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Contents

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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: Cessna Citation X operated by Pen-Avia from their Luton Airport Base

The Key to a Successful SMS – An Effective Reporting Culture

by Rich Jones, Chief Executive UKFSC

Although the proactive approach to aviation safety has been around the aviation business for a decade or more, Safety Management Systems only grasped the imagination of the Commercial Aviation sector once ICAO mandated its implementation some two years ago. Now it seems that the opportunities for SMS consultants and practitioners are almost endless, as is the proliferation of SMS guides, courses and articles. However, there is an understandable but overwhelming tendency to concentrate on establishing the process through which safety data, is collected, analysed and stored. But this is barely half the story.

A process is clearly necessary in order to enable individuals within each company to understand their duties and responsibilities under SMS; the data handling and its exploitation is relatively straightforward but the real challenge is how safety data is generated in the first instance and herein lies the rub. Right from the outset, without an open and honest reporting culture and environment to provide safety data of sufficient quantity and quality, through which trends can be identified early and timely, proactive action taken, SMS is the proverbial chocolate teapot!

In the past, personal pride and concerns about career progression were the major obstacles to admitting our mistakes and our close-run incidents and events. Nonetheless, many old and bold were persuaded to reveal all after a 'decent' lapse of time or after they had run out of grip on the greasy career pole – and these have been valuable, if somewhat behind the drag curve. But we now have a series of more formidable challenges playing against the generation of safety data upon which SMS' future effectiveness depends.

The threat of criminalisation immediately comes to mind and in particular the propensity for the judiciaries and lawyers of some Nation States to pursue pilots, engineers and even designers who have laid down their slide rules long ago. Internal company disciplinary action is another area of serious threat to open reporting, which is being seen increasingly in the commercial aviation sector. The major point here is that the vast majority of mistakes and errors can often be traced back to uncomfortable organisational failings within the company – a lack of training, inappropriate selection, inadequate management, insufficient resources – and not a deliberate or wanton act of the employee. Ill-considered disciplinary action against an individual will invariably mean the same mistake will be made by someone else and that the near misses by others will go unnoticed or unreported and will cost the company more in the long run.

Another threat which actively discourages safety data sharing between players in the aviation industry in some States is anti-trust legislation, where airline company legal teams have been known to counsel against airlines exchanging safety information for fear of being accused of engaging in activity leading to mutual commercial advantage.

So what are the principles needed to make Safety Management Systems deliver the safety advantages that ICAO hopes for from its implementation across the industry. First and foremost, openness in occurrence reporting and freedom to share safety information amongst safety professionals is fundamental to enhancing aviation safety into the future. This will very much depend upon the development of a culture in which aviation practitioners are not punished for actions, omissions or decisions taken by them that are commensurate with their training and experience, but clearly where gross negligence, wilful violation and destructive acts are not tolerated.

ICAO has sought to promote this approach in Annex 13 where, in Attachment E, the protection of safety information from inappropriate use is cited as essential in ensuring its continued availability, since its use for anything other than safety-related purposes will inhibit occurrence reporting and adversely effect aviation safety. Nonetheless, ICAO should be encouraged to further clarify the precise nature of the disclosure of safety records described in Annex 13 and, even more urgently, to develop the definition of 'a culture of safety' which is so vital for open and honest reporting to thrive unhindered.

European legislation is also taking strides in the right direction by seeking to facilitate the establishment of a non-punitive reporting environment, and by asking Member States to take the appropriate measures to provide protection of safety information and those who report it. To support this, there is also promise of some engagement between the Ministries of Justice and Transport in the European Community to promote a better understanding about the part played by an open reporting culture in enhancing aviation safety.

However, in pursuit of this important goal, we must be realistic in not trying to seek special treatment for the aviation industry by the judiciary, since this will never happen. Our real challenge must be to educate and influence public opinion against the understandable need to blame someone for incidents and to explain that human beings, however well trained and experienced, will make honest mistakes. Anything that denies open reporting of unintentional human error in any high risk industry is unwelcome and does nothing to enhance safety into the future.

focus ON COMMERCIAL AVIATION SAFETY

"A New Risk & A Tragic End"

by Capt. Tony Wride (Monarch Airlines) Chairman UKFSC

In my last article I made a comment "so that perhaps we are better prepared to cope for the next time Mother Nature decides to test us." Little did I know that yet again I was tempting fate because having given us the bad winter weather Mother Nature came up with a new challenge, (the threat has always been there and is very prevalent in other parts of the world), in the form of an Icelandic Volcano with a totally unpronounceable name!

The Eyjafjalljokull Volcano, (I do wonder if way back in the mists of time some Icelander decided to give the likely troublemakers these names as a joke!), and more specifically the ash cloud, has presented the aviation industry with a new challenge to safe operations. Right from the start the thing that stood out was that Airlines where required to carry out Risk Assessments and provide the Authorities with a robust Safety Case to allow flying to re-commence and continue. It has been interesting to listen to the various arguments and discussions regarding the hazards and more importantly the likelihood issue. Currently the scenario that has generated a number of different results is the consideration of an Emergency Descent following the loss of pressurisation. If you take the view that a total pressurisation failure is 'Possible' then you are forced to restrict operation over the No Fly Zone so that you can be clear of the zone before descending to FL100/MSA. However, if you take the view, based on statistical analysis, that a total pressurisation loss is 'Unlikely' then you can justifiably reduce the restriction and allow more flights.

So how can you effectively do 'Statistical Analysis'? To start with you have to have access to a sensible set of statistics, which for a large airline should not be an issue, but for a small operator could be a bit problematic. If in the safety case you can argue that in 500,000 sectors operated by your airline you have never had a total pressurisation loss incident then it would be reasonable to say that the event is 'Unlikely'. For a relatively new airline with only 4 aircraft they may only have done 500 sectors so they don't have the quantity of data to back up their case. This is where access to a Global database such as STEADES helps because it is possible to get some figures for the particular aircraft type you operate based on the worldwide fleet. Even in the case of the big airline if on top of their own figures they can add the worldwide fleet statistic the argument for making the event 'Unlikely' can become even stronger.

What the statistical analysis scenario does highlight is the need for a free and open culture of information exchange between airlines. However, that information exchange must have sufficient built in protection mechanisms to prevent the data being used by the media to create sensational and unfounded headlines. Whilst the very nature of the UKFSC promotes an open and protected information exchange between members the larger global exchange could be improved. In my opinion there should be a centralised worldwide database that all airlines, regardless of whether you are a member of a particular group or not, are required to submit to if realistic risk assessments are to be carried out.

I had completed this article when the tragic news of the Afriqyah Airlines A330 crash on final approach to Tripoli came in. A total of 103 people lost their lives in a modern commercial airliner, delivered in September 2009, doing something that every aircraft does every flight, an approach to a runway. The cause of the accident won't be known until all the evidence, particularly the flight recorders, has been analysed but already the speculation is running rife. The classic calls of 'pilot error', 'aircraft technical problems', 'poor approach aids', 'adverse weather' and 'complex automatics' have all been put forward as possible causes. I have seen the 'theorists' argue their particular corner and the easy target, for these so called experts, is to blame the aircraft and in particular the automatics. As an Airbus pilot, (I had the brain transplant in 1994!), I am always amazed at how suspicious people are of automation. At the end of the day the A330 is perfectly conventional, if the pilots let it, the aircraft will crash!

As I have mentioned in the early part of this article assessing the risk of an event should ideally be based on statistical analysis. With this in mind if I was doing a risk assessment on a non-precision approach to an airfield what likelihood should I choose of the aircraft crashing? There have been a number of crashes, and significant events recently, of aircraft doing non-precision approaches. There have been incidents where the ground based navigation equipment has given erroneous information and in one case the aircraft was saved by both the GPWS triggering and the prompt action of the pilots. Therefore it could be argued that the likelihood level should be set as 'Possible' rather than 'Unlikely' which when added to the Consequences, which would have to be 'Major/Catastrophic, would require some pretty robust mitigation action. This is where the statistical factor comes in because if you take the global number of non-precision approaches made and add in the number of reported incidents for your particular airline it should be possible to assess the likelihood as 'Unlikely'. Even if you feel you can't do that, if your Safety Management System is sufficiently robust then the mitigation required to reduce the risk should already be in place in the form of regular training and safe operating procedures.

But is there anything else that could slew the assessment? In previous articles I have highlighted the value of experience as being unquantifiable. To an accountant they see pilots as costing an amount and the experienced ones as costing that amount plus say 40%. To a Safety Manager, and possibly to the insurance companies, it could be argued that an experienced crew can reduce the risk and be used in the risk assessment. This brings me to my final point.

In the last Focus magazine Dr Simon Bennett wrote a very informative article "Anatomy of an Accident" which if you haven't done so I strongly recommend you read. The article focuses on the Colgan Air crash last year in Buffalo and in particular highlights the low pay of the regional carriers which it is argued forced the crew to try and take rest prior to the flight in less than ideal conditions, an airlines Operations room! Having looked at the replay of the flight and at all the other information it was a classic 'Swiss Cheese' with all of the holes lining up to produce the tragedy. So who is to blame in what should be a blame free culture?

I personally believe something I mentioned in a previous article still holds. The general public now expects too much for not a lot and this mentality is creating a potentially serious threat to future aviation safety.

Idle Approach

by Mark Lacagnina

Neither pilot was aware that the autothrottle system had disengaged with the thrust levers at idle during an instrument landing system (ILS) approach to Bournemouth (Hampshire, England) Airport. The Boeing 737-300 initially decelerated according to the flight crew's expectations. However, after final flap extension, the commander noticed that indicated airspeed had dropped 10 kt lower than the target speed. He was moving the thrust levers forward to initiate a go-around when the stall-warning system activated.

The flight crew's subsequent actions to avoid the impending stall were inadequate, said the U.K. Air Accidents Investigation Branch (AAIB) in its final report on the serious incident.

As airspeed had decreased, the autopilot had increasingly trimmed the 737 nose-up to maintain the glideslope. The aircraft pitched up further as thrust from the underwing-mounted engines increased as the commander advanced the thrust levers.

The combination of the nose-up trim and the application of maximum thrust "overwhelmed" the elevator, the report said, but neither pilot considered retrimming the stabilizer. Both pilots were pushing their control columns against the stops when the aircraft finally stalled and descended in a steep nose-up attitude. The commander was able to recover from the upset only after reducing thrust to the go-around setting, which restored elevator authority.

None of the 132 passengers or five crewmembers was injured, and there was no damage. The AAIB's investigation of the Sept. 23, 2007, incident led to recommendations to ensure that flight crews are effectively alerted to the disengagement of an autoflight system and to clarify procedures for recovering from an impending stall.

Night Instrument Conditions

The aircraft was en route on a scheduled flight from Faro, Portugal. The commander, 56, had 11,280 flight hours, including 420 hours in type. He had served as a 757/767 first officer for the operator before upgrading as a 737 commander in 2006. [1] The first officer, 30, had 3,170 flight hours, including 845 hours in type. He had flown twin-turboprop regional aircraft before being employed by the operator in 2006.

The 737 stalled after the autothrottles disengaged without notice

"Before departing Faro, the crew discussed the weather at Bournemouth, uplifted additional fuel to permit two approaches and decided on a full-flap (flap 40) landing," the report said.

Night instrument meteorological conditions prevailed at Bournemouth, which is on the southern coast of England. Surface winds were from 220 degrees at 14 kt, visibility was 4,000 m (2 1/2 mi) in light rain, and the ceiling was overcast at 400 ft. Cleared to conduct the ILS approach to Runway 26, the crew calculated a landing reference speed (Vref) of 129 kt and decided to add six knots for the final approach.

As the autopilot captured the glideslope at 2,500 ft, the first officer, the pilot flying, asked the commander to extend the landing gear, select flap 15 and begin the landing checklist. He also selected a lower speed on the mode control panel (MCP). The autothrottle system moved the thrust levers to idle to reduce airspeed to the selected value. About 20 seconds later, the autothrottles disengaged. "The disengagement was neither commanded nor recognized by the crew, and the thrust levers remained at idle through-out the approach," the report said.

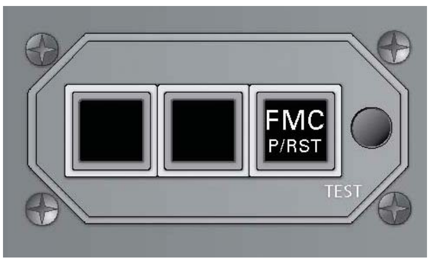
Indicated air-speed initially decreased normally at about one knot per second. "As the speed decreased below 150 kt, flap 25 was selected," the report said. "The autopilot tracked the glideslope accurately, gradually increasing the pitch of the aircraft to minimize glideslope deviation and adjusting the stabilizer angle to keep the aircraft in trim."

The report said that the approach was stable and that there was no sign the crew was "rushing the approach." However, the pilots momentarily became distracted when the first officer increased the illumination of his map light to read a placard showing the flap limit speeds before asking the commander to select flap 40. About this time, airspeed began to decrease rapidly.

'I Have Control'

After selecting flap 40, the commander also selected 135 kt — the planned Vref plus 6 kt final approach speed — on the MCP and completed the landing checklist. "The commander stowed the checklist on top of the instrument panel, and when he looked down he saw an IAS [indicated airspeed] of 125 kt," the report said. "He called 'speed.' The [first officer] made a small forward movement with the thrust levers, and the commander called, 'I have control.'"

The aircraft was descending through 1,540 ft with a 12-degree nose-up pitch attitude and airspeed slowing below 110 kt when the commander moved the thrust levers full forward.



The autothrottle (A/T) annunciator flashes so often during approach that it may be perceived as a nuisance message.

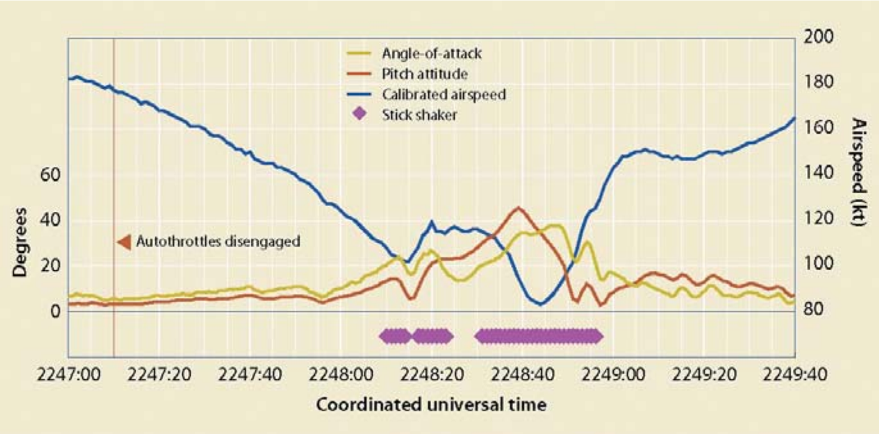


Figure 1 - Source: U.K. Air Accidents Investigation Branch
QAR = quick access recorder

As he did so, the stick shaker activated to warn of an impending stall. (see figure 1) The commander engaged the autopilot's control wheel steering mode and moved his control column forward, reducing the pitch attitude to 5 degrees nose-up. "The stick shaker operation stopped, and the minimum airspeed was 101 kt," the report said. "A small, apparently unintended application of right aileron induced a right roll."

As engine low-pressure rotor speed (N1) increased though 81 percent, the takeoff/go-around (TOGA) mode activated. "The autopilot disengaged, the pitch attitude started to increase again, and the stick shaker reactivated," the report said. "A corrective roll input was made to bring the aircraft wings-level, and although the control column was positioned fully forward, the nose-up pitch increased to 22 degrees."

N1 increased to nearly 98 percent, which is above the rated go-around thrust setting of 94 percent. The pitch attitude stabilized briefly at 22 degrees, and the stick shaker ceased as airspeed increased to 118 kt. However, the pitch attitude again began to increase when the crew selected flap 15, the go-around setting.

"A small continuous left rudder input started a left roll," the report said. "As the flaps reached flap 15, the pitch angle was increasing through 27 degrees and the left roll was increasing through 7 degrees. The stick shaker reactivated, full nose-down elevator was still being applied, and the airspeed began to decay."

'Full Forward Stick'

The first officer called "high pitch," and the commander replied, "I have full forward stick." The first officer also held his control column full forward. "Both pilots reported (during post-incident interviews) that they had no pitch control authority", the report said.

Calibrated air-speed (CAS) decreased below 107 kt as the pitch attitude reached 36 degrees and the left bank increased beyond 13 degrees. The TOGA mode disengaged. A right rudder control input brought the wings level before the 737 stalled with a nose-up pitch attitude of 44 degrees.

"With no change in elevator position, the pitch rate reversed from positive to negative although angle-of-attack continued to increase as the aircraft started to descend," the report said. "Despite reducing pitch, the airspeed continued to decrease for a further five seconds to a minimum recorded CAS of 82 kt when the pitch was 33 degrees nose-up."

The commander regained control after reducing N1 to 86 percent. Pitch attitude decreased rapidly to 5 degrees nose-up, and airspeed increased to 147 kt. "The commander initially leveled the aircraft at 3,000 ft before climbing to 4,000 ft and self-positioning for a second approach," the report said. The commander remained as pilot flying during the second approach, which was conducted without further incident with the autopilot and auto-throttles engaged. The 737 was landed at 2301 local time.

After taxiing to a stand and shutting down the engines, the commander told the operator's base engineer that there had been an incident and that, although he believed the aircraft was serviceable, the operator likely would want to review the recorded flight data. "No defects were entered in the technical log," the report said. "The engineer assured the commander that the operational flight data monitoring (OFDM) information was sent from the aircraft by an automatic mobile telephone based data link."

Questions Unanswered

The next morning, the commander advised the operator's safety department of the incident and completed an air safety report (ASR). The AAIB report said that the ASR "contained limited information" and "did not depict the event accurately." Not realizing the seriousness of the incident, the operator did not file a mandatory occurrence report with the U.K. Civil Aviation Authority.

The OFDM analyst who read the ASR was not a pilot and flagged the event for further review by a pilot representative. An OFDM pilot representative was on duty in the safety department that day but was too busy with other tasks to review the incident aircraft's flight data. The report said that the seriousness of the incident was not identified and appropriate action was not taken until the next pilot representative came on duty again at the OFDM office 11 days later.

"[The aircraft] was not subjected to an engineering examination to ensure its continued airworthiness and remained in service throughout this period," the report said. Data recorded by the cockpit voice recorder and flight data recorder during the incident were overwritten, and the AAIB's incident investigation was limited to interviews and analysis of the flight data captured by the quick access recorder (QAR) for the OFDM program.

The investigation did not resolve why the autothrottle system disengaged during the approach. Manual disengagement is achieved by selecting the autothrottle switch on the glareshield panel to "OFF" or by pressing a push-button on either thrust lever. The QAR data indicated that neither of these actions had been taken.

The uncommanded disengagement of the autothrottle system could have resulted from detection of an internal fault by built-in test equipment. "Due to the delay in notification of the incident, the aircraft had completed more than 10 flights, and therefore the fault history information from the incident had been overwritten," the report said. Post-incident tests of the autothrottle system revealed no faults that could cause an uncommanded disengagement.

Why the pilots did not see the flashing red light on the instrument panel that warns of autothrottle disengagement also was unanswered. The annunciator is a small rectangular pushbutton lens in the upper center of the instrument panel. Labeled "A/T P/ RST" — "autothrottle, push to reset" — the annunciator also generates a flashing amber caution light when airspeed is 10 kt above or 5 kt below the selected speed or decreases to "alpha floor," or 1.3 times the stalling speed.

"The autothrottle warning… flashes amber routinely for extended periods during the approach phase of flight," the report said. "It is likely that flight crews are subconsciously filtering out what is perceived as a nuisance message."

Investigators identified "a number of other events" that involved uncommanded and unrecognized autothrottle system disengagements in 737s. "Consequently, the efficacy of the autothrottle warning became of interest during the investigation," the report said, noting that the 737 did not have, and was not required to have, an aural indication of autothrottle disengagement.

As a result, the AAIB recommended that Boeing and the U.S. Federal Aviation Administration review the effectiveness of the autothrottle system disengagement warnings in 300-, 400- and 500-series 737s and improve them if necessary. The AAIB also called on the European Aviation Safety Agency to review Certification Standard 25 for transport category airplanes to "ensure that the disengagement of autoflight controls, including autothrottle, is suitably alerted to flight crews."

The incident investigation revealed that the flight crew did not apply nose-down trim to regain elevator authority. The flight crew training manual (FCTM) and the quick reference handbook (QRH) for the 737-300 both say that the first action in response to a stall warning or a stall is to apply full thrust. However, only the FCTM advises that the aircraft's nose will pitch up as the engines accelerate and that the stabilizer must be trimmed nose-down to assist in pitch control. "The [QRH] drill does not mention the use of pitch trim," the report said.

Based on this finding, the AAIB called on Boeing to "clarify the wording of the approach-to-stall recovery [in the QRH] to ensure that pilots are aware that trimming forward may be required to enhance pitch control authority."

This article is based on AAIB Aircraft Accident Report 3/2009, "Report on the Serious Incident to Boeing 737-3Q8, Registration G-THOF, on Approach to Runway 26, Bournemouth Airport, Hampshire, on 23 September 2007."

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A PC Traffic Alert and Collision Avoidance System (TCAS) Simulator Trainer

by N.J. Lawson[1], R.Bailey[2] – National Flying Laboratory Centre (NFLC). Cranfield University

Background

From 1st January 2000, all aeroplanes registered in the United Kingdom, wherever operated, and all other registrations operating in UK airspace, powered by jet or turbopropeller engines either having a maximum take-off weight (MTOW) exceeding 15,000 kg or a capacity of 30 plus passengers were mandated to carry a TCAS II collision avoidance system. This was extended on 31st March 2006 to include all civil fixed wing turbine aircraft with a MTOW exceeding 5700kg or a capacity greater than 19 passengers. This requirement for TCAS came from a long process of development, dating back to the 1970's, of independent and aircraft portable collision avoidance systems. Following the fatal collision of a DC9 with a small Piper aircraft in 1986 near Los Angeles, the US FAA mandated the use of TCAS. This was followed by a further FAA requirement for TCAS II in 1993. In each case, the European states followed afterwards with similar mandates. The newest version of TCAS II, version 7.1 is expected to be mandated in Europe and the US in the near future.

TCAS II is an aircraft safety system based on secondary surveillance radar (SSR) transponder signals. The TCAS system provides the pilot with collision protection from other aircraft equipped with A, C and S mode transponders. All TCAS systems rely on a time-to-collision principle as originally proposed by Dr John Morrell in the 1950's. Depending on the type of transponder signal the TCAS system is monitoring, i.e. mode A, C or S, the TCAS system will alert the pilot through aural announcements and a visual display on the flight deck, of the relative position of the threatening aircraft or intruder in height and azimuth. If mode S is on board both the intruder and pilot's aircraft, TCAS can coordinate manoeuvres in height using the VSI display, or flight director, to ensure collision avoidance with minimum height deviations. If the intruder aircraft is squawking Mode A + Mode C, TCAS will provide an advisory to prevent a collision but, without Mode S in the intruder aircraft, the manoeuvre cannot be coordinated. During the avoidance manoeuvre, the VSI and aural alerts guide the pilot and may involve a climb, a descent, both or maintaining a current condition.

The extension of TCAS to all turbine aircraft with MTOW's of more than 5700kg led to the requirement for a substantial number of retrofits of TCAS equipment to aircraft which were previously non-TCAS equipped such as the Cessna CJ3, BAe 125 or Jetstream 31/32. This use of TCAS II is also now being extended to older rotary wing aircraft such as the Super Puma which was recently fitted by Bristow and Honeywell with TCAS II in 2008. Training pilots for the use of TCAS II is ideally done in a flight simulator environment and for the vast majority of large modern airliners, this is not a problem. For older aircraft such as the Jetstream 31/32, for example, there is no TCAS system fitted into the simulator or in some types there is no simulator at all. In these cases, the training manager generally has to resort to instructor generated oral alerts in the simulator. In both cases the pilot will not receive the full visual picture from the cockpit instruments that would occur in a real scenario. This presents an opportunity for improvements in TCAS II training using a computer based training (CBT) simulator device. Such a CBT trainer using an inexpensive personal computer (PC), can provide an economic method to complete comprehensive and recurrent TCAS training with the correct visual and aural representation for the pilot.

In the following article, the author will outline the limited options that were initially found for a CBT TCAS trainer and the subsequent joint development of a high specification X-Plane based PC TCAS trainer with the American company Advanced Simulation Corporation.

Current CBT TCAS Trainers

Given the background to this training opportunity and the author's experience in the Jetstream 31, it was decided to initially search for PC trainers that were available on the open market using common simulator platforms such as Microsoft Flight Simulator (MSFS) or X-Plane. In former case, although the TCAS cockpit displays were available from third party add-on software for MSFS, none of this add-on software allowed direct control of the TCAS scenarios. So although you could generate a TCAS scenario by increasing the simulator traffic density and flying at the traffic, because of the random nature of the traffic and the variance in the pilots flying, it was not possible to obtain a repeatable TCAS scenario. A search for X-Plane third party add-ons did not find anything acceptable in terms of TCAS training. In fact the only PC flight simulator which had potential control of the TCAS scenario was a non-windows based simulator called Precision Simulator 744 (PS744) by Aerowinx. This appeared to have instructor options for TCAS training although it was not clear what could be directly controlled by the instructor. The other problem with PS744 was it was developed over 10 years ago as a DOS based programme through legacy windows systems such as Windows 95 and had an EFIS only style

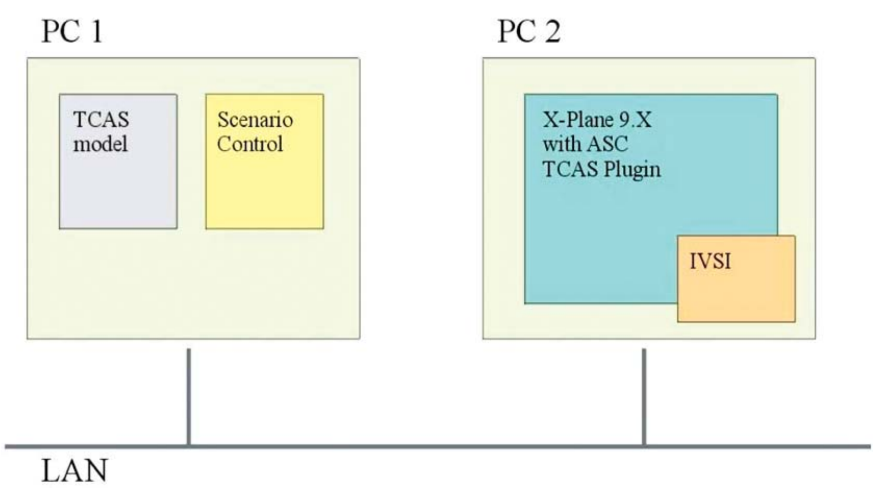

Figure 1 - Schematic of CBT TCAS Trainer Set-up

display. Furthermore, although priced at around $300, Aerowinx was not producing or selling the software anymore.

Following these initial inquires, a further option was considered for a TCAS PC trainer based on the widely available MSFS. Given the simple process of networking MSFS version 2000 or X, it was thought if two PC's were connected, an intruder pilot could fly TCAS scenarios at the trainee pilot on the other PC. This potential solution was tested on MSFS with several types of third party add-on TCAS aircraft. In all cases, although the two pilots could see each other visually and see other computer generated traffic on their TCAS displays, they could not see each other on TCAS. Despite attempts to find out why this was the case through PC simulator forums and Microsoft, no answer for this problem could be found thus leading to an unworkable solution.

After these preliminary enquiries for an off-the-shelf solution for a PC based trainer, it was decided a more bespoke PC trainer was required which to be developed by specialists, ideally professional programmers and simulator designers.

Bespoke CBT TCAS Trainers

Although there are a number of major aircraft simulator companies worldwide who have the potential to develop such a PC TCAS trainer, the author initially contacted the aerospace research organisation Nationaal Lucht- en Ruimtevaartlaboratorium (NLR) in the Netherlands. NLR have developed their own generic four-degree-of-freedom flight simulator for ergonomic and human factor research in both civil and military cockpits. NLR considered the proposal for a PC TCAS trainer and offered to develop the software. But the development cost was outside the budget available to NFLC.

Further enquires were made to numerous simulation companies and eventually an American flight simulation company called Advanced Simulation Corporation (ASC) based in Washington State, offered to consider the proposal for the CBT trainer. After some negotiations, Cranfield University approved the development of a comprehensive CBT TCAS II trainer by ASC which met the limited budget available to NFLC. The simulator proposal was based on the use of X-Plane and ASC TCAS software code. The following now describes the AdvSim CBT solution.

Advanced Simulation Corp. CBT TCAS Trainer

The TCAS CBT trainer for NFLC is a PC based TCAS simulator that runs on a pair of networked PCs using a standard local area network (LAN). PC1 is the instructors PC and PC2 is the pilot flying PC, both with independent displays. This arrangement can also be extended through the LAN to contain a set of student PC's and a single instructor PC to simultaneously train multiple pilots in a given session. In NFLC's case, the two PC system is made up of a number of components as illustrated in Figure 1 below.

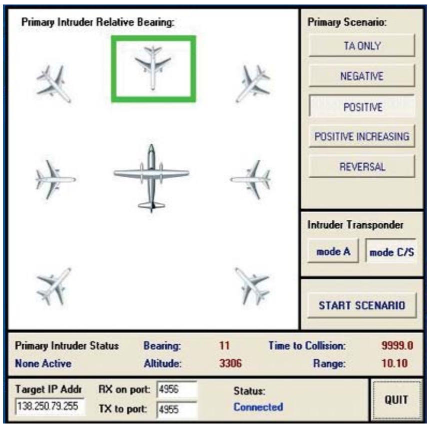

Figure 2 - (a) Instructor window

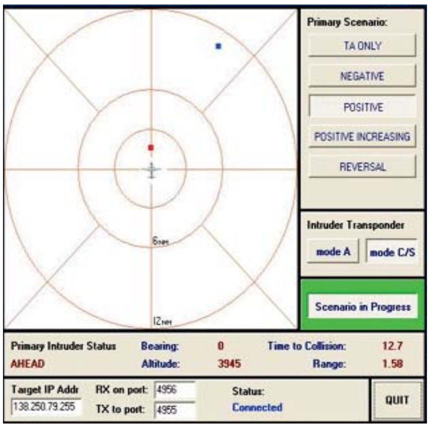

Figure 2 - (b) scenario monitoring

The instructor PC, PC1 contains a number of elements of software which provide inputs to the pilot PC PC2, via the LAN. The two elements consist of a TCAS model which contains all the rules of engagement during an encounter based on TCAS v7.0 and the

Figure 3 - X-Plane 9 B200 Cockpit with TCAS IVSI

Scenario Name	Scenario Detail
TA Only	No guidance TA
RA Negative	'maintain vertical speed' or 'monitor vertical speed' RA
RA Positive	Climb or descend guidance followed by 'clear of conflict'
RA Strengthening	Climb or descend guidance followed by 'increase climb' or 'increase descent' terminating with 'clear of conflict'
Reversal	Climb or descend guidance followed by a reversal as the intruder senses the change of vertical speed and moves in opposition to the pilots response

scenario generator which generates synthetic intruders and other aircraft and also the graphical user interface (GUI) with the instructor as shown in Figure 2a and 2b. The positions of these synthetic aircraft are fed into PC2 which uses X-Plane as the pilot / cockpit interface with the TCAS model. The other major element, displayed on PC2, is the TCAS graphical interface between the pilot and cockpit which is in the form of an IVSI display. This display is driven by the TCAS model and replicates the normal symbology and graphics that would be expected on an aircraft IVSI during a real encounter. The IVSI has also been arranged to be overlaid ontop of the X-Plane cockpit display with a stretchable window and display. This IVSI arrangement then allows any X-Plane cockpit to be combined with the TCAS IVSI thus allowing rotary or fixed wing TCAS training. Figure 3 shows an example of this cockpit environment which is a generic X-Plane B200 King Air cockpit. To complete the cockpit environment, the TCAS model also triggers the same aural announcements that would be found in the actual cockpit using either a male or female voice. X-Plane v9 is currently in use for the cockpit interface which allows the selection of numerous cockpit environments and the use of inexpensive USB hardware such as a yoke, rudder pedals and a throttle quadrant.

To train for a TCAS scenario, the pilot and instructor can initially agree on the intruder aircraft type and training aircraft and cockpit configuration through selections on X-Plane. The pilot then departs from an airport of choice flying PC2 with the transponder set to TA only or RA/TA and the instructor sets up a TCAS scenario on PC1 using the GUI shown in Figure 2a. This GUI allows the relative bearing of the intruder to be set and the type of engagement. When ready the instructor then triggers the start of the scenario and a number of targets appear on the pilot's TCAS IVSI. The instructor can also track these targets and the progress of the pilot using his/her GUI (see Figure 2b). One of the IVSI targets will engage the trainee pilot with a preset engagement set by the instructor from one of the following general scenario set: (See above).

The trainee can then fly the manoeuvre; ensuring aircraft vertical speed matches that demanded on the IVSI green sector, the *skills* part of the training exercise; and make the standard calls such as 'TCAS RA' and 'Clear of Conflict' as the encounter develops, which is the *knowledge of procedures* part of the training exercise.

Following the resolution of the conflict, the pilot can make a report to ATC and either return to his cleared flight path or receive a new clearance from the instructor acting as ATC, and the instructor can continue to trigger the next scenario.

The first version of the ASC system has recently undergone testing at Cranfield University by the NFLC pilots and is proving to be a very effective visual and aural training aid. Further improvements are currently being completed by ASC including the option to increase the number of IVSI false targets during the encounter and the scenario set is also being expanded to cover a second group of engagements based on the full set of TCAS aural alerts. On completion of this development phase, the ASC system is expected to be available for general release to the aviation community.

Notes

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Volcanic ash flight disruption: a step too far for passenger rights?

by Sue Barham, Edward Spencer - Barlow, Lyde & Gilbert

The restrictions on UK and much of European airspace which began in April following a volcanic eruption in Iceland have caused unprecedented disruption for both airlines and their passengers. Whilst the skies have remained silent and free of air traffic, airlines have been facing unprecedented turbulence on the ground, exacerbated by their legal obligations to passengers which arise under EC Regulation 261/2004.

This infamous piece of legislation – the EU's flagship air passenger rights regulation – has hardly been away from the forefront of carriers' thinking since last November when a European Court of Justice ruling suggested that, quite contrary to the regulation's own terms, passengers could be entitled to recover lump-sum compensation for flight delays. With the ongoing disruption to travel caused by volcanic ash, Regulation 261/2004 once again is being trumpeted as providing extensive rights to passengers in circumstances that can never have been contemplated when it was first introduced.

One reassurance for the airline industry is that the airspace restrictions are about as clear an example of "extraordinary circumstances" under Regulation 261 as it is possible to get; hence there should be no question of airlines having to pay lump-sum compensation to passengers as a result of the cancellation of flights. However, the concern instead is the extent of the passenger welfare obligations imposed by the Regulation. Where flights have been cancelled, carriers are obliged to provide care and assistance (including, where applicable, hotel accommodation) and also, at the passenger's option, reimbursement or re-routing of the passenger to their destination. Regulation 261 has been criticised on numerous occasions in the past for being vague and imprecise and these provisions run true to that form. Fundamentally, there is no time limit expressed as to the duration of these strict obligations.

There are two areas where there is some small comfort for airlines. First, re-routing can be offered using other "comparable" modes of transport and so, where ground transportation is feasible as a practical alternative in order to return passengers to the UK, that option is likely to have discharged carriers' re-routing obligations under Regulation 261. Clearly, however, ground transportation will not have been a practical alternative in many cases and, even if it is, airlines remain exposed to claims for passengers' accommodation costs until such time as re-routing can be arranged. Secondly, EC guidance states that if a passenger has been offered a re-routing but has chosen instead to travel at a later date when a more convenient routing is available, any obligation to provide further care and assistance ceases at that point when they could have accepted the initial offer of re-routing. In those circumstances, airlines will be well placed to assert that their obligations to provide care and assistance and to pick up hotel bills overseas cease at that stage.

Due to the well-publicised expense of finding alternative ground transportation, the ability of airlines to minimise their exposure to the passenger welfare obligations arising under Regulation 261 is in fact very limited in the current situation. This would seem to highlight that the fundamental issue going forwards is whether it is now time for governments of EU Member States to exert all the pressure they can on the European Commission and Parliament to look properly at amending Regulation 261 in order to limit its damaging financial effects on the industry. An appropriate level of air passenger rights is unobjectionable. However, the aim of the passenger welfare provisions of Regulation 261 is to provide care and assistance whilst passengers are waiting for their delayed flights to depart or for the airline to re-route them on an alternative flight (including provision of hotel accommodation where the re-routing cannot take place until the following day). Here, the ability to re-route passengers has been rendered all but impossible in many cases and it must be arguable that that there ought to be some express limits on the passengers' entitlement to welfare.

It simply cannot have been the expectation of those who drafted Regulation 261 that it would make airlines responsible for paying many days' hotel bills in circumstances as extreme as those we have seen over the last few weeks. Arguing against consumer legislation is of course not likely to be a vote winner but it is time for the European legislators to look again at how far air passenger rights ought to extend.

Avoiding Convective Weather Linked to Ice-Crystal Icing Engine Events

by Mathew L. Grzych - Meteorologist, Atmospheric Physics and Flight Test Engineering

High-altitude ice crystals in convective weather can cause engine damage and lower loss in multiple models of commercial airplanes and engines. (More formation about engine power loss in ice crystal conditions can be found in AERO fourth-quarter 2007.)

Pilots typically use the term "icing conditions" to refer to weather conditions usually below 22,000 feet where super-cooled liquid droplets form ice on cold airframe surfaces. On the contrary, ice-crystal icing conditions connected to engine power loss are thought to be due completely frozen ice crystals. When flying near convective weather through ice crystal conditions, pilots have reported a lack of airframe icing or ice detection (no supercooled liquid present), but they do notice the appearance of rain on the windscreen, sometimes at temperatures too cold for liquid water to exist. It has been confirmed that the appearance of rain is caused by small ice particles melting on impact with the heated windscreen. Pilots also have noted that the sound made by flight through ice crystals is different from the sound they hear when flying through rain. Although it's not present on all airplanes, a total air temperature (TAT) anomaly also has occurred simultaneously during some engine events.

The TAT anomaly is due to ice crystals building up in the area in which the sensing element resides, where they are partly melted by the heater, causing a 0 degrees C reading. This phenomenon seems to depend on where the TAT sensor is installed on the fuselage. In some cases, TAT has stabilized at 0 degrees C during a descent and may be noticeable to pilots. In other cases, the error is more subtle and not a reliable-enough indicator to provide early warning to pilots of high concentrations of ice crystals.

This article provides detailed information about the convective weather associated with engine-power-loss events and recommendations on how to increase pilots' awareness of this weather and help them avoid conditions that can result in power loss.

In a majority of ice-crystals icing engine events, convective weather occurs in a very warm, moist, tropical-like environment.

Overview of engine events associated with Convection Ice Crystals

Engine-power-loss and -damage events are being reported within anvil cloud regions of convective storms at high altitudes. The engines in all events have recovered to normal thrust response quickly.

It has been accepted that ice crystals are the primary source of the engine icing because of the lack of airframe icing reports, lack of radar reflectivity, and the fact that many of these events are occurring at extremely cold temperatures where only frozen particles can exist. There appear to be certain environments and particular regions within each storm system that most often lead to engine events. The most common observations during these events include:

- The airplane is traversing a convective anvil cloud.
- Pilots are avoiding heavy radar return regions at flight level by 20 miles or more.
- Only light to moderate turbulence is reported leading up to and during the engine events.
- No hail is reported.
- There is no lightning.
- Either a lack of airplane weather radar returns or light radar returns present at flight level.
- Moderate to heavy precipitation (amber or red radar returns) is located below the airplane and the freezing level.

Weather associated with Ice Crystals engine events

Because it is believed that the clouds where engine events occur are composed of high concentrations of small ice crystals, scientists and meteorologists refer to these as regions of high ice water content (HIWC). Engine events associated with HIWC have occurred in two distinct types cloud: classic convection and nonclassic HIWC - producing convection (referred to as nonclassic convection from here forward). Roughly 20 percent of engine events occur in classic convection, while the remaining 80 percent occur in nonclassic convection.

Classic convection: Classic convection has vigorous updrafts, is typically found over land, and will have moderate to heavy radar signatures present up to high altitudes, making the core areas and danger zones detectible so the flight crew can avoid them (see fig. 1). Because this region of convective weather can be detected by the plane's radar system, pilots can avoid the cell by diverting to the upwind side. In these more typical convective clouds, engine events have been recorded in the anvil cloud downwind from the cell's core. In the anvil, even though there can be HIWC, ice particles return only enough radar energy to occasionally record green signatures on the pilot's radar. At other times, there may be no radar returns at all.

Pilots should avoid the region of anvil cloud downwind from heavy cores near these typical convective cells, especially if light radar returns are present at high altitudes. However, in the majority of ice crystal engine events, pilots unknowingly pass directly over heavy convective precipitation through the anvil cloud into regions of high ice content within nonclassic convective cells as discussed in the next section.

Nonclassic convection: The type of weather that is most associated with ice crystal icing and subsequent engine events is not what is

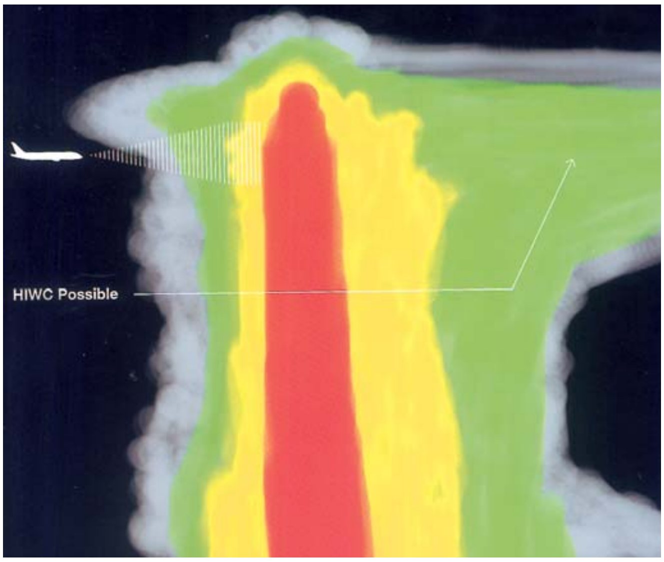

Figure 1: Classic convection: Cores readily detectable by radar
This image depicts a verticle cross-section view as an airplane is headed for a classic convection cell. Colours represent standard airplane radar returns where green is light, amber is moderate, and red is heavy. In this scenario, the radar beam pointed straight ahead detects heavy precipitation and the airplane diverts and avoids the weather. There is, however, an area of high ice water content (HIWC) possible in the anvil cloud downwind from the convective core that pilots need to be aware of and avoid.

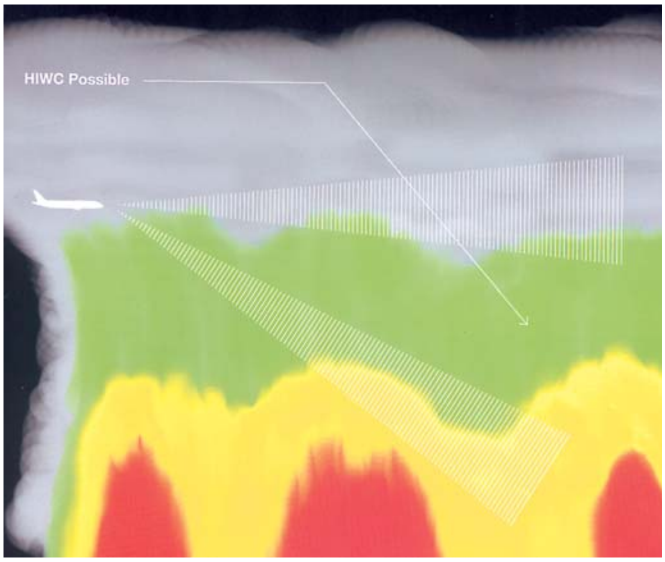

Figure 2: Radar view of typical ice crystal engine conditions
This image depicts a cross-section view as an airplane is headed for a nonclassic convective system. During a typical ice crystal engine event, the airplane will be flying in convection cloud with light radar returns at flight level. However, if the pilot uses the radar tilt function to scan below the airplane, moderate to heavy radar returns will be seen. These are regions to avoid because they are associated with regions of HIWC.

generally considered typical convection, which has vigorous cores that can be detected at flight level. Instead, the convective weather that is of greatest concern is associated with nonclassic convective clouds that have weak updrafts, regions of decaying convection, and regions of HIWC aloft, but lacks reflectivity at flight level, making it more difficult for pilots to identify (see fig. 2).

Many times areas of HIWC may be associated with residual areas of merging and decaying cell updrafts within a larger convective system. HIWC regions are typically characterized by relatively weak updrafts that are not strong enough to loft large ice particles, such as hail, to high altitudes, but are able to loft high concentrations of small ice particles up to the tropopause (tropopause height varies lepending on the latitude and the season). Large ice particles, such as hail or graupel, are effective radar reflectors and show up on weather radar readily. However, radar returns are not reported during ice crystal engine events, leading meteorologists to conclude that only small ice particles can be present during these events.

Ice Crystals Engine Event: A Case Study

Airlines can gain valuable insights into convective weather associated with engine power loss and damage by examining an actual engine icing event (see fig. 3). In the enhanced infrared satellite image of a large convective system where an engine icing event occurred, the colored areas represent regions of deep convection and the bright white region is where cloud tops have penetrated through the tropopause into the lower stratosphere. The airplane flew along the path from right to left, entering a large anvil cloud associated with a tropical convective system. A TAT anomaly was observed shortly after the airplane entered the anvil cloud, followed by a series of engine events as the airplane penetrated the deepest part of the storm at temperatures well below freezing. The engines recovered quickly, and the airplane continued safely to its destination.

In this region of the convective system, large amounts of moisture are lifted, converted to ice crystals, and then lofted to high altitudes. This event represents a fairly typical scenario for ice crystal engine events in which an airplane enters a large tropical-like convective system while on ascent or descent at temperatures well below freezing. The engine event then occurs while passing through a region of deep glaciated convective cloud with moderate to heavy rain below the airplane.

Radar data provides another view of this ice crystal engine event (see fig. 4). The red arrow represents the airplane's flight trajectory; a series of engine events occurred between the white dots. Low-level radar returns along the path were mostly moderate with some embedded heavy return regions. However, at flight level—where the series of events occurred—radar returns were only scattered light return (green) areas. Using the radar's tilt function to scan below the airplane would have revealed moderate to heavy returns below.

Characteristics of system with areas of high Ice content

Although the exact physics and dynamics that contribute to ice crystal engine events are not completely understood, there are many similarities among events.

For example, a majority of the events has occurred in tropical and subtropical regions of the world (usually between 30 degrees south

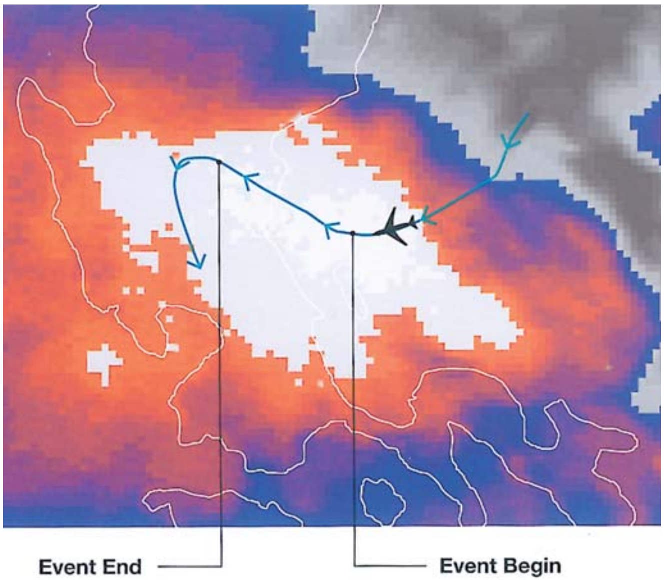

Figure 3: Infrared satellite image of a large convective system where an engine icing event occurred

This satellite image shows a typical scenario for ice crystal engine events in which an airplane enters a large convective system while on ascent or descent at temperatures well below freezing.

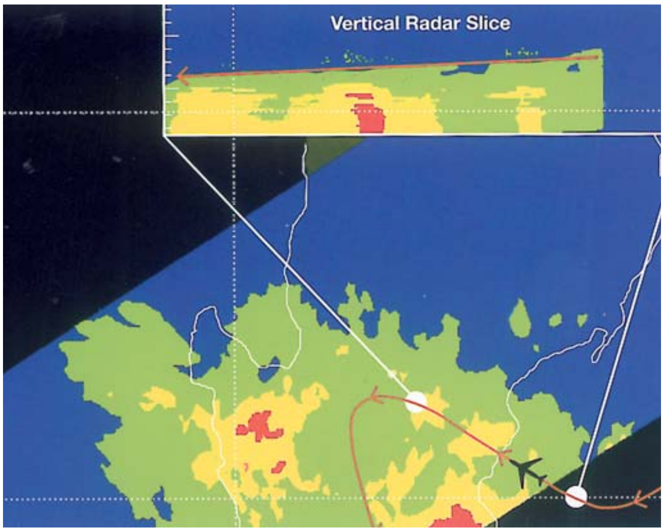

Figure 4: Satellite-based radar view of convective system where an engine icing event occurred

Radar data for this event shows a top-down view (main image) and a vertical slice looking northeast through the storm (inset). The red arrow depicts the airplane flight trajectory.

and 30 degrees north latitude). In these cases, the airplane penetrated into the deepest part of a nonclassic convective system, flying directly over heavy rain in the glaciated cloud above.

Nonclassic convection events have also occurred at higher latitudes during summer months; for example, they have been reported in the eastern United States and Japan.

A smaller percentage of engine events, on the order of 20 percent or less, has occurred in classic convection. These events typically occur in mid-latitude, continental storms as an airplane diverts from a heavy weather core at altitude and flies into a region of HIWC adjacent to or downwind of the core.

A conceptual model helps illustrate where areas of high ice content might be found (see fig. 5). In these systems, there can be several areas of active convection where heavy returns may be present to high altitudes, as well as broad regions of decaying convection and moderate to heavy stratiform precipitation regions at lower levels.

Engine event threat areas include regions above the freezing level either adjacent to or downwind of heavy convective cores or above moderate to heavy rain associated with decaying convection or stratiform regions within the convective system. Both regions are labeled "HIWC Possible" in figure 5.

From an observer's perspective at high altitudes, the anvil region may grow so large that it can take on the appearance of a thick cirrus cloud shield and lose its visual convection and moderate to heavy stratiform precipitation regions at lower levels.

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From an observer's perspective at high altitudes, the anvill region may grow so large that it can take on the apperance of a thick cirrus cloud shield and lose its visual convective qualities. Essentially, many individual convective cells and their associated anvil clouds all merge into one large, broad system and each individual anvil cloud loses its identity.

Engine events most commonly occur at altitudes of 20,000 to 35,000 feet at temperatures ranging from -10 degrees C to -40 degrees C. However, some outlier events have occurred at altitudes as low as 9,000 feet with a temperature of -8 degrees C and at altitudes as high as 41,000 feet with temperatures down to -63 degrees C.

In a majority of the ice crystal engine events, convective weather occurs in a very warm, moist, tropical-like environment. The atmosphere is generally slightly to moderately unstable, resulting in weak to modest updraft strength. During engine events, pilots report only light to moderate turbulence. These convective systems are generally large, heavy rain producing storms that have life cycles ranging from several hours to 24 hours or more.

Typically, events do not occur in severe convection with strong updrafts because these cells are detectable at altitude, and pilots are able to avoid them. However, in some cases high concentrations of ice crystals can be present within the anvils of these storms either adjacent to or downwind from heavy cores.

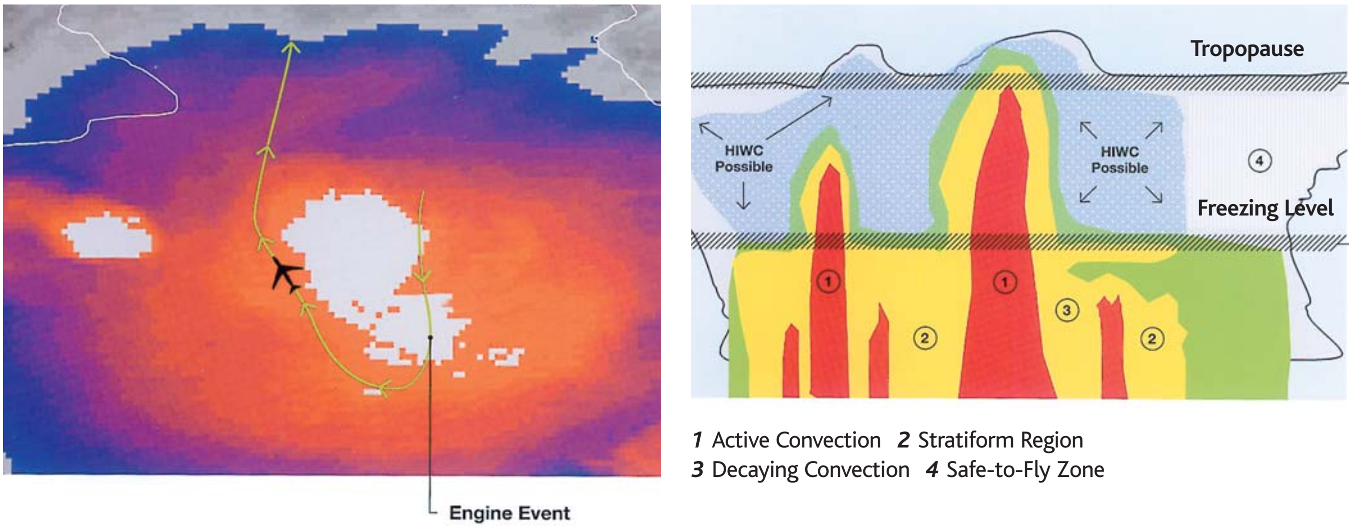

Figure 5: Conceptual model showing areas of high ice content

An infrared satellite image of a tropical mesoscale convective system where an engine event occurred (top) and an idealized east-west verticle cross-section through the storm's centre viewing it from the south looking north bottom. Green, yellow, and red areas represent light, moderate, and heavy radar return regions, respectively. Ice content is labelled

What can flight crews do to assess and avoid weather associated with ice-crystal icing engine events?

Recognize areas where ice crystals may exist

- Above the freezing level in convective weather
- Near the deepest part of a convective cloud

Recognize common conditions

- Moderate to heavy rain is present below the airplane, producing amber and red radar returns, but little or no returns at flight level
- Weak to modest updraft velocities
- Light to moderate turbulence

Operating instructions

- During flight in instrument meteorological conditions, avoid flying directly above significant amber or red radar returns
- Use the weather radar gain and tilt functions to assess weather radar reflectivity

Recommended actions

Based on an analysis of the ice crystal engine event database, Boeing has developed the following recommendations to help flight crews avoid regions of HIWC:

- During flight in instrument meteorological conditions (IMC), avoid flying directly above significant amber- or red-depicted map weather radar regions.

- Use the weather radar gain and tilt functions to assess weather radar reflectivity below the airplane.

For example, if an airplane is flying in IMC above the freezing level and there are amber or red radar returns in the vicinity or cloud tops up to the tropopause, or the airplane is known to be in a convective cloud, regions of HIWC may be in the area. In this scenario, the pilot should point the radar down to look below the freezing level. If amber and red areas indicating heavy rain are detected below the freezing level, HIWC areas are possible above these low-level moderate to heavy rain regions. Under these conditions, the pilot should consider evasive action.

Summary

To date, the engines affected in all recorded ice crystal events have recovered to normal thrust response quickly. However, due to the possibility of continued power loss and the risk of engine damage, airlines can use this information to help them avoid flying in convective weather associated with engine-power-loss events.

For more information, contact Matthew Grzych at matthew.l.grzych boeing.com.

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What is convective weather?

Convective weather, or atmospheric convection, is the result of an unstable atmosphere where ascending air parcels condense moisture to high altitudes sometimes resulting in one or more of the following:

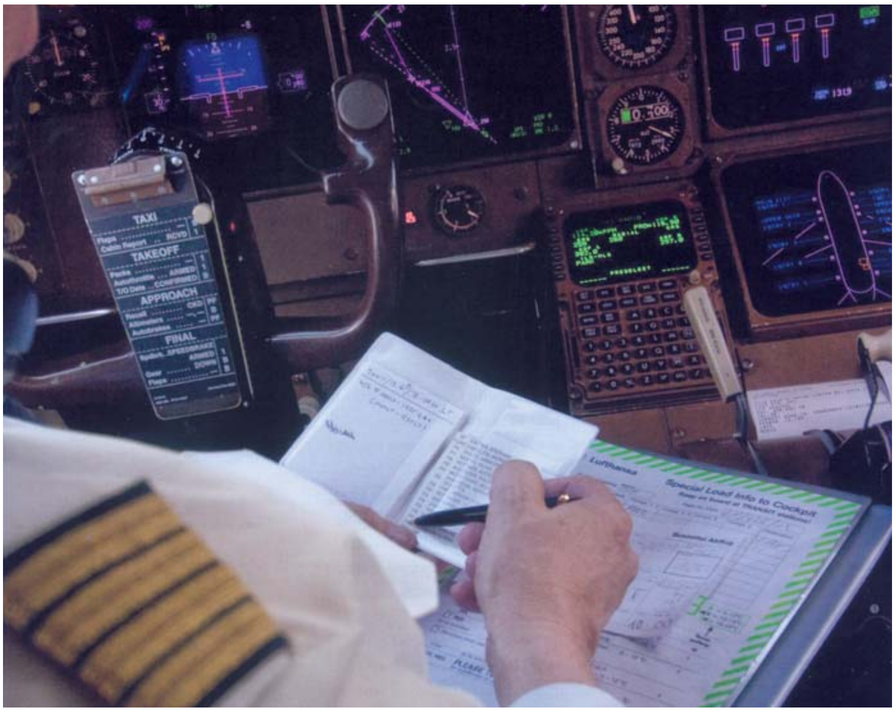
- Vertically deep cloud with a large cirrus (anvil) region.
- Areas of strong wind shear and turbulence
- Lightning
- Areas of high condensed-water content
- Heavy precipitation and hail
- Regions of high concentrated ice particles

Thinking Things Through

by Clarence E. Rash and Sharon D. Manning

A pilot's cognitive processes – thinking and decision-making skills – often are the key to successfully overcoming in-flight safety risks.

On the chilly afternoon of Jan. 15, 2009, having lost power from both engines of their Airbus A320 minutes after takeoff from New York's LaGuardia Airport, the crew of US Airways flight 1549 landed the aircraft in the Hudson River.[1] Although the A320 was destroyed, all 15 people inside survived.



There is little doubt as to the role that the training and experience of the flight crew played in the successful emergency landing, but ultimately, it was their decision-making skill that turned a potential tragedy into a triumph.

When faced with a challenging situation, pilots must use their skills, abilities and knowledge to overcome the immediate circumstances. Cognitive psychologists consider decision making as the interaction between a *problem* needing to be solved and a *person* who wishes to solve it within a specific environment and set of circumstances.[2] Although making the right decision does not always lead to success, making the wrong decisions makes success considerably less likely.

When the crew is faced with a threatening situation in the cockpit, the outcome is largely determined by three groups of factors:

- External factors, such as weather, runway conditions, takeoff weight and presence of birds;
- Aircraft and flight deck design factors, such as the structural limits of the aircraft and the human factors engineering design of flight deck displays and input controls that affect the workload; and,
- Factors related to human capabilities, such as those that influence a pilot's level of cognitive processing and his or her decision-making capability.

The first two groups are largely predetermined and beyond the immediate control of the pilot. However, the third group of factors centres around the human performance of the pilots and is within their direct control.[3] This group includes high profile factors that are recognized as important enough to be regulated, such as the amount of rest time provided and alcohol consumed within a specified preceding time period, as well as factors that frequently are overlooked, such as nutrition state, hydration level, smoking rate and ambient noise level. These and other seemingly unimportant factors can significantly degrade pilot performance by impairing cognition, and, as a result, problem-solving and decision-making capabilities.

Cognitive Capacity

Although philosophers have been interested in human thought for thousands of years, the field of cognitive science — the scientific study of the human mind or of intelligence — is barely more than 100 years old. Despite tremendous advances in the understanding of how the mind works, it remains difficult, even for cognitive specialists, to predict the cognitive capabilities of an individual in most sets of circumstances.

When cognitive demands exceed an individuals capacity — a condition referred to as cognitive saturation — newly presented information may not be perceived or understood.[4] This implies that individuals have a set amount of cognitive resources — a term that refers to information-processing capabilities and knowledge that can be used to perform mental tasks. Different cognitive tasks appear to involve different information processing systems, and the resources and limits of these systems determine the cognitive capability to perform a given set of tasks. One of the main goals of cognitive science is to identify the properties of these systems and characterize their limits.

Scientists have explored human cognition by studying its fundamental processes and how they are affected by internal and external factors called stressors.

Cognitive Processes

To make decisions that lead to doing the "right thing" at the "right time" requires pilots to acquire, process and act on information available within the immediate situation. This information is acquired through the five basic human senses—sight, hearing, smell, taste and touch—and the so-called sixth sense of

proprioception, or the ability to sense the position and movement of the body and its parts (see "How Humans Obtain Information").

On the flight deck, there is an unusually broad unitization of the senses to continually update pilot information. For example, vision is used to monitor panel displays and to detect airspace and runway incursions. Hearing is used to detect aural warning signals and in communication. Smell—and in some cases, taste—can help detect the presence of fire, fuel leaks or chemicals. Proprioception supplies not only the sensations associated with "seat of the pants" flying but also a range of other signals from sensors in the skin, muscles, tendons and joints that aid in establishing awareness of the position of the body relative to the Earth.

As information is provided by the senses, it is interpreted by the respective cognitive processes of perception, attention, memory, knowledge, problem solving and decision making, after which a course of action is implemented. This defines just one cycle in the decision-action sequence, which is a continuous feedback loop of acquisition, processing, decision and action.

Perception

Perception is a series of conscious sensory experiences. It is a combination of the information from the stimuli, or sources of information, in the world around us producing sensations in the sense organs —via sensory receptors—and cognitive processes that interpret those sensations. Perception deals with the psychological awareness of objects in the world, based on the effect of those objects on the sensory systems. It often is defined as the mental organization and interpretation of the visual sensory information with the intent of attaining awareness and understanding of the objects and events in the immediate environment.

Because perception is an interpretation by the cognitive processes of the information obtained by the senses, it is possible for an interpretation to be wrong. These misperceptions are called "illusions" and are attributed to all of the senses. The flight environment is known for inducing a host of sensory illusions in pilots. When not recognized as incorrect interpretations of the current state of the aircraft, these illusions impair situational awareness and frequently lead to incorrect decisions and courses of action, often with disastrous consequences.

Attention

Because humans have limited cognitive processing capability, there is a distinction between the total information provided by the real world and the amount of this information that actually is processed. The mental process that is involved in producing this distinction is referred to as "attention." A stimulus can be processed very differently when attended to, compared with when it is unattended. For example, if someone is asked a question while he is busy attending to something else, he may not even hear the question.

Generally, attention involves a voluntary or intended focusing of concentration. It is believed that attention can be directed to different aspects of the environment. In reality, attention is not based on a single mechanism but involves the properties of many different cognitive systems.

Cognitive scientists distinguish between voluntary and involuntary attention.[5] Voluntary attention occurs when a person makes an obvious cognitive effort to remain focused on a particular task. Involuntary attention often is related to environmental stimuli, such as warning signals, that seem to automatically draw attention.

One attention condition that has been the subject of considerable interest in aviation is "cognitive tunneling." Cognitive tunneling refers to a difficulty in dividing attention between two superimposed fields of information—for example, head-up display (HUD) symbology as one field and see-through images as another field. It sometimes is referred to as "attentional tunneling" or "cognitive capture." In the aviation environment, such difficulty can lead to serious problems. Studies have found that pilots sometimes have failed to detect an airplane on a runway when they are landing while using a HUD system.[6,7] Cognitive tunneling is an extreme form of a trade-off between attending to displays and attending to the outside world. Several studies have shown that a HUD improves monitoring of altitude information in a simulated flight but at the expense of maintaining the flight path.[8,9]

Memory

Memory interacts with attention and perception. Indeed, many failures of attention are described as breakdowns in memory of recent events. Cognitive scientists have identified various components of memory, such as short-term memory, working memory and longterm memory.[10]

Short-term memory deals with memory of items for several seconds and generally has a relatively small capacity, holding only a few items before forgetting takes place. Working memory, which typically involves the manipulation of a piece of information — such as the mental comparison of two remembered airspeeds — is broken down into subsystems that process information in a variety of ways.[11]

Long-term memory refers to the important memories that are stored for long-term use. For example, training information, information about rules for behavior in specific situations and other developed forms of knowledge are stored in long-term memory. Closely related to this type of knowledge is a sort of mental model, a cognitive structure called a "schema" that helps interpret information about how particular situations typically play out; for example, of how a specific aircraft will behave under stall conditions. Schemas allow people to adapt to new situations by using knowledge about other similar situations.

The cognitive process of problem solving refers to an immediate distinction between the present state of circumstances and a goal for which there is no immediately obvious path to attainment.[12] The ability to solve a problem is interrelated with the previously discussed cognitive processes. Some problems are difficult because their solution requires retaining more information than can be held by working memory, and others are difficult because individuals lack the appropriate schemas to characterize and analyze the important issues of a problem.

One important aspect of problem solving is to identify the differences between expert and novice problem solvers. Pilots are specially trained for their duties and are thus experts at solving some aviation-related problems. As a result of their training, experts in a particular field solve problems faster and with a higher success rate than novices. The primary difference between expert and novice problem solvers seems to be that experts have more specific schemas for solving problems.

Experts also generally have more knowledge about their field of specialization than novices. Their knowledge is organized differently than novices' knowledge. In particular, experts often organize their knowledge in a way that reflects the fundamental aspects of solving a class of problems.

Decision Making

The culmination of the other cognitive processes is the decision-making process.

The major elements of decision making are: outcome selection, certainty and uncertainty, and risk. An outcome is what will happen if a particular course of action is selected. Training helps identify the list of possible outcomes

How Humans Obtain Information

Humans obtain information via a number of senses. Although most cognitive scientists have moved away from the historical concepts of physiological senses and their resultant sensations and toward the psychological concept of perception – the understanding of sensory information – these older concepts are useful in understanding how we obtain information to make decisions.

Our senses acquire information using specialized receptors (Table 1). The most basic sense modes are sight, hearing, touch, taste and smell.

Along with the sense of balance (equilibrioception, or vestibular sense), these senses sometimes are referred to as exteroceptive senses, because they relate to our perception of the world around us. However, scienctists have identified a second group of senses called interoceptive senses that pertain to our sense of self. This group includes thermoception, or temperature; nocieption, or pain; and proprioception, the sense of the orientation and position of oneself in space. Proprioception does not result from any specific sense organ but from the nervous system as a whole.

– CER, SDM

Human Senses

Human Sense	Receptors	Sensations/Perceptions
Sight (Vision)	Photoreceptors (Cones and rods)	Brightness and colour
Hearing (Audition)	Hair cells (Vibration receptors)	Sound
Touch (Tactility)	Touch receptors (Mechanoreceptors)	Touch and pressure
Smell (Olfaction)	Chemoreceptors (Odor receptors)	Smell (Odor)
Taste	Taste buds	Salty, sour, sweet, bitter and umami[1]
Thermoception (Temperature)	Themoceptors (Heat receptors in the skin)	Temperature (Heat and Cold)
Proprioception	Muscle spindles, Golgi tendon organs, and joint receptors	Self orientation and position
Nociception (Pain)	Nocioptors (Pain receptors)	Pain
Equilibrioception (Vestibular sense)	Otolith organs	Balance (Direction of gravity)

Note: 1. Umami, the lesser-known "fifth taste", is described as savory or "meaty".
Source: Clarence E. Rash and Sharon D. Manning

Table 1

and the courses of action that may lead to each outcome. Knowledge of possible outcomes is important when multiple courses of action are available. Certainty implies that decision makers have complete and accurate knowledge of the possible outcomes for each possible course of action, and that there is only one outcome for each course of action. This last condition is not always met.

Risk becomes a factor when there are multiple outcomes for one or more courses of action. Risk can be managed if a probability can be assigned to each outcome when a specific course of action is taken. Uncertainty is present when the probabilities cannot be assigned; such a decision situation is referred to as "decision under uncertainty."

Researchers at the U.S. National Aeronautics and Space Administration (NASA) Ames Research Centre examined decision-making errors in aviation[13] and found most errors to be intentional—that is, they resulted from a positive selection of an incorrect course of action (a mistake) and not from a failure to take action (a lapse) or because an intended action was carried out incorrectly (a slip).[14]

However, as has been described, the decision-making process is the culmination of the other cognitive processes; if the other processes are degraded or go awry, then the decision-making process and the resulting selected course of action will be incorrect. The consequences can be disastrous.

To assist pilots with their decision making skills, the U.S. Federal Aviation Administration (FAA) developed a six-step model for use in teaching the elements of decision making. Known by the acronym "DECIDE," the six elements are:[15,16]

- *Detect* that a change has occurred;
- *Estimate* the need to counter or react to the change;
- *Choose* a desirable outcome;
- *Identify* actions that could successfully control the change;
- *Do* take the necessary action to adapt to the change; and,
- *Evaluate* the effect(s) of the action.

Decision making is a skill. Pilots, like other professionals, must learn to become better decision makers. The DECIDE model — one of many human factors approaches to teaching decision-making skills — has proved to be a successful resource for learning the crucial components of making more effective decisions.

Developing good decision-making skills is not just an academic exercise for pilots; it is a necessity. With lives at stake, making the right decision at the right time is imperative. From 1990 through 2002, decision errors were identified as a contributing factor in 30 to 40 percent of commercial and general aviation accidents.[17,18]

Clarence E. Rash is a research physicist with 30 years experience in military aviation research and development and the author of more than 200 papers on aviation display, human factors and protection topics. His latest book is Helmet Mounted Displays: Sensation, Perception and Cognition Issues, U.S. Army Aeromedical Research Laboratory, 2009.

Sharon D. Manning is a safety and occupational health specialist at the Aviation Branch Safety Office at Fort Rucker, Alabama, US., and has more than 20 years experience in aviation safety.

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Wake Vortex Encounters

by Dr Debbie Mitchell – NATS

Wake vortices are tightly spinning tornadoes of air generated at an aircraft's wingtips and are an unavoidable by-product of the generation of lift. A wake vortex pair can last for several minutes and stretch for many kilometres behind the aircraft with wind speeds of over 300km/h in the vortex core. The effect on a following aircraft's attitude can be dramatic and is commonly characterised by an uncommanded roll and/or a change of altitude. For example, in 2007 a light business jet following a Boeing 747 inbound to a UK airport reported.

"Whilst at 3000ft ... the aircraft encountered severe wake turbulence and rolled right through 90 degrees. At this point the pilot disengaged the autopilot, applying full power and rolled the aircraft in the opposite direction. The aircraft returned to straight and level flight with a loss of height between 300-400ft".

In order to reduce the risk of an aircraft encountering wake turbulence, wake turbulence separation minima were introduced in the early 1970s between certain types of aircraft. The wake turbulence separation minima are broadly based on the Maximum Take-Off Weight of both the leader and follower aircraft, since heavy aircraft generate stronger vortices and smaller aircraft are more susceptible to encountering them.

Wake vortex encounter reporting in the UK

The UK Civil Aviation Authority (CAA) established a voluntary wake turbulence encounter reporting scheme in the UK in 1972 in order to monitor the effectiveness of current separation minima. The scheme was designed to improve understanding of the operational conditions that result in wake vortex encounters and also the effect of wake vortex encounters on civil aircraft. The UK is considered to be a world leader in wake turbulence encounter reporting and monitoring and over the past 38 years more than 4500 wake vortex encounters have been reported via the scheme.

Each report received is assessed against the level of risk and depth of investigation appropriate. Investigations are initially carried out by the appropriate ATC unit. A feedback

process is in place whereby the results of investigations are disseminated back to the pilot or airline who reported the encounter.

The details of all reported wake vortex encounters are stored on the UK Wake Turbulence Encounter Database, which is managed by the Operational Analysis department in NATS on behalf of the CAA. The database is recognised to be the largest and most well-established of its type in the world and other states and international organisations are now looking to set up their own wake turbulence encounter reporting schemes based on the NATS model.

The UK Wake Turbulence Encounter Database is used to identify aircraft types that experience a higher rate of wake turbulence encounter than others and also to identify aircraft that generate greater vortices than their MTOM would suggest.. This information can be used to support operational decisions about changing the separations between certain aircraft types and has allowed the UK to file differences from the ICAO wake turbulence separation minima over the last 30 years, for example the introduction of the Small category in 1978 and the splitting of the Medium category in the mid-1990's.

The NATS Wake Turbulence Analysis Team also use the database to identify trends in the data, for example, particular locations, phases of flight or altitudes where encounters are most likely to occur. In addition, data compiled about wake vortex encounters provides essential information for any proposed *changes* to ATC procedures or separation standards. This data can be used for risk assessment and monitoring from project inception to implementation.

How to report a wake turbulence encounter

The success of the UK voluntary wake vortex encounter reporting scheme relies on accurate and consistent reporting of events from the aviation community. If a pilot encounters wake turbulence then he/she is encouraged to report the incident to ATC (who can also report the encounter) and then to either fill in a SRG1423 wake turbulence report form, which is available on the CAA's website:www.caa.co.uk/docs/33/SRG1423FF.pdf or fill in the relevant section of their company's Airline Safety Report (ASR) form. If the encounter was considered to be reportable under the Mandatory Occurrence Report (MOR) Scheme, then it should be sent directly to the CAA by email or post at:
E-mail: sdd@caa.co.uk

Safety Data
Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick Airport South, West Sussex, RH6 0YR

If the encounter was a non-MOR event then it should be sent to the NATS Wake Turbulence Analysis Team by email or post at:
E-mail: waketurbulence@nats.co.uk

Wake Turbulence Analysis Team, NATS Corporate and Technical Centre, 4000 Parkway, Whiteley, Fareham, Hampshire, PO15 7FL

Information which is considered to be essential when analysing a wake vortex encounter and where possible should be included in the report form is as follows:

- Date and time of encounter.
- Details of the affected aircraft (including callsign and aircraft type).
- Location and phase of flight where the encounter occurred (e.g. "on turn on to the glideslope at Heathrow").
- Altitude at which encounter occurred.
- Affect of encounter on aircraft, e.g. degree of uncommanded roll, loss of altitude, change in pitch, etc.
- Result of wake vortex encounter, e.g. go-around, injuries, etc.
- Separation between causing and affected aircraft at time of encounter (if known).
- Prevailing wind direction and speed.
- Details of causing aircraft (if known).

The UK Wake Encounter Working Group meeting

Any pilots, airlines or other relevant parties (e.g. EUROCONTROL, the UK Flight Safety Committee) who are interested in the subject of wake turbulence are invited to attend the annual UK Wake Encounter Working Group (WEWG) meeting, which is co-chaired by the NATS and the CAA. The objective of the WEWG is to provide a forum for all interested parties to share information and data on the issue of wake turbulence encounters primarily in the UK. The meetings provide an opportunity to share information on wake vortex matters, and include discussion of wake turbulence encounter trends (UK and other states); significant wake encounter incidents; concepts and developments in wake encounter arena; and amendments to UK wake requirements. The next meeting will take place in Autumn 2010 and any interested parties should contact NATS on the following email address: waketurbulence@nats.co.uk.

The UK also actively participate in the wake turbulence field at a global level and are involved in international wake turbulence projects such as Wakenet3-Europe (details of the project can be found at http://www.wakenet3-europe.eu/) and the newly formed ICAO Wake Turbulence Study Group.

Please keep reporting...

Please continue to report any wake turbulence encounters (even if the encounter is minor) as the information is essential for monitoring the wake turbulence encounter risk in UK airspace.

More information about reporting wake turbulence encounters can be found in the Aeronautical Information Circular P064/2009 at: http://www.nats-uk.ead-it.com/aip/current/aic/EG_Circ_2009_P_064_en.pdf

EUROCONTROL voluntary ATM incident reporting (EVAIR)

by Ms Dragica Stankovic – EVAIR Function Manager

We are very glad that we have the opportunity to address FOCUS readers. For those who are encountering the name EVAIR for the first time, you will wish to know that EVAIR is the first voluntary ATM incident data collection scheme organised at Pan-European level. It was set up in late 2006 in response to a request from EUROCONTROL's Provisional Council, which called for the establishment of a single European ATM safety repository. The aim was to adopt a more pro-active approach to the ATM safety by learning from low level incidents in order to prevent accidents and serious incidents. This new approach necessitates the availability of data, which in turn can only be made available if a number of prerequisites are fulfilled: data collection and data flow mechanisms and an appropriate legal, managerial, cultural and technical framework.

Within the EVAIR mechanism, ATM incident reports are provided on a daily or monthly basis depending on the agreement with data providers. These are 63 volunteering airlines coming from airlines associations such as IATA,IACA, ERA, ELFAA, who are also in a full support of the EVAIR activities. In addition, almost all EUROCONTROL member ANSPs provide feedback on airlines' Air Safety Reports (ASRs). EVAIR also collects and analyses data related to ACAS incidents either from airlines through the manual reporting of ASRs or from the ANSPs via automatic data collection systems from Mode S radars. The activity covers the whole ECAC airspace including some neighbouring areas.

The recent problems caused by the Icelandic Volcanic Ash cloud that engulfed much of Northern Europe in April 2010, triggered FABEC states Germany, France, Belgium, Switzerland, Nederland and Luxembourg to authorise EVAIR to assist in data collection, analysis and sharing of information related to volcanic ash on a pan-European level. The UK CAA also agreed to join and is also providing data.

In collecting and processing the data, EVAIR follows strict security and confidentiality arrangements and the information is only used for the promotion and enhancement of aviation safety.

In establishing EVAIR, EUROCONTROL has two main objectives:

- The fixing of problems within the shortest time possible.
- To promote a data driven approach to further safety enhancement activities based on low or medium risk bearing incidents, instead on serious incidents and accidents.

EVAIR focuses its efforts on a 3 main pillars:

- Data collection, recording and analysis.
- Feedback facilitation between the data supplier (usually airlines) and ANSPs.
- Monitoring and provision of periodical statistics through EVAIR Safety Bulletins, customised analysis following requests from stakeholders and ad-hoc meetings for stakeholders. Further details on these products can be found at **http://www.eurocontrol.int/esp/public/standard_page/evair.html**

EVAIR works intensively to:

- Support regional, local and EUROCONTROL Agency safety activities.
- Promote Just Culture through its non-punitive voluntary incident reporting policies.
- Enlarge the number of ATM incident data providers and improve the cooperation with its main stakeholders.
- Develop safety data reporting and analysis tools.

Data collection

Through manual data provision from Nov 2006 until February 2010, EVAIR collected more than 3100 ASRs and 3000 valid Airborne Collision Avoidance System (ACAS) Resolution Advisories (RAs) through the automated data collection. EVAIR also collects data related to other ad hoc safety concerns such as ATM 'contingency' events, call sign confusion occurrences and the growing problem of malicious laser 'interference' in aviation.

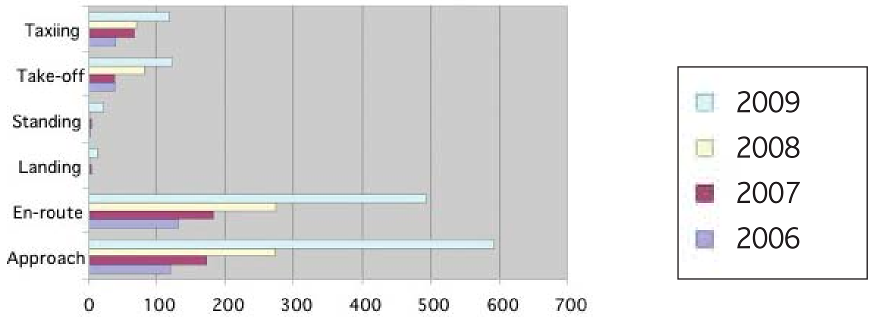
Feedback faciliation

The EVAIR feedback mechanism is becoming increasingly recognised by all stakeholders as a means to help airlines and ANSPs address safety related issues promptly and facilitate quick-fixes. Indeed, there is a growing understanding between EVAIR, ANSPs and the airlines, that the timely provision of the feedback helps not only to implement timely solutions but also to enhance trust between airlines and ANSPs. Most importantly, it motivates pilots and ANSPs to submit more safety reports.

Statistics

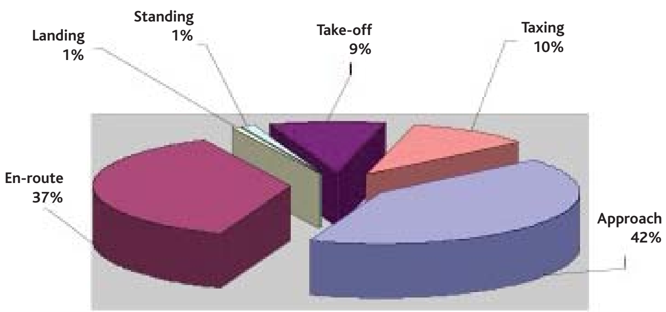
EVAIR periodically produces Safety Bulletins which portray ATM safety trends through statistical presentations. It also provides customised analysis to numerous stakeholders on an 'on request' basis. Here are a few examples:

1 Yearly spread of incidents per phase of flight in absolute figures for the period



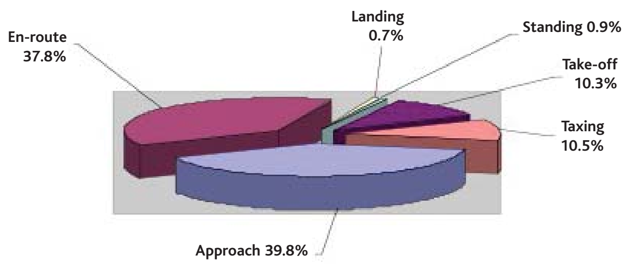
Incidents distribution per phases of flight 2006-2009 (absolute figures)

2 Spread of ATM incidents through phases of flight for the cumulated 2006 - 2009



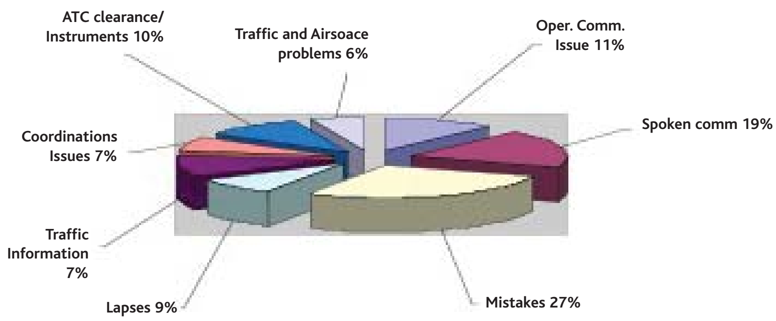
2006-2009

3 Spread of ATM incidents through phases of flight for the cumulated summer periods (April to September 2006 - 2009)



Incidents per phase of flight Summer 2006-2009 (absolute figures)

4 Contributors to ATM incidents Summer 2006 - 2009



Contributors to ATM incidents Summer 2006-2009 (absolute figures)

In this final example (figure 4) it can be seen that four contributors (Mistakes, Spoken communication, Operational communication and Traffic information) account for almost 70% of the overall ATM contributors. This provides an indication which areas to target when developing corrective measures.

The full inventory of EVAIR statistics can be found in EVAIR Safety Bulletins at:
http://www.eurocontrol.int/esp/public/site_preferences/display_library_list_public.html#4

EVAIR is constantly looking at ways to enlarge the number of data providers and improve its services and products. The contact person for all issues is: Ms Dragica Stankovic, EVAIR Function Manager: dragica.stankovic@eurocontrol.int

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