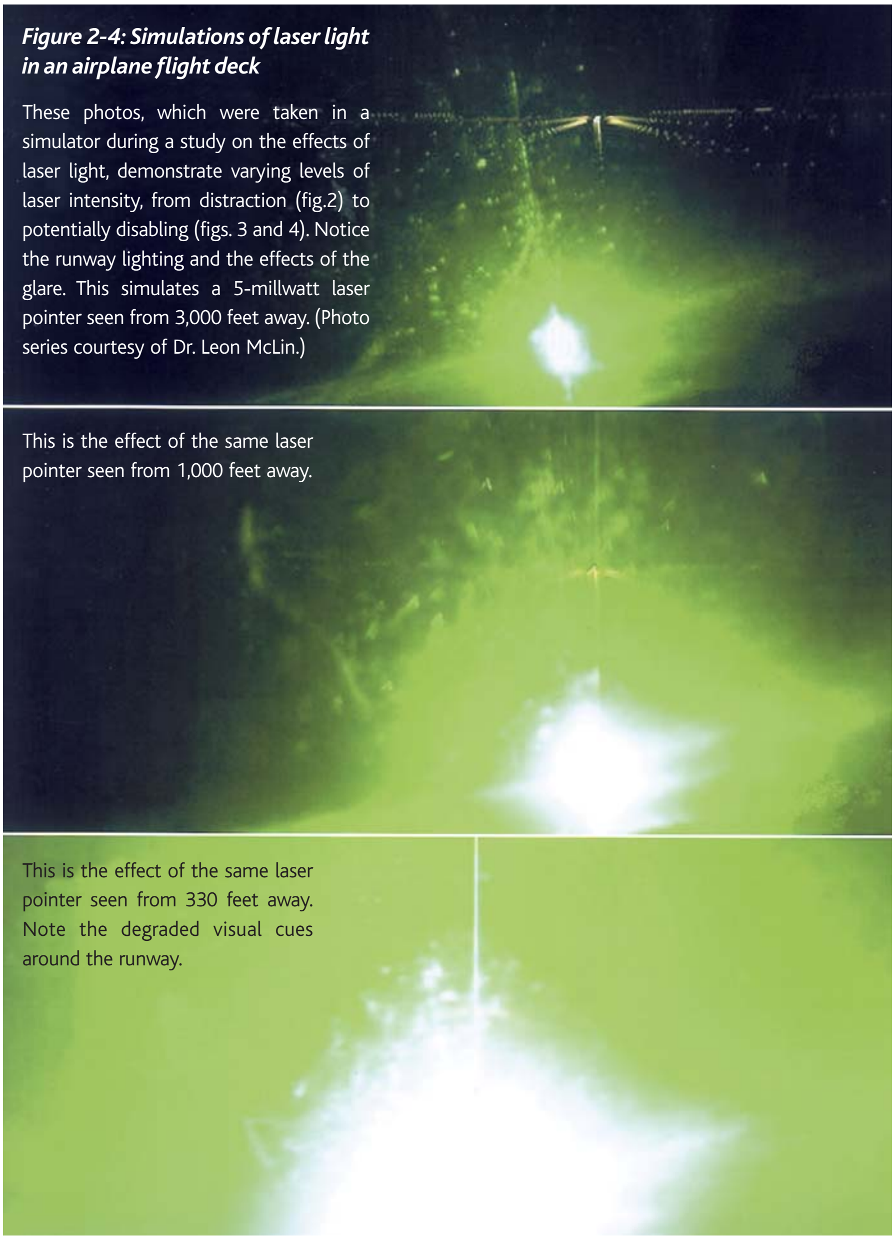

Figure 2-4: Simulations of laser light in an airplane flight deck

These photos, which were taken in a simulator during a study on the effects of laser light, demonstrate varying levels of laser intensity, from distraction (fig.2) to potentially disabling (figs. 3 and 4). Notice the runway lighting and the effects of the glare. This simulates a 5-millwatt laser pointer seen from 3,000 feet away. (Photo series courtesy of Dr. Leon McLin.)

This is the effect of the same laser pointer seen from 1,000 feet away.

This is the effect of the same laser pointer seen from 330 feet away. Note the degraded visual cues around the runway.

consider the drawbacks that are associated with them. Filtering light reduces the total amount of light entering the eye, which can adversely affect normal viewing, especially at night when most laser incidents occur. In addition, filtering green light can remove some green flight symbology on flight deck displays and change the appearance of some of the other colors used. As a result, protective glasses should be used with care. Regular sunglasses do not provide any protection from lasers.

Procedural changes. Flight crews who find themselves in a situation involving laser light in the cockpit should consider taking these steps:

- Look away from the beam or shield eyes from the light.
- Execute a missed approach if the light is severe enough to warrant it.
- Engage the autopilot or transfer airplane control to the other pilot if that pilot is not affected.
- Use Autoland if available. Autoland, included on all Boeing production models, works with a ground-based instrument landing system and uses the autopilot to fly an approach all the way to roll out without the direct involvement of the pilot.
- Increase the brightness of the interior lights to reduce some of the effects of the laser and put additional light on the instrument panel.
- Inform the controlling agency and provide the approximate location of the source.
- Avoid rubbing the eyes after an exposure to laser light and seek professional medical help, if necessary. If the surface of the eye is damaged, rubbing will make it worse.

Additional Information

Additional information about laser safety can be found in these publications:

- The American National Standards Institute (ANSI) publication Z 136.1: Safe Use of Lasers.
- SAE Aerospace Recommended Procedures (ARP) 5535: Observers For Laser Safety in the Navigable Airspace.
- SAE ARP 5572: Control Measures for Laser Safety in the Navigable Airspace.
- SAE ARP 5598: Laser Visual Interference: Pilot Operational Procedures.

Summary

The number of laser incidents involving commercial airplanes continues to increase every year. The best way for flight crews to protect themselves is by being aware of the problem and by following proper procedures if affected by laser light.

For more information, contact Peter Derenski at peter.a.derenski@boeing.com.

Airspace zones at U.S. airports

In the United States, the Federal Aviation Administration (FAA) has established airspace zones designed around airports and other sensitive airspace that should be protected from the hazards of visible laser light exposure.

Laser-Free Zone (LFZ). Airspace in the immediate proximity of the airport, up to and including 2,000 feet above ground level (AGL), extending two nautical miles (nmi) in all directions measured from the runway centerline (see fig. A). Additionally, the LFZ includes a three-nmi extension that is 2,500 feet on each side of the extended runway centerline, up to 2,000 feet AGL of each usable runway surface. The effective irradiance of a visible laser beam is restricted to a level that should not cause any visible distraction or disruption.

Critical Flight Zone (CFZ). Airspace within a 10-nmi radius of the airport reference point, up to and including 10,000 feet AGL (see fig B). The effective irradiance of a visible laser beam is restricted to a level that should not cause transient visual effects (e.g., glare, flash blindness, or afterimage).

Sensitive Flight Zone (SFZ). Airspace outside the critical flight zone that authorities (e.g., FAA, local departments of aviation, military) identify to be protected from the potential visual effects of laser beams (see fig. B).

Normal Flight Zones (NFZ). Airspace not defined by the laser-free, critical flight, or sensitive flight zones. As with all the zones, the NFZ must be protected from a laser beam that

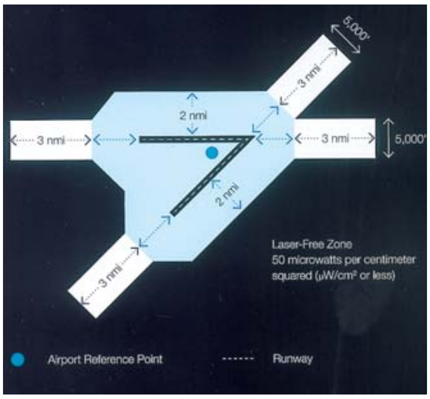

Figure A: Laser-free zone
The FAA prohibits the use of any visible laser beam that can cause any visible distraction or disruption in the immediate airport landing area.

Figure B: Airspace flight zone
Critical and sensitive flight zones, as defined by the FAA.

exceeds the maximal permissible exposure, as defined by the FAA.

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EU Accident Investigation Regulation Comes Into Force

by Charlotte Marfleet, BLG

The Regulation on the investigation and prevention of accidents and incidents in civil aviation is now being published in the Official Journal of the European Union and comes into force on 2 December 2010.

The proposed overhaul of aviation accident investigation rules was previously discussed in Issue 78 of *Focus*, at which point the proposal was still being considered by the Council.

The Regulation repeals Directive 94/56/EC and takes into account the legal and institutional changes that have taken place in the European Union since 1994, in particular the establishment of the European Aviation Safety Agency (EASA) in 2002. The key features of the Regulation are as follows:-

Investigation versus blame

The Regulation stresses the independence of the safety investigator and adds to his duties, as well as the need for cooperation between the judicial authorities and the safety investigator. There is however still scope for judicial proceedings to occur in order to apportion blame or liability, although the need to promote a 'just culture' within civil aviation is noted in the recitals. The Regulation re-enforces the principle that the sole objective of accident investigation is to prevent future accidents without attributing blame or liability. To this end, the Regulation implements international standards on the protection of sensitive air safety information.

Local authorities

A European Network of Civil Aviation Safety Investigation Authorities will be set up to advise the institutions of the European Union, make Europe-wide air safety recommendations, promote best investigation practices and strengthen national safety investigation authorities. Each Member State must set up a civil aviation accident emergency plan and ensure that all airlines based in its territory have a plan to assist victims of accidents and their relatives, which will inevitably lead to increased costs for airlines. A database of safety recommendations will also be set up.

Role of EASA

The Cologne-based EASA will be entitled, under strict conditions ensuring the absence of any conflict of interest, to participate as a technical advisor in accident investigations in order to ensure the safety of aircraft design. EASA will also have access to the safety occurrence reports produced by Member States.

Passenger details

In order to allow passengers' relatives to obtain information quickly concerning the presence of their relatives on board an aircraft involved in an accident, the Regulation places an obligation on airlines to offer passengers the opportunity to give the name and contact details of a person to be contacted in the event of an accident. This may lead to airlines needing to adapt their current websites, booking systems and other customer interface procedures to meet this requirement.

Provision of Information

European Union airlines, as well as non-European Union airlines departing from an airport in the European Union will be obliged to, as soon as possible, and at the latest within two hours of the notification of the occurrence of an accident, produce a list of all the persons on board. Furthermore, a list of any dangerous goods on board the aircraft will have to be released by the airline immediately after the accident. Airlines in particular will need to be aware of these strict time limits and the practicalities involved in meeting them. The article does not specify a time by when these procedures need to be put in place, which may result in some uncertainty for airlines.

Official Investigation reports

As is the case at present, under the Regulation the safety investigation authority will be obliged to make public the final accident report "in the shortest possible time and if possible within twelve months of the date of the accident or serious incident".

Finally, the Regulation stipulates that the Commission should bring forward a proposal to revise Directive 2003/42/EC on occurrence reporting in civil aviation to take place before December 2011.