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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: A mission by Helimed 71 to Haytor on Dartmoor last summer

Big Data and Weak Signals

by Dai Whittingham, Chief Executive UKFSC

On 31 October 2015 a Kogalymavia A321 (branded Metrojet) crashed in the Sinai desert shortly after departing Sharm el-Sheikh. The inevitable and often ridiculous speculation played out in commercial and social media ranged from pilot suicide or an MH17-style missile attack, fuel starvation and double engine failure, to a stall and loss of control at altitude. It now seems highly probable that the cause of the accident was a bomb and hence the issue today is principally one of security rather than safety, though that is small comfort for those who lost loved ones, or for the operator, or for Airbus as the OEM.

There have been 53 bombings of aircraft since 1933, almost all by religious or political terrorists, but the destruction of 2 B747s, Air India 182 in 1985 and Pan-Am 103 at Lockerbie in December 1988, were a wake-up call for the industry and led to far-reaching changes to our airports and security processes. There have been other recent but unsuccessful attempts at bombings, including suicide attacks, using means such as liquids, shoes, underpants and even printer cartridges, which have resulted in further layers being added to security arrangements. For example, we will all be familiar with the 100ml limit on hand-carried fluids and gels, a legacy of the liquid bomb plot that was successfully disrupted in the UK in 2006. We can expect more rhetoric from those who for their own reasons will claim responsibility, but the Sharm incident will inevitably put additional focus on security and passengers can expect to spend more time going through the screening process on their future travels.

The 1985 Air India bombing, in which 329 people lost their lives, is interesting as a case study into the failure of intelligence and, in particular, the lack of reaction to small or weak signals. Sikh extremists had been actively planning the attack for some months but accurate reports made to the Canadian Security Intelligence Service and the Royal Canadian Mounted Police were dismissed as 'unreliable'. Two individuals later identified as primary suspects in the case had been under surveillance by CSIS; when these two followed to a remote location, an explosion was heard but there was no subsequent stop and search or follow-up, even though the site contained plenty of detritus to indicate an explosion had indeed taken place. A police informer reported that the prime suspect and another known extremist had warned members of a Sikh temple "it would be unsafe to fly" Air India, and police monitoring other extremists heard that "Something will be done in 2 weeks", but no action was taken. Nine days after the report, on 22 June, a wait-listed passenger was allowed to check a suitcase onto an intermediate flight from Vancouver. He did not check in at the intermediate stop at Toronto, or at Montreal, where the aircraft became Flight 182.

In the weeks prior to the bombing, threats from Sikh activists had prompted Air India to ask for additional security. Canada assigned extra policemen in the Toronto and Montreal terminals, and all baggage was being checked by X-ray or by hand. Unfortunately, the X-ray machine broke down on 22 June, so baggage inspectors used a portable PDD-4 explosive sniffer; the sniffer was later heard to beep with a low volume at a soft-sided maroon suitcase. However, Air India was not informed because the PDD-4 demonstration for the checkers had involved a lit match that produced a loud screeching noise from the sniffer device. The checkers were not told how to react to short or quiet beeps, and the bag was allowed to pass into the loading system. Seven hours into its flight, Air India 182 disappeared from radar about 120 miles off the coast of Ireland. It would be 15 years before the prime suspects were arrested, only for them to be acquitted for lack of evidence at a trial concluded almost 20 years after the loss of the aircraft and its occupants. Following a public inquiry, the Canadian Prime Minister acknowledged "the catastrophic failures of intelligence, policing and air security that led to the bombing, and the prosecutorial lapses that followed."

Similar intelligence failings were in play on Christmas Day 2009 when Umar Farouk Abdulmutallab unsuccessfully attempted to bring down Northwest Airlines 253, an A330 with 290 people on board. The weapon was a quantity of plastic explosive sewn into his underpants, but the bomb failed to detonate as designed, probably because the explosive had deteriorated during the 3 weeks that the garment had been worn. The US authorities had information from a variety of sources that should have ensured Abdulmutallab was prevented from flying to a US destination, but the handling of the information – the failure to connect the various signals - meant that the opportunity was lost.

The question that arises from both cases is whether the signals were too weak to be recognised as being significant, or whether the system was so large that the signals effectively became weakened to the point where they were lost in the noise. There are obvious implications for safety here, and not just for security, as we move ever closer towards the 'Big Data' environment that will form the bedrock of Performance-Based Regulation (PBR). The characteristics of Big Data have been described as volume, variety, velocity (speed of generation), variability, veracity and complexity, and I would offer that volume, velocity and complexity are likely to present us with the most difficult challenges.

As the industry gets safer through developments in reliability, automation and other safety improvements, the risk is that potentially significant occurrences will more frequently manifest as small signals in an increasingly large volume of data. Our difficulty will lie in finding the correct tools for analysis to determine what the data is actually telling us and recognising those small signals as being something we need to explore. We will also need to find a means of heeding our gut instincts and making our own judgements – the machine-learned judgements will only be as good as the programming allows them to be, and we cannot afford to find ourselves in a Little Britain "computer says..." scenario that drives where we invest ever more scarce safety resources.

On this side of the Atlantic, Regulation (EU) No 376/2014 has now entered force and should drive EASA member states to more consistent and comprehensive safety reporting. As well as being seen by the relevant NAA, future MOR and voluntary reports will be stored in the European Central Repository; full access to stored data will be available online to all NAAs and investigatory authorities. Other entities such as AOC operators and ATOs will be able to request information pertinent to their operation. ECCAIRS is the main vehicle for handling reports and will use the ADREP taxonomy pending development of a more suitable system by the EASA Network of (national) Analysts; a European Risk Classification system is also being developed and should be fielded by May 2017. In the interim, there is nothing to stop operators including their own keywords in the free-text element of MOR and VOR submitted via the CAA to ECCAIRS.

The bombing of Pan-Am 103 at Lockerbie produced some changes beyond the security sphere, as the event led to work aimed at mitigating the effects of an on-board explosion. This included changes to fuselage structures and manufacturing techniques intended to limit the propagation of tears and punctures and control the venting of high pressure gases generated by an explosion, as well as the use of energy-absorbing materials and closure of voids and channels to reduce the effect of Mach stem shocks - these shocks, which form via the coalescence of reflected shock waves from the primary explosion, propagated through voids and were responsible for airframe damage far from the point of origin. Recent developments have included containment devices that are capable of managing the effects of a small explosive device in hold baggage but these will be ineffective against a device in the cabin introduced by a determined suicide bomber boarding through weak airport security.

That said, the Sharm bombing and the latest terrorist attacks in Paris have raised the temperature in the security environment to the point were some individuals are now over-reacting. Incidents of innocent travellers being removed from flights in the USA for being guilty of speaking Arabic or simply 'looking middle-Eastern' do nobody any favours. We need to remember that not all Muslims are terrorists, that not all terrorists are Muslims, and that (thanks to the efforts of our various security services) terrorist attacks on aircraft are mercifully rare. We also need to retain a sense of proportion in the industry's longer-term response, lest we find that we hand victory to the opposition by generating disruption, delays and operating losses far beyond that which a terrorist might have hoped for.

As we look to the future it will be the analysts, in both safety and security spaces, who will bear the brunt of work to keep us safe in the air. They will be the ones who have to identify the small signals in the world of big data, and give them meaning and substance that the rest of us can act on. We can help them best by reporting promptly, accurately and thoughtfully. Please don't be the person who lets a crucial small signal go astray because it was too difficult or you were too tired – your report might turn out to be the key piece of the puzzle.

Peter Granston Richards I.Eng, FRAeS (May 12th 1945 – November 1st 2015)

When Peter Richards succumbed to Motor Neurone Disease on 1 November 2015, the UKFSC lost a staunch supporter and a much-valued friend. By January this year he had completed 30 years of service to the Committee as the representative of the Royal Aeronautical Society and, previously, of the Society of Licensed Aircraft Engineers and Technologists. His was the longest service in the 54-year history of the Committee and his unbroken period of membership is most unlikely to be matched.

He was an outstanding servant of the UKFSC and spent almost 15 years as one of our elected officers, including a period as Vice-Chairman which he completed in 2009. His contribution included the organisation and management of a series of safety seminars and he was for some time Chair of the Communication Sub-Committee. Throughout his time with the UKFSC the minutes record his measured and thoughtful inputs to the safety meetings, where he drew on his encyclopaedic and detailed technical knowledge and on his own experience to ensure the correct conclusions were drawn from the information being presented.

Peter left school at 16 to become an apprentice aircraft electrician with BOAC, completing his training easily and impressing his colleagues and supervisors thereafter. Already the recipient of the Queen's Badge for the Boys Brigade (the highest achievable) he was also among the first groups to receive the Duke of Edinburgh's Gold Award and needed special leave from BOAC to attend the Palace and his meeting with HRH. He rose rapidly to become an instructor for other apprentices before further advancement to instructing the instructors themselves. A chance meeting in 1973 led to him joining the (by now BA) flight engineer cadre, where he would remain until his retirement from flying in 2000.

In his 'retirement' Peter gave unstintingly of his time to the promotion of aviation safety. He was very active with the Royal Aeronautical Society, where he had been a council member for 12 years, and a member of its professional standards board since 1987. He also worked with the Engineering Council from 1967 – 2015, where he was the RAeS nominated representative on the Quality and Audit Committee. In his spare time he was a volunteer with the National Trust at Petworth; his personal project to identify and catalogue over 700 large trees on the estate has set a standard to which other NT properties now aspire, and visitors will continue to benefit from his knowledge in the form of a guided walk to examine the most significant trees at Petworth.

Peter Richards made many friends during his time with the UKFSC. Always a source of sound and practical advice, he was a kind and generous man who epitomised the 'service before self' ethos. With his ready smile and easy sense of humour, he was usually the first to welcome new faces at our meetings. The courage and dignity with which he dealt with his illness was inspirational; as ever, his first thought was for others and not for himself. It was our privilege to know and work with him, and he will be much missed.

Donations in Peter's memory may be made to the Motor Neurone Disease Association at www.mndcommunity.org/givinginmemory

Take-off Performance Data Entry Errors

by Chris Brady, Chairman UKFSC

One of the most valuable aspects of membership of the UKFSC, and attendance at the SIE meetings in particular, is that it gives you a unique view of what is on the mind of the industry. The meetings are attended by airlines, the armed forces, corporate operators, helicopter operators, GASCO, manufacturers, airports, insurers, the CAA, MAA, AAIB, database suppliers etc; all of whom come and exchange their most significant safety issues since the previous meeting.

As you can imagine this eclectic group bring quite different events and subjects, but occasionally a common theme arises that seems to be affecting everybody and this cascades into a well-informed debate from which lessons or actions can be taken back from the meeting. Recent examples of such themes have included airport security, laser attacks and drones.

The last SIE threw up another such topic, take-off performance data entry errors. There were six significant events reported by airlines, a corporate operator and the AAIB. Was this a coincidence or is it a trend? I fear that it may be the latter.

Aviation safety has continued to improve over the years as the big ticket items, such as technical failures, CFIT, airborne collision etc were addressed with technological improvements such as improved engine and system reliability, GPWS and TCAS etc. This was done in conjunction with a greater understanding of the human factors which resulted in better design ergonomics, more robust SOPs, better education and training. Such improvements are an evolutionary process, it has taken over 100 years to reduce the above examples to today's levels by carefully studying accidents and safety reports; learning the lessons and incorporating them into the way we operate to minimise the risk.

However performance data entry errors, both take-off and landing are a new phenomenon, an example of a new threat created by new technology - the EFB, which by and large is welcome, but does have some unintended consequences which have yet to be fully mitigated.

Ten years ago few of us used EFBs to calculate performance so we don't have the luxury of generations of experience in this area. When I started flying airliners the take-off speeds were looked up from a thick book of performance tables and generally the worst mistake was being a row or a column adrift which would give a minor error. However, performance on EFBs seems to have increased the risk of gross errors being made and going undetected. Those of us of a certain generation can remember a similar revolution in schools when pocket calculators were allowed into the classrooms. Minor accuracy errors gave way to errors which were a decimal place out. In the classroom it can be embarrassing; in an aircraft it can be fatal.

Errors such as ZFW-TOW transpositions, incorrect aircraft, intersection, runway or airport; In short, anything that can be mis-selected on an EFB will eventually be. Transferring data by voice and/or hand from a loadsheet to an EFB and on to an FMC/FMGC is inherently error prone and a recipe for disaster. There have even been occasions when crew have inadvertently used performance data carried over from the previous sector. There was a nasty example of this at the SIE when a crew used light short ferry flight data on the subsequent heavy long-haul sector. Fortunately they got away with it, but only just. You may recall back in 2004 that an MK Airlines 747 was destroyed on take-off from Halifax in similar circumstances.

So what is to be done? First we need to fully understand the problem. This starts with crew filing safety reports for EFB issues, errors caught or missed, no matter how trivial, to give their safety department a full picture of the extent of the problem. The operator can then look at their own procedures and training. The operator can also pass their feedback up to the EFB/software supplier, who can collate the reports from all users to see where the weaknesses are. The CAA are encouraging operators to participate in an EFB study being run by EASA.

Industry awareness of the frequency of these errors has been raised but a solution has yet to be found. There have been some studies into the feasibility of a technological solution, namely Take-off Performance Monitoring Systems (TPMS). These systems operate on the principle of satisfactory aircraft acceleration and would provide an alert to the flight crew if a take-off was not progressing as expected. The AAIB made two Safety Recommendations concerning take-off performance monitoring systems in the report on an incident involving G-OJMC (AAIB Bulletin 11/2009). Safety Recommendation 2009-080 stated:

"It is recommended that the European Aviation Safety Agency develop a specification for an aircraft takeoff performance monitoring system which provides a timely alert to flight crews when achieved takeoff performance is inadequate for given aircraft configurations and airfield conditions."

Safety Recommendation 2009-081 stated: "It is recommended that the European Aviation Safety Agency establish a requirement for transport category aircraft to be equipped with a takeoff performance monitoring system which provides a timely alert to flight crews when achieved takeoff performance is inadequate for given aircraft configurations and airfield conditions."

There are some developments in the pipeline such as Take-off Securing 1 & 2 from Airbus which monitor the aircraft take-off performance compared to the remaining distance but these are still some years away.

I am a big fan of EFBs and of the many functions including and beyond performance that they can perform; but the last SIE demonstrated that the human-machine interface for data transfer, entry and checking is a weak area that needs urgent attention before the industry suffers another hull loss from natural human error due to poor interface design.

Take-Off Performance Errors

By Chris Brady, easyJet

Accidents and serious incidents involving take-off performance calculation errors continue to be a source of concern for the industry.

A review of large aircraft accident and incident data from 2011 has shown that there have been at least 20 major occurrences where take-off performance was significantly different from scheduled performance. Five of the aircraft involved were destroyed and there were 304 fatalities.

Several of these occurrences involved flight crews that attempted a take-off using incorrect performance data, and then did not recognize the inadequate take-off performance of the aircraft. There were other accidents where the take-off performance has been inadequate because of mechanical failures, incorrect aircraft configuration or incorrect instrument indications. These occurrences were not isolated to any particular aircraft type, commercial operation or geographic area.

Underlying most of these occurrences was the failure of procedural defences to detect an error in the take-off performance data; and/or the failure of the crews to recognize abnormal performance once the take-off had commenced.

The following are some representative accidents:

On 28 December 2001, a B747-200 cargo aircraft had a tail strike on take-off in Anchorage, Alaska, and sustained substantial damage (See NTSB report ANC02LA008). The crew did not account for the weight of 45,360 kg additional fuel taken on board in Anchorage, and inadvertently used the same performance cards that were used for the previous landing. The crew members were unaware that the tail had struck the runway until after arrival at their destination.

On 14 June 2002, an Airbus A330 had a tail strike on take-off in Frankfurt, Germany, because incorrect take-off data were entered into the flight management system (See TSB report A02F0069). The tail strike was undetected by the flight crew, but they were notified by air traffic services during the climb-out. The aircraft sustained substantial structural damage to the underside of the tail.

On 11 March 2003, a Boeing 747-300 in Johannesburg had a tail strike on take-off (See NTSB report DCA03WA031). The flight engineer had entered the zero fuel weight of 203 580 kg instead of the take-off weight of 324 456 kg into the hand-held performance computer, and then transferred the incorrect computed take-off speeds onto the take-off cards.

On 12 March 2003, a Boeing 747-400 suffered a tail strike on take-off in Auckland, New Zealand, and became airborne just above the stall speed (See New Zealand Investigation 03 003). The aft pressure bulkhead was severely damaged, but the crew managed to land safely. The cause of the tail strike was a result of the flight crew entering a take-off weight 100 tonnes less than the actual weight into the flight management system, resulting in low take-off speeds being generated. There was no crew cross-checking of the speeds.

On 14 October 2004 a 747 freighter was destroyed on take-off killing all 7 PoB after the crew used take-off data based upon their previous sector TOW, which was 113,000Kg lighter than the actual TOW. The aircraft took off with a scheduled reduced thrust as permitted by the lighter weight. At 130kts, the control column was moved aft to 8.4° to initiate rotation as the aircraft passed the 1680 m mark of runway 24 / (1010m of runway remaining). The aircraft began to rotate. The pitch attitude stabilized briefly at approximately 9° nose-up, with airspeed at 144kts. Because the 747 still had not lifted off the runway, the control column was moved further aft to 10°, and the aircraft responded with a further pitch up to approximately 11°; initial contact of the lower aft fuselage with the runway occurred at this time. The aircraft was approximately at the 2450m mark and slightly left of the centreline. The control column was then relaxed slightly, to 9° aft.

The pitch attitude stabilized in the 11° range for the next four seconds, and the lower aft fuselage contact with the runway ended briefly. With approximately 185m of runway remaining, the thrust levers were advanced to 92 per cent and the EPRs increased to 1.60. With 130m remaining, the lower aft fuselage contacted the runway a second time. As the aircraft passed the end of the runway, the control column was 13.5° aft, pitch attitude was 11.9° nose-up, and airspeed was 152Kts. The highest recorded nose-up

Figure 1 Burnt remains of the 747 freighter that crashed after take-off.

pitch of 14.5° (06:54:24) was recorded after the aircraft passed the end of the runway at a speed of 155Kts. The aircraft became airborne approximately 205m beyond the paved surface and flew a distance of 100m. The lower aft fuselage then struck an earthen berm supporting an ILS localizer antenna. The aircraft's tail separated on impact, and the rest of the aircraft continued in the air for another 370m before it struck terrain and burst into flames.

One of the conclusions for this event was that: "It is likely that the flight crew member who used the Boeing Laptop Tool to generate take-off performance data did not recognize that the data were incorrect for the planned take-off weight in Halifax. It is most likely that the crew did not adhere to the operator's procedures for an independent check of the take-off data card."

On 20 March 2009, A340, A6-ERG sustained a tailstrike and overran the end of the runway by 148m on departure from Melbourne Airport, Victoria. The investigation found that the accident resulted from the use of erroneous take-off performance parameters. Those erroneous parameters were themselves a result of an incorrect take-off weight being inadvertently entered into the EFB during the pre-departure preparation. Due to a number of factors, the incorrect data entry passed through the subsequent checks without detection.

In November 2010 a Nigerian 737-700, 5N-MJI, took off from Southend with a flex temp instead of TOGA thrust. The flight was running late and the crew were rushed; performance had been done for Runway 24 but it was changed to Runway 06 whilst taxying out. The F/O, who was also a qualified Captain, reprogrammed the FMGC and re-entered the speeds but accidentally entered a flex temperature from habit as is the norm from the long runways of their route network. Although he called out the data he was entering, the Captain did not detect the error because he was not engaged in the standard cross-checking process. Furthermore the Captain did not backtrack the full length of 06, thereby missing 600ft of runway. During the take off run the Captain, seeing the slow acceleration through 100kts, elected to go to TOGA thrust and the aircraft cleared the obstacles. It has been calculated that if the take-off had been rejected just before V1 the aircraft would have overrun by 656ft. Those of you that know Southend will know that this would put you well into the railway embankment.

In August 2014 a Qantas Airways Boeing 737-838 had a tailstrike on take-off from Sydney Airport. The ATSB found the tailstrike was the result of two independent and inadvertent data entry errors in calculating the take-off performance data. As a result, the take-off weight used was 10 tonne lower than the actual weight. This resulted in the take-off speeds and engine thrust setting calculated and used for the take-off being too low. As a result, when the aircraft was rotated, it overpitched and contacted the runway. The ATSB also identified that the Qantas procedure for conducting a check of the Vref40 speed could be misinterpreted. This negated the effectiveness of that check as a defence for identifying data entry errors.

In April 2011, A321, G-NIKO, took off from Manchester on a flight to Heraklion. The Commander (PF) reported that the sidestick control felt heavy as he rotated the aircraft and, after lift off, he noticed the VLS increasing. He reduced the aircraft's pitch attitude and the airspeed increased. The aircraft was then able to resume a climb. The ZFW had been used instead of the Actual TOW for the takeoff performance calculations before departure and the FMGC had been programmed with the incorrect speeds.

Figure 2 Contact marks on the runway, overrun grass and underside of the aircraft.

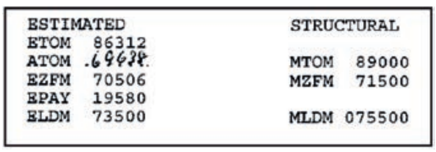
THE AAIB REPORT FOR THIS EVENT IS REPRODUCED BELOW:

History of the flight

The flight crew reported at Manchester Airport at 0720 hrs for a scheduled two-sector duty to Heraklion, Crete and return, departing at 0820 hrs. The flight crew were operating an Airbus A321 aircraft but more often flew the smaller A320. The commander was designated as PF for the first sector.

The weather conditions at Manchester were: surface wind from 040°M at 12kt, temperature 12°C, dewpoint 7°C and pressure 1016HPa. Runway 05L, with a TODA of 3,245m, was in use for departures.

The loadsheet was generated by the handling company at 0837 hrs, 17 minutes after the scheduled departure time. The commander accepted the loadsheet from the dispatcher and checked it. While he was doing so, the co-pilot asked him for the takeoff weight so that he could begin the performance calculations. The commander read out what he thought was the Actual Take Off Mass (ATOM) but mistakenly read out the Zero Fuel Mass (ZFM) of 69,638kg. The commander then wrote down that figure in a space provided on the navigation log for the ATOM (see Figure 3). The Standard Operating Procedure (SOP) then required him to compare the Estimated (E)TOM, on the line above, with the ATOM. However, he actually compared the figure he had written down as the ATOM (69,638) with the EZFM on the line beneath.



ESTIMATED		STRUCTURAL	
ETOM	86312		
ATOM	.69638	MTOM	89000
EZFM	70506	MZFM	71500
EPAY	19580		
ELDM	73500	MLDM	075500

Figure 3 Nav log weights section.

The commander next entered some data into the FMS, which included entering the ZFM from the loadsheet in the INIT B page. The ZFM is a mandatory pilot entry which allows the FMS to compute TOM, speed management and predictions. The pilot cannot enter the TOM directly. The loadsheet was passed to the co-pilot who checked it and confirmed that it matched the commander's entry in the FMS.

The commander then used the figure which he had incorrectly written on the navigation log as the ATOM (69,638kg) to perform his takeoff calculation. The SOPs required each pilot to carry out a takeoff performance calculation separately. In order to do this, the ATOM figure is taken from the loadsheet and each pilot uses a laptop computer on which to carry out the calculation. The calculations are compared and the takeoff data, speeds, flex thrust, configuration and trim position, are entered into the FMS.

In this case, the laptop computer calculated the following speeds: V1 = 131kt, VR = 134kt and V2 = 135kt, using Flap 2, Flex2 57°C and a green dot3 speed of 214kt. (The figures that would have been generated by the laptop computer for the correct ATOM of 86,527kg were: V1 = 155kt, VR = 155kt and V2 = 156kt, with Flap 2, Flex 39°C and a green dot speed of 240kt.) The SOP required the crew to crosscheck the green dot speed generated by the laptop computer against that generated by the FMS. However, although they crosschecked the performance figures between the two laptops, the crosscheck with the FMS green dot speed was missed.

Before the aircraft departed, a Last Minute Change (LMC) addition of one male passenger plus bag (+89 kg) was made to the loadsheet. This did not require a recalculation of the takeoff performance data.

Later, when the aircraft took off from Runway 05L, the commander noticed that the side stick control felt heavier than expected at rotation and, as the aircraft lifted off, the Lowest Selectable Speed (VLS) indication moved "too far" up the speed scale. He reduced the pitch attitude and covered the thrust levers in case more power should be required. The aircraft accelerated and climbed, but at a slower than normal rate. When the aircraft was in the cruise, the crew checked the performance figures and realised that they had used the ZFM instead of the TOM for the takeoff performance calculation.

Discussion

The aircraft took off using less thrust and lower reference speeds than were required. The effect of the attempted rotation at too slow a speed was noticeable to the PF through the feel of the aircraft and the displays on the speed scale. He responded by reducing the pitch attitude, which allowed the aircraft to accelerate to a safe climb speed.

The ATOM was 17,000kg heavier than the figure used by the crew for their performance calculations. This had a significant effect on both the thrust and speed computations. There were a number of errors that occurred but the first was the misreading of the ZFM, instead of the TOM, by the commander, in response to the co-pilot's request for the takeoff weight. Thus, at this early stage both pilots were using incorrect data. Later, there were a number of missed opportunities to detect the error through the SOPs. In particular, a crosscheck of the laptop computer green dot speed against the FMS calculated green dot speed should have highlighted a discrepancy. Direct entry of the TOM into the FMS is not possible and the TOM and green dot speed are computed from the ZFM entered by the pilot. Thus, the erroneous data entry into the laptop computer could not have been replicated in the FMS.

A takeoff with early rotation has the potential to cause a tailstrike, and a takeoff with inadequate thrust and speed could lead to a loss of control of the aircraft. The operator has highlighted this event to their flight crews through the issue of a Flight Safety Bulletin in order to stress the importance of accurate performance calculations. The operator has also made changes to the layout of the navigation log and to the SOPs concerning the crosscheck of the green dot speed.

Other events

There have been a significant number of reported incidents and several accidents, resulting from errors in takeoff performance calculations, around the world in recent years. There must also have been many similar events which were either unreported and/or unnoticed, some of which will have had the potential to cause accidents. Several studies of these events have been carried out, including the Australian Transport Safety Bureau (ATSB) Aviation Research and Analysis Report AR-2009-052, 'Take-off Performance Calculation and Entry Errors: A Global Perspective', and the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) Safety Study 'Use of Erroneous Parameters at Takeoff'. The overall conclusions are that they occur irrespective of the airline or aircraft type, and the causes of the errors have many different origins. Many errors which occur are successfully detected but there is no single solution to ensure that such errors are always prevented or captured.

Industry awareness of the frequency of these errors has been raised but a solution has yet to be found. There have been some studies into the feasibility of a technological solution, namely Takeoff Performance Monitoring Systems (TPMS). These systems operate on the principle of satisfactory aircraft acceleration and would provide an alert to the flight crew if a takeoff was not progressing as expected. The AAIB made two Safety Recommendations concerning takeoff performance monitoring systems in the report on an incident involving G-OJMC (AAIB Bulletin 11/2009).

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The European Aviation Safety Agency has not yet accepted these Safety Recommendations but they are under consideration.

Lessons for Crew

Performance calculation errors have been happening for years and continue to happen. There is no single source of error and a technological solution, such as TPMS, is being developed by manufacturers but is still many years from introduction. This means that we all need to be aware of this problem and guard against it.

SOPs surrounding the use of the loadsheet, EFB and FMC/FMGC data transfer, entry and associated cross-checking are written with the hindsight of the above events to be robust, but they cannot ever be 100% foolproof and incidents continue to occur.

Typical errors include:

- Taking off with the ZFW used as the TOW Using performance figures for the wrong runway
- Using performance figures for the wrong airport
- Using the wrong flex temp
- Using the wrong flap setting

In fact almost every error which could be made, has been made, and history tells us may happen again.

Summary

Performance errors can kill, have killed and will probably kill again. The fact that these calculations have many steps and are done at a busy time in the turnaround, with all of the usual time pressures and distractions, mean that you need to be especially careful and focused. Take the time to do the performance slowly and according to SOP. If any of the results are not like the numbers you expect or simply do not feel right, stop and recheck your steps And finally, if you feel the aircraft is sluggish or not accelerating as you expect, select TOGA immediately.

Getting Upset Right

Ahead of looming regulations requiring upset recovery training capability, simulator manufacturers are vying to address airline and bizjet operator demand. Rick Adams looks at UPRT and other pilot training technology developments.

CAE has developed half a dozen instructor driven scenarios. Image credit: CAE.

If I am ever a passenger in an aircraft which deviates into an "upset" attitude, I'd prefer that it be at least the second time the pilot has encountered the situation.

"On their second attempt, they get it right," Dann Runik told me. Runik is executive director of Advanced Training Programs for FlightSafety International and the lead on development of the "expanded" aerodynamic model for the first full flight simulator approved by the US Federal Aviation Administration (FAA) for Upset Prevention and Recovery Training (UPRT).

At the end of the intensive one-day academics and simulator UPRT course for Gulfstream 550 pilots, the trainees are presented with six unannounced upset scenarios, all of which are based on realworld accidents which killed pilots and passengers. "For the most part, they will crash in two or more of the scenarios," Runik said.

"With this new model in place, the simulated airplane will violently depart controlled flight. You've got about three seconds to recover correctly or it will get into a deep stall that may or may not be recoverable, which is exactly like the airplane."

Runik is a former pilot for Delta, Northwest, and Flying Tigers, and was an engineer on the Space Shuttle programme leading up to the first launch of Columbia in 1981. He's been with Flight-Safety for more than a decade.

The FlightSafety G550 simulator is one of multiple initiatives by training organizations, airlines, and business aircraft operators to get in front of FAA and European Aviation Safety Agency (EASA) mandates requiring UPRT pilot training. The new EASA regulations kick in 4 May 2016; the FAA effective date is March 2019.

Delta Air Lines, for example, is planning to develop an in-house, type-specific UPRT programme after it has cycled 16 instructors (two for each aircraft type in the fleet) through a Jet Upset Simulator Instructor course at Aviation Performance Solutions' Arlington, Texas facility. APS has similar contracts with South African Airways and three other non-US airlines, and is in discussions with more than a dozen other carriers.

Insurer Global Aerospace has partnered with Calspan on a Loss of Control In-Flight (LOC-I) training programme using a modified Learjet simulator. California company Flight Research offers a two- to four-day academic and onaircraft course in the Mojave desert with "upsets from extreme nose-high and nose-low angles of attack and progressive bank angles from 70 to 180 degrees."

Textron's TRU Simulation + Training is incorporating full-stall training capability in multiple new flight simulators in development for Beechcraft models. Xavier Stack, After sales manager for France's Alsim, which produces flight training devices priced at under a million US dollars, said they've developed a rudimentary high-altitude stall to 39,000 feet as part of a new software load for their Evolution customers.

Sim manufacturing leader CAE claims to offer "the most extensive buffet model in the industry, which is a principle cue when the aircraft is not happy," according to Marc St-Hilaire, vice president, Technology and Innovation. CAE has developed half a dozen instructor driven scenarios such as low-speed close to the stall boundary or 60 degrees of bank with the nose down 20 degrees. A set of pages allows the simulator instructor to configure and pre-position the aircraft. The IOS screen monitors the recovery, plotting the flight path against the boundaries of the desired flight envelope.

"We were the first company to include the upset recovery package inside the simulator," St-Hilaire claims. The "EASA-approved, FAA-approved and ICAO-compliant" package comes "out of the box" for Boeing 737 and Airbus A320 aircraft in CAE's Series 7000XR Level D flight simulator, introduced a year ago at the World Aviation Training Conference and Tradeshow (WATS) with the first delivery in March 2015 to the Middle East Aviation Academy in Beirut, Lebanon. The UPRT module is also available as a retrofit for older sims.

FlightSafety International has the first FFS approved by the FAA for Upset Prevention and Recovery Training. Image credit: FlightSafety International.

Extended Envelope Data

Until the new regulatory requirements for upset recovery training, the aerodynamic models used in flight simulators went only so far as the onset of stall conditions. Not because relevant aircraft data beyond stall did not exist but because the FAA and EASA did not require anything further for simulation. And sim manufacturers were not about to incorporate pricey data or training scenarios which might open them to liability in the case of an accident traceable to non-regulated training.

Most major aircraft OEMs, in fact, have collected various stall and upset conditions data as part of the certification process. Reams of data. Runik said Gulfstream test pilots performed nearly 1,000 aerodynamic stalls in the prototype G550s. Whereas the normal redline, or maximum recommended speed for the aircraft is 340 knots, the test pilots pushed it to 444 knots. They also took it beyond the normal maximum cruise of Mach 0.855 to just below Mach 1 (0.955).

"They stalled it in all three configurations: Clean, Flaps 10, and Flaps 20. And then fully configured, gear down, and Flaps 39. And they stalled it at forward CG [center of gravity], mid CG, and aft CG."

"It took us about five or six months to get all the data collated, put into the model, flight tested, and then finding where we went wrong," Runik explained. "If the model didn't feel right in one regime, we found out the error in the data. Then we flight tested it to my satisfaction, that it met the flight test reports." The Gulfstream test pilots then evaluated the simulator model. "They said, 'This takes us right back to the day.' That's when we knew we really had something."

The four-hour simulator portion of the FlightSafety G550 training course somewhat mimics the aircraft flight data collection process. "We start out by getting them to know the low end and the high end of the envelope. We take them up to altitude and have them stall the airplane and have them recover from that. And then have them do it at the different flap configurations so they get comfortable with exactly what it is they're feeling – the airframe vibration, the roll off, how much you've got to reduce the pitch attitude to reattach airflow over the wing. They learn and get comfortable with all that in the low-speed regime," Runik described.

"Then we take them up to altitude, 48,000 feet, setting engines to max power, and take them up to near Mach 1, about 0.96 Mach, and have them feel what happens as the shock wave begins, as the wings produce their supersonic flow. You get tendencies like Mach Tuck [an aerodynamic effect whereby the aircraft nose tends to pitch downward when approaching supersonic speeds] and 'aileron buzz' [a very rapid oscillation of the ailerons]. All these very confusing things begin to happen if you're not familiar with flight in those regimes."

Sim Only or On-Aircraft?

Unlike many other UPRT programmes, FlightSafety does not include any on aircraft training. Runik cites two primary reasons: one, potential negative transfer of training – "Whatever you learn in an Extra 300 with the recovery techniques could be and likely are completely inappropriate for a Gulfstream or a Falcon or an Embraer and could actually tear the airplane apart."

Two: "With a stick between your legs in an aerobatic style airplane that's often way different than a yoke in your left hand and throttles in your right hand. So there's the muscle memory problem, and how do you transfer that to a different aircraft?"

Runik summarized, "We're doing an aerodynamic model that's type-specific with recovery techniques approved by the OEM that we know will work for that particular aircraft. The ability to do this kind of training very low to the ground showed us that anything to be gained in the aircraft doesn't outweigh the danger of going up in an aerobatic airplane and maybe having something go wrong and actually dying from it."

Randall Brooks, vice president Training and Business Development for APS, said not using an actual aircraft in a UPRT training curriculum "is certainly any training provider's prerogative, but it is clearly not in line with current guidance on the subject. The global perception is changing rapidly on the subject of UPRT, with growing realization that part of the reason behind the epidemic of aircraft loss of control is from limitations inherent in a strictly simulator-based approach."

Although the International Civil Aviation Organization (ICAO) stops short of absolutely recommending aircraft training, in part because some Member States lack sufficient resources, their Manual on Aeroplane Upset Prevention and Recovery (Document 10011), released last March, advocates an "integrated training concept" involving academics, on-aircraft training, and flight simulation as providing the most comprehensive approach. ICAO's revised pilot training standards (PANS-TRG) do call for UPRT "in actual flight" at the cadet level prior to commercial licencing.

"The human factors associated with upset events, both psychological and physiological, cannot be fully replicated through flight simulation, even with advanced – and quite rare and expensive – continuous G (centrifuge) devices," Brooks said.

New guidance issued this summer by the International Air Transport Association (IATA) states: "On-aeroplane UPRT can be a valuable tool to build long-lasting confidence for the young pilot. This confidence is psychologically built on realistic proof of the student's ability to control and recover the airplane to normal flight from any '3D' set situation. The existence of such proof forms the underlying basis of true confidence and is a prerequisite for the ability to contain the effects and the duration of startle."

Brooks notes, "The psychology of being in actual flight is a larger contributor than even the accelerations missing from the simulator. When pilots are bolted to the ground it is difficult to create the degree of surprise and startle encountered in actual flight. The recovery strategies should include how to manage surprise and startle induced by unusual attitudes and stall, and how to perform even counter-intuitive actions under the presence of deviations from 1g flight."

Axis' first simulator delivery to Sicily incorporates the Axis Technical Monitoring and Control System. Image credit: Axis Flight Training Systems.

Tech Threads

Though UPRT developments have dominated recent training industry announcements, there are a few other pilot training technology threads.

Belgian startup Venyo, which first appeared publicly at the 2013 Paris Air Show, expects to deliver its first "metered" pay-by-the-hour flight training device by the end of this year and a second in mid-2016. The 737NG trainer (EASA FNPT2/MCC, FAA FTD Level 2) is scheduled for Belgian Civil Aviation Authority evaluation toward the end of August, according to Jean-Claude Streel, Business Development manager. Eventually Venyo hopes to upgrade their capabilities to Level D full-motion simulators.

Axis Flight Training Systems, based in Austria and Switzerland, has delivered a Level D Cessna 560 XLS simulator to Mediterranean Aeronautics Research and Training Academy in Enna, Sicily, where it will be used for both training and human factors research. The device incorporates the Axis Technical Monitoring and Control System (TMCS), a web-based application that allows monitoring and control of key aspects of the simulator, including remote assistance.

Rockwell Collins raised the ante in visual image generators with the EP-8100. The upgrade is geared more for military applications but includes some airline training features such as higher-fidelity snow and rain effects with "full-depth image rendering" and a large catalog of high-resolution airport models. The primary benefit to commercial customers, senior director Nick Gibbs told us, is that the new IG iteration is compatible with existing EP-8000 databases and all interfaces. "It is literally and truly a drop-in replacement with the advantage of having a much lower life-cycle cost and much higher reliability. Radical innovation is exciting to our customers but life cycle stability is critical. It's a smaller footprint, more reliable, 100 percent compatible product, hardware and software, with the existing EP-8000 library."

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Adverse Weather and its Effects on Air Safety

by The Air Safety Group

Introduction

Airliners versus adverse weather encounters appear to be increasing, with resulting damage to airframes and, in the worst cases, loss of the aeroplane and life. The increased frequency and convective violence associated with storm clouds, of late, may be associated with climate change and research on this subject continues.

In recent years there have been two major accidents, both with loss of life to all on-board, in which adverse weather in the tropics has played a role. The most recent was a Swiftair MD83 on the 14th July 2014, in Mali and the other was an Air France A330 on the 1st June 2009 that crashed into the Atlantic Ocean. Adverse weather was a causal factor in both accidents. Though the aeroplane types differed, both relied on automatics for managed flight and the flight crew were experienced (heavy crew, 3 pilots on the A330).

There are similarities with regards to the causal factors in both accidents:

- Both aeroplanes penetrated mesoscale convective systems (MCS).
- Both accidents were at night.
- Both accidents were caused by the flight crew's inability to recover from a stall situation induced by adverse weather (Icing - ICI).
- Neither flight was subjected to a regulatory and administered flight watch oversight.

Additionally, on the 28th December 2014 Air Asia flight QZ8501 was lost in the Karimata Straights and though a final accident investigation report is yet to be published, adverse weather may have been a contributory factor.

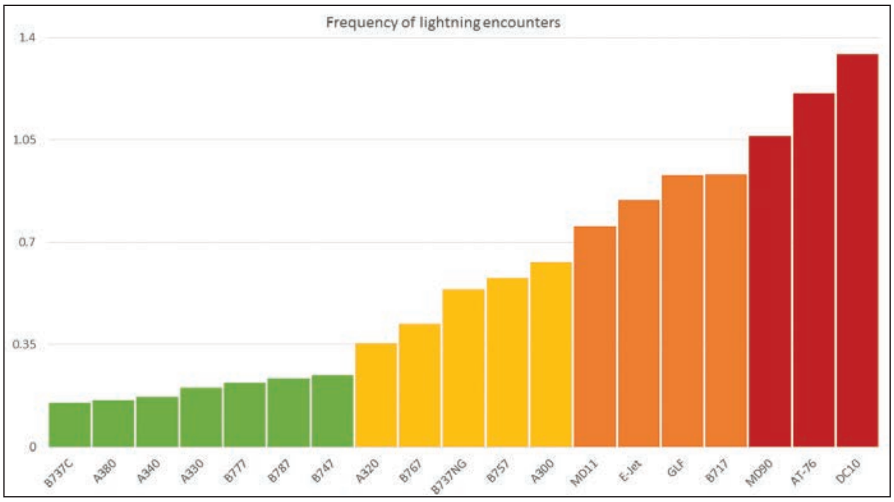
Recovery of the vertical stabiliser AF447

Courtesy of Capt. Michael

Adverse Weather Forecasting Detection and Notification

Adverse weather is a catchall for a large variety of atmospheric phenomenon that can affect the safety of a flight. These range from the relatively benign, such as fog, to the explosively energetic convective storms that are commonplace in the tropics. In extreme cases, these storms can produce up- and down-drafts that far exceed the climb performance of an airliner whilst their tops sometimes reach 60,000ft. Even smaller storms that do not reach typical cruise altitudes can produce ill effects through clear air turbulence and high altitude wind shear. Successfully navigating such weather relies on a concerted effort from flight planners, Air Traffic Controllers (ATC) and the flight crew themselves. Each of these groups has access to a distinct set of experience and data: Planners will be able to access weather forecasts and observations that can indicate likely conditions along a planned route.
ATC may be able to see weather radar or satellite images for their sector and they will receive reports from other aircraft that encounter adverse weather conditions. Flight crews have limited external weather information but can make direct observations of conditions using the on-board weather radar as well as simple, but often very effective, visual observations.

In some cases, this safety mechanism can break down, though. Weather forecasts can be wrong, in some cases the 'significant



The percentage of all flights (global), subdivided by aircraft type that passed within 10km of a lightning strike. Measured during March 2014 – May 2015. Courtesy of Dr Simon Proud, AOPP, University of Oxford.

weather' charts miss regions of bad weather while at other times they may show such large regions of bad weather as to be too vague to be practicable. Ground and satellite-based weather data can be out-of-date, particularly in the case of long-haul flights: The weather information used by the flight planners may be 10 hours old by the time an aircraft is close to its destination. Lastly, on-board weather radar does not always detect adverse weather: Its efficacy relies upon the flight crew correctly manipulating the radar settings to provide an optimum view of the conditions ahead.

A common occurrence, particularly south of the European Alps, is for an aircraft to encounter heavy turbulence without any warning. The crew using a radar tilt setting that is too shallow, meaning that rapidly building convection is not seen by radar until the aircraft is dangerously close to it, often causes these surprise encounters. This has, in a number of cases, led to crew and passenger injuries. For some regions, such as the Alps, the problem is exacerbated by the congested airspace: Deviating to avoid bad weather may bring an aircraft too close to other traffic. Managing the dual threat posed by weather and traffic requires good communication and planning between ATC and flight crews.

A further problem is that, in some cases, convective storms can produce broad, dense, clouds composed of very small ice crystals – too small to be detected by radar. The crystals are, however, still capable of causing difficulties for the unprepared flight crew. The chain of events that resulted in the loss of Air France flight 447 began with airspeed sensors obstructed by ice crystals. Several other flights have also suffered from unreliable airspeed due to pitot tube obstruction whilst others have experienced engine difficulties caused by ice crystals building up on internal surfaces. Radar, therefore, cannot be relied upon to be a foolproof warning system for bad weather – the skill of the flight crew in manipulating its settings and interpreting the data it displays is vitally important.

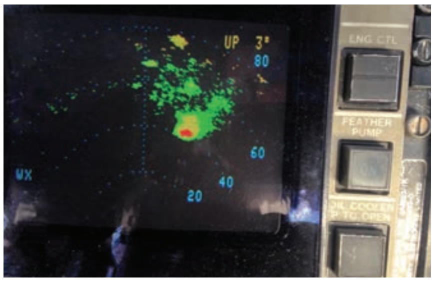
Use of Airborne Radar by Aircrew

In flight, the only equipment pilots have at their disposal for tactical weather avoidance

Storm cell right on the centre line

are the on-board weather radar and the naked eye. Radar use and interpretation is vital to flight safety. Every pilot studies the use of weather radar as part of their CPL/MPL/ATPL course. However, as technologies change, it is difficult for course syllabi to remain current. Furthermore, flight simulators are often unable to replicate the weather radar for training purposes. Consequently, pilots can be limited to the information available in aircraft manuals, instruction during training or learning by osmosis during line flying. Radars themselves are becoming more automated and it is all too easy for pilots to simply switch the device on and leave it alone.

For pilots to maximise the information available for decision making and to enhance their situational awareness, they must manipulate the weather radar's controls (tilt, gain, range etc.). The need to scan the most reflective part of convective activity, to identify where the most intense convection can be found, cannot always be left to the automatic modes of weather radars.



Adverse weather detected by airborne radar

And this is what was detected

There are some (unofficial) online resources and videos which can be used to improve pilots' knowledge and supplement that found in operators' literature. Ultimately, responsibility lies with individual pilots to ensure that they make the most of their on-board radars, know how to use the equipment installed and understand how to interpret the information presented to them. In the absence of formal training or recurrent training, this may only be possible through regular in-flight practice.

Just as important, is understanding the limitations of the fitted equipment; there are two main issues. Firstly, the low reflectivity of ice crystals and hail can make weather detection difficult at high altitude. It is essential to scan the 'wet' part of a convective system – which will be found much lower down – to identify the most active regions. But, it must also be understood that speckled green returns at high altitude can indicate dangerous conditions with ice crystals, hail and turbulence. Secondly, appropriate use of the radar's range and an appreciation of signal attenuation are vital in ensuring that pilots do not fly down 'blind alleys' or mis-identify 'hidden' areas of convection behind other areas of activity. Using this information, pilots should apply the recommended lateral separation which, depending on altitude, can be many tens of nautical miles and should, ideally, be upwind.

The future should see enhanced strategic and tactical tools becoming available to crews via Operational Control and Supervision (OCS) and live weather data streamed direct to the flight deck.

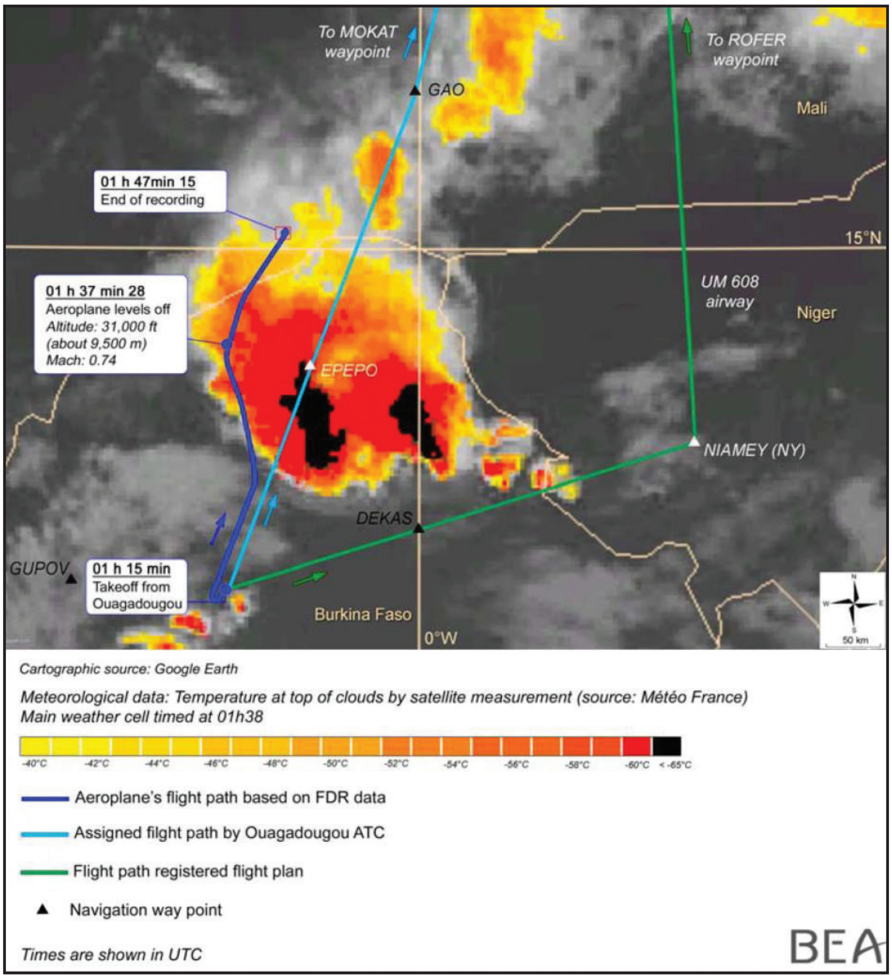
Finally, if all strategic (flight planning/flight watch) and tactical (radar/live data/visual) measures fail, pilots may have to resort to mitigating the effects of adverse weather. We have seen recent incidents of large transport aircraft suffering Loss of Control In-flight (LOC-I). It is essential that all pilots are familiar with the required responses. However, as the AF447 accident shows, there is still a place for 'sitting on our hands'; notwithstanding the turbulence, when the unreliable airspeed indications first manifested themselves, simply maintaining the datum pitch attitude and thrust setting for level flight may have kept the aircraft flying safely until the checklist allowed the crew to diagnose the problem.

In time, the fidelity of flight simulators will improve and meaningful upset training should become possible. In the 'bizjet' community, some organisations are already using small, ex-military, swept wing aircraft to train and refresh upset recoveries. Recently, the FAA mandated recurrent upset training for commercial pilots and EASA are currently going through a rule making process to do the same. This will likely require simulator software to be updated and will take time but, as recent incidents show, the single most important element in avoiding LOC-I is avoiding or exiting the aerodynamic stall. In the last few years, the manufacturers of large commercial transport aircraft have updated their advice and procedures. In terms of the stall, this is best achieved by prompt, positive action to unload the wing. Furthermore, in the case of underwing engines, thrust is not used initially due to the pitch effect and risk of a secondary stall. More generally, current upset recovery advice should be familiar to all pilots from their basic training. All aircraft have their own type-specific procedures and characteristics but the essence is to unload the wings if necessary, roll wings level and recover to level flight; thrust or power is used as appropriate.

Pilots must have a comprehensive knowledge of radar use, radar limitations, aircraft performance datums and basic recovery techniques to ensure safe flight in the dynamic and energetic atmosphere in which we operate.

Operational Control and Supervision

The accidents involving AF447 and AH5017 flights could have been averted if European operators were required to comply with



Courtesy of the BEA AH5017 Interim Report vigorous and vigilant operational control and supervision methodologies.

Other countries and ICAO signatories do have robust systems that are compliant with national regulations; notable amongst these is the USA with 14 CFR Part 121 and subparts E,M,N,P,T,U where the requirements for operational control and supervision is clearly defined, the high level headings of which are:

- Flight Release (Pre Flight) 121 subpart F
- Flight Following (In-Flight) 121 subpart U

Under these two headings requirements for the safety of a flight are planned and supervised by qualified people on the ground. This includes, but is not exhaustive; the assessments of airworthiness, fuel requirements (RCF as applicable), weather observed and forecast, performance, crew fitness and avoidance of fatigue, NOTAM and ATM liaison. This oversight augments the safety of a flight and assists the commander of a flight in his decision making; it does not override any decision made by the aeroplane commander.

If we look at the case of AF447, active flight watch, of a flight planned to transit the Inter Tropical Convergence Zone (ITCZ), could have alerted the crew to an encounter with adverse weather of extreme convectivity on their planned route, by ground based personnel.

In the case of AH5017 the departure routing (SID) was changed by the Ouagadougou controller from the planned Niamey (NY) ROFER, to EPOPO GAO. This routed AH5017 into the teeth of a mesoscale convective system and though radar was used to guide the flight around a highly convective storm cell, the proximity of the deviation was insufficient to avert aerodynamic upset caused by it. Had this flight been subject to a flight release system the route alteration could not have been allowed without approval of the operational control centre (flight dispatch).

In Europe we have no such operational oversight as the FAA system and no descriptive regulations as to how an operator should comply with an operational control and supervision requirement for the "Initiation, Continuation, Termination and Diversion of a flight" see EASA AIR OPS Annex III AMC1 ORO.GEN.110(c) and then the contradiction to this rule:

GM1 ORO.GEN.110(c) Operator responsibilities

OPERATIONAL CONTROL

(a) ORO.GEN.110(c) does not imply a requirement for licensed flight dispatchers or a full flight watch system.

It is an irony that EASA opinion 01/2014 *"Amendment of requirements for flight recorders and underwater locating devices"* concerns the detection of the CVFDR post-crash, yet there is no concern at the lack of supervision methodologies that could potentially avert the loss of a flight as well as track the actual position of it, at a minimum of 15 minute intervals.

AF447 was lost for two years under the South Atlantic Ocean and AH5027 was lost for 23 hours in the Saharan Desert; MH370 is still missing since the 8th March 2014.

Summary

There have recently been some high profile incidents and accidents in which adverse weather encounters were or may have been a contributory factor. For operators and pilots to be able to make sound judgements about the optimum course of action when faced with severe weather, they need a multi-layered defence system consisting of strategic (flight planning/flight watch), tactical (weather radar/live data/ATC) and, as a last resort, physical (visual) mitigations.

For crews, regular recurrent weather radar training might improve confidence in using this valuable tool and also situational awareness when confronted with adverse weather encounters. The radar is far from a 'turnkey solution' and requires an enhanced knowledge about the specific radar and its use in terms of optimum settings to correctly interrogate and interpret the weather display. It is also vitally important that the limitations of the radar are trained and updated as technologies improve. Also placing more emphasis on traditional pilot handling skills, both in basic training and in recurrent and initial type conversion, would be of value if a crew were to find themselves with an in-flight upset following a weather encounter.

Current EU regulations make for lightweight operational control and supervision. Improved operational oversight, similar to FAR Part 121, is a thorough means to provide up-to-date weather information, perhaps via the ACARS, which is of particular relevance for long-haul flights where the weather in-flight may be significantly different from the planning forecasts. Furthermore, this method of operational oversight might also be of benefit in the worst-case of a 'lost' flight in finding the most likely location to begin a search.

With airspace becoming ever-more-congested it is possible that weather encounters may increase, in part due to lack of alternative routings. We consider that greater operational oversight along with enhanced pilot training may go some way towards mitigating this risk.

The Air Safety Group
September 2015

Expertise in the Cabin

Cabin crew training continues to evolve; Fiona Greenyer highlights a number of training trends and solutions.

Generation Y makes up the vast majority of new entry cabin crew today. As a result of this, training departments must keep their training up-to-date and relevant and delivered in such a way as to keep the interest and attention of their students. The long days of sitting in a classroom, listening to an instructor and looking at PowerPoint presentations seem to be on the decrease. Training departments are using the latest technology and training devices, to fully immerse their crews in the reality of their jobs.

Competency-Based Training

The area of competency-based training was covered extensively at WATS 2015 earlier this year. Martin Maurino, Safety, Efficiency and Operations Officer at ICAO and Kellie White, Safety and Emergency Procedures, Training Manager, with Emirates, both spoke in-depth on this subject.

ICAO's Cabin Crew Safety Training Manual (Doc 10002), published in 2014, presents cabin safety training from a competency-based approach. ICAO has developed this approach to cabin crew safety training so crew members may be proficient to perform their duties and responsibilities, and has the goal of establishing an international baseline for cabin crew competencies.

ICAO defines a competency as, "a combination of skills, knowledge and attitudes required to perform a task to the prescribed standard."

This approach to training is characterized by an emphasis on job performance and the knowledge and skills required to perform on the job. Competency-based training aims to progressively build and integrate knowledge and the skills required.

But why should training departments move to competency-based training? This approach gives training departments a detailed and accurate job/task analysis, it is fully integrated and has outcome-focused training. It provides crew members with competencies to be safe, efficient and highly effective in the performance of their duties. This approach to training means all training carried out is tailored to the operators needs, and any operational issues can be specifically targeted. It is not a 'one size fits all' approach. Training is more scenario-based, using an operators own operational data, and can simulate realistic flight conditions when human error occurs. Scenario-based training also helps with the integration of skills, and the crews perform as a team as opposed to performing as an individual.

Emirates has, over the past few years, developed competency-based training within their cabin crew training department. A three phased approach, to establish this form of training, was introduced over a 12 month period. Phase 1 was SEP competencies, Phase 2 was instructor competencies and Phase 3 was air crew competencies. In all three phases' skills, attitudes and knowledge were defined. These were to ensure a thorough understanding of the task required to perform to the desired standard. Knowledge has been built progressively over the three year period, and all theory has been practiced in practical scenarios, using a number of training devices. The airline has developed a collaborative learning approach in an open environment, and all simulator scenarios are based on reported on line incidents.

The challenges faced by Emirates when developing this training have been the recruitment of skilled external trainers, managing an increase of practical failures in year one of implementation and also educating the crew community and existing trainers.

But the achievements far outweigh the challenges. There has been a decrease in failure rate of recurrent theory exams and practical assessments from 8% to between 3-5%, measured over a three year period. Practical skills are now consistently measured objectively and there has been improved cabin crew operational performance, to name just a few.

Evolution

Other airlines that are also developing their training methods include SkyWest Airlines, who has been evolving its recurrent training programmes over the last few years.

In 2007 recurrent training consisted of yearly CBTs, a 150-page study packet, two days of recurrent with equipment drills, evacuation drills, PowerPoint and lecture, and a written final exam. In 2010, the training had developed with scenario-based training being introduced, but still had yearly CBTs, only one day of recurrent with equipment drills, evacuation drills, PowerPoint and lectures and paper testing. In 2011 AQP was rolled out which allowed SkyWest to look closely at operational data to see which subjects should be covered in training.

So in 2015, CQ training, as it is now called, comprises of quarterly CBTs, an optional training guide, one day of CQ, one PowerPoint and hands-on testing. Paul Caldwell, Manager of InFlight Training Development (AQP), at SkyWest, and who also spoke at WATS 2015, explained that the benefit of introducing AQP was the end of ‘death by PowerPoint’. It has allowed them to develop more realistic training, and are now able to put crews in scenarios that are driven by line data. The airline has found that this method of training is highly engaging for their flight attendants who enjoy demonstrating that they know how to do the things they do.

The InFlight training department is now also able to identify areas they need to spend more time on and also areas they did better than expected.

Joint recurrent training at SkyWest has been tailored in the same way. In the early days joint recurrent training was a full day, predominantly PowerPoint, with little interaction, and predominantly instructor led. As it developed, joint training was reduced to two and a half hours, instructors facilitated discussions and were able to focus on ‘hot’ topics. They also carried out joint scenarios in the cabin trainer.

In 2015 joint training has shifted to using short videos. Operational data is used to select the content of the scenarios and the crews then work together to resolve the problem. The airline has found that the benefits of this new, improved training method can help identify conflicts between flight attendant and pilot procedures. It is a non-threatening environment to ask questions and also gives pilots a better understanding of what flight attendants do in the cabin.

New Threats

A recent news item from BALPA (British Airline Pilots’ Association) proposed that UK pilots ask airlines to advise passengers to carry laptops, phones, tablets, e-books and cameras with lithium batteries safely in the aircraft cabin to cut the risk of fires in the luggage hold. BALPA is encouraging airlines and regulators to look at what steps they could take to ensure devices powered by lithium batteries are only carried in the aircraft cabin, where a build-up of gases or fire can be tackled more easily.

Although lithium batteries are very safe, their high energy levels mean they can pose a fire risk if damaged. Between March 1991 and July 2013, 135 air incidents involving batteries were recorded by the FAA. 61 of these events were related to lithium batteries. In recent years there has been a significant rise in the number of PEDs that have lithium batteries as their power source.

On a typical flight, an aircraft carrying 100 passengers could have more than 500 lithium batteries on board, including devices such as laptop computers, tablet devices, mobile phones, cameras, electronic watches, e-readers, electronic flight bags etc. In 2010, a passenger seat caught fire on board an Air France Boeing B777 over the Atlantic. The fire was successfully extinguished and there were no injuries to passengers or crew. Subsequent investigation found a passenger’s spare lithium battery had fallen down the side of the seat which was then crushed as the seat was reclined, causing the battery to ignite.

Because of this potentially serious fire hazard, which can also include explosion, smoke and fumes, it is essential that cabin crew are trained to deal with this very specific type of incident.

A Specialist Paper published in 2014 by the Royal Aeronautical Society entitled “Smoke, Fire and Fumes in Transport Aircraft (SAFITA) Part 2: Training” provides operators and training organisations with guidance on how to comply, as a minimum, with regulatory requirements and also provides references to relevant advisory material which may assist in the provision of aircrew fire and smoke training. It states that it is essential that aircraft crew are trained to deal with lithium battery fires.

ICAO has issued ‘Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods’ which includes incidents involving PED fires with lithium battery cells. SAFITA Part 2 states that although the guidance from ICAO stresses the importance of not moving a PED which is, or has been involved in a fire, it would be prudent to have an alternative procedure to deal with such an event if it occurs in or close to the flight crew compartment. ‘Containment devices are now available on the market that may reduce the risk associated with a PED fire. Considering the proliferation of lithium battery powered devices being carried on board aircraft, the industry should consider evaluating the suitability of such devices for managing PED fires in-flight.'

Christine Stronock, director Cabin Crew Training and Operations at Airbus spoke at EATS (European Airline Training Symposium) last year in Berlin on the development of cabin crew procedures for lithium battery fires. Airbus has developed cabin crew procedures following the identification of risk. These procedures are being continually evolved.

In August 2011, Airbus included a generic "Guidelines on Lithium Battery Fires" in the Cabin Crew Operating Manual (CCOM) for A320 Family, A330/A340 Family and A380 aircraft. Some instructions were also included in the "Getting to Grips" for aircraft without a CCOM. Further procedural changes were included in the CCOM from Q1 2014. This included 'consider any fire in an overhead storage compartment (OHSC) is a potential lithium battery fire' and 'remove and secure device that has caught fire'.

In 2015 a revised passenger seat smoke/fire procedure was introduced for all aircraft. Fighting a lithium battery fire is a whole crew responsibility and Airbus has ensured that its flight crew procedures interlink with their cabin crew procedure.

The UK Civil Aviation Authority (CAA) has produced a series of videos which highlight the potential fire risks to aircraft posed by the improper carriage of lithium batteries. The videos were produced in association with the Federal Aviation Administration (FAA) and target key airline and airport staff, including cabin crew.

Available online, the videos are intended to be used to supplement existing dangerous goods training programmes. The videos highlight different scenarios by recreating real-life situations and the correct procedures for dealing with those situations are demonstrated in detail.

These developments and others will continue to improve cabin crew training and continue the move away from 'traditional' learning methods.

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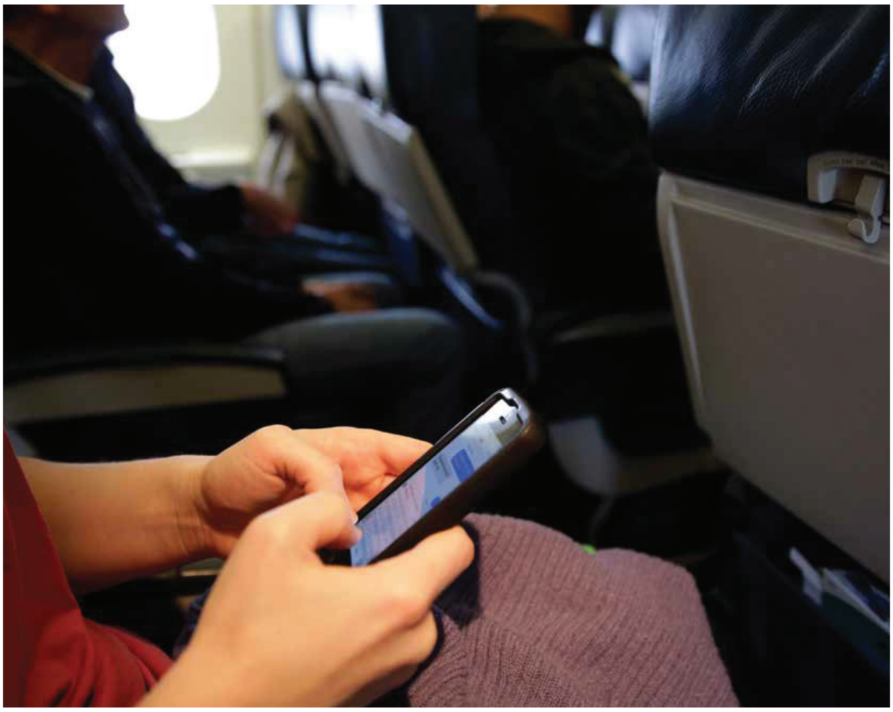
Expanding use of portable electronic devices (PEDs) in the Cabin

by Martin Maurino M.Eng, a Safety, Efficiency and Operations Officer for ICAO's Air Navigation Bureau

Regulations regarding the use of portable electronic devices (PEDs) during commercial aircraft flight were essentially unchanged since the 1960s. As technology continues to evolve and passenger expectations for almost-constant connectivity increase, many regulatory agencies have begun relaxing the restrictions. In December, the ICAO Cabin Safety Group (ICSG) published Circular 340 – *Guidelines for the Expanded Use of Portable Electronic Devices* – to help States effectively deal with the change.

A year and a half ago, the U.S. Federal Aviation Administration (FAA) announced that commercial airlines could safely expand passenger use of PEDs during all phases of flight and provided operators with implementation guidance. In the wake of this highly visible shift in policy, ICAO received many queries from States wishing to follow the FAA's example of relaxing restrictions on passenger PED use. Shortly after, the European Aviation Safety Agency (EASA) advised ICAO that it would also begin working on the expanded use of PEDs for passengers.

To discuss the topic at an international level, ICAO representatives met with FAA and EASA colleagues and the International Coordinating Council of Aerospace Industries Associations (ICCAIA) in November 2013. The participants agreed that the situation required global harmonization, as many States wished to follow the United States' changes. In January 2014, the parties met again, this time with participation from the International Air Transport Association (IATA), to discuss a strategy to promote seamless international implementation. The stakeholders agreed that, prior to allowing the expanded use of PEDs, States should develop a clear process for the approval/acceptance of changes in operator policy and procedures, and determine actions that should be taken to maintain or enhance safety while implementing this change.



"...precise and clear information should be given to passengers regarding the types of PEDs that can or cannot be used during various phases of the flight ..."

The main issues of PEDs

The initial discussions revolved around two main issues:

1. Technical considerations to determine the tolerability of an aircraft's onboard electronic systems and equipment to PED interference.

2. Cabin safety issues related to the expanded use of PEDs

EASA and FAA conducted gap analyses for each of these issues to assess if any differences between their approaches could potentially hinder international implementation.

The results showed that technical considerations were not an issue of concern. Both regulatory agencies addressed PED tolerability testing through the use of internationally recognized standards.

However, cabin safety issues raised concerns, particularly due to differences between approaches from the United States and Europe which could lead to passenger confusion on international flights. The stakeholders agreed that these issues should be addressed by ICAO through development of guidance material which would tackle these points:

- Cabin safety aspects related to expanded use of PEDs by passengers
- Technical aspects of aircraft PED tolerability testing
- The process for States to approve the use of PEDs across the phases of flight for existing aircraft types

ICAO Cabin Safety Group tasked

Since the main focus of the ICAO guidance would be cabin safety, the task of developing the material was assigned to the ICAO Cabin Safety Group (ICSG), comprised of cabin safety experts from States, operators, aircraft manufacturers, and international organizations. However, since the guidance material would also cover technical aspects such as airworthiness considerations, ICAO sought the expertise of other groups: members from the FAA PED Aviation Rulemaking Committee (ARC), subject matter experts from EASA, the European Organization for Civil Aviation Equipment (EUROCAE) working group on PEDs (WG-99), and the IATA Engineering and Maintenance Group (EMG).

The ICSG's work on the guidance material is reflected in ICAO Circular 340 - Guidelines for the Expanded Use of Portable Electronic Devices, published in December 2014. The content of this document was developed through a consensus process.

The purpose of Circular 340 is to present a harmonized, internationally agreed approach to the implementation of the expanded use of PEDs. In order to promote international harmonization, ICAO encourages States to incorporate the guidance presented in this circular into their regulations and/or guidance material.

"The distinction between devices which must be stowed or secured is based on size."

The circular provides guidance for States who wish to allow operators to transition to an expanded use of PEDs. It presents a series of considerations that the State should integrate into the approval / acceptance process, including modifications to regulations and changes in policy and procedures, which should be required of any operator considering or planning to allow the expanded use of PEDs onboard its aircraft. Guidance is also provided to assist operators in implementing the expanded use of PEDs. Additionally, the circular addresses post-implementation activities, such as ongoing surveillance by the State and safety assurance processes by the operator in relation to the expanded use of PEDs (e.g. reporting suspected PED interference).

The circular includes these chapters:

- Glossary
- Introduction
- Regulatory considerations
- Technical considerations
- Operator safety risk assessment
- Operator policy and procedures
- Training for crew members and State inspectors
- Passenger awareness
- Post-implementation activities, including reporting and investigation
- Additional resources (from States and international organizations)

Aircraft-PED tolerability testing

The decision to allow use of PEDs is based on determining the potential for PED interference with onboard electronic systems and equipment, especially those required for continued safe flight and landing. States' regulations governing the use of PEDs on aircraft typically place the responsibility on aircraft operators for determining if PED use is acceptable. The circular explains how an operator may make the determination based on aircraft type certification data, specific PED tolerance tests, or aircraft operational tests. The use of available industry standards from standard-making organizations such as the RTCA (Radio Technical Commission for Aeronautics), and EUROCAE is recommended for determining if PED use is acceptable on an operator's aircraft.

The circular cites these documents as references:

- RTCA/DO-294 – *Guidance on Allowing Transmitting Portable Electronic Devices (T-PEDs) on Aircraft*
- EUROCAE ED-130 – *Guidance for the Use of Portable Electronic Devices (PEDs) On Board Aircraft*
- RTCA/DO-307 – *Aircraft Design and Certification for Portable Electronic Device Tolerance*

PED challenges for cabin safety

Cabin safety issues were at the forefront of the discussions during the development of Circular 340. The three main challenges tackled by the ICSG were:

- Stowing versus Securing of PEDs
- Passenger attention during the safety demonstration
- Implications for international operations

The issue of "stowed vs. secured PEDs" created considerable debate within the ICSG; members initially could not agree on how PEDs should be handled once an aircraft is in movement. Concerns were raised that PEDs used by passengers during taxi, takeoff, or landing roll could become projectiles in a sudden deceleration and cause injury to other cabin occupants. After lengthy discussions, the group decided that a clear differentiation should be made between devices considered to be stowed versus secured.

If a PED is "stowed," it must be placed into an approved stowage location on board the aircraft. These locations have been designed and certified to comply with the requirements for retention of articles of mass. Approved stowage locations have specific weight and size limitations. When a PED is "secured," it is restrained by a method which may not have been certified for retention of articles of mass.

The distinction between devices which must be stowed or secured is based on size. Larger PEDs such as laptop computers should be stowed in a location that is certified for retention (e.g. an overhead bin). Smaller hand-held PEDs such as mobile phones or tablets should be secured during surface movement, take-off, descent, approach, and landing. Passengers should secure smaller PEDs on their person by means acceptable to the State. PEDs should not be left unsecured in an adjacent empty seat or lying on the lap of a passenger.

Passengers may also secure small PEDs by placing them in the seat pocket. The use of seat pockets also generated a lot of discussion. As a result, the circular recommends that the operator's policy should address the use of seat pockets for securing PEDs (i.e. is it allowed?). As part of the approval process, the operator should conduct a safety risk assessment to determine an acceptable weight limit for items placed in a seat pocket.

Passenger attention during the safety demonstration was another challenge associated with the expanded use of PEDs. The pre-flight passenger safety demonstration is important for providing information to passengers on the safety aspects of the flight and demonstrating the use of safety and emergency equipment and aircraft systems. Unfortunately, accident investigations and studies have shown that passengers generally pay little attention to the safety demonstration. With the expanded use of PEDs, some experts expressed concern that even fewer passengers will be paying attention to the safety demonstration.

Although prohibiting the use of PEDs during the safety demonstration may address this concern, this was not considered a realistic solution, particularly on large aircraft, since cabin crew members would not be able to verify every passenger's compliance with this requirement. The ICSG agreed that distractions caused by use of PEDs during the safety demonstration should be avoided so that passengers can focus their attention on the safety briefing and crew instructions.

Operators are encouraged to emphasize the importance of passengers paying attention to the safety demonstration and encourage them to focus on the briefing and cabin crew instructions. The operator may consider restricting the use of PEDs during the safety demonstration (e.g. by means of a passenger announcement), if it is deemed feasible for its particular operation (e.g. on smaller aircraft, or for passengers seated at emergency exits).

The implications of the expanded use of PEDs on operators conducting international flights also generated a great deal of debate during the development of the circular. Two scenarios were discussed:

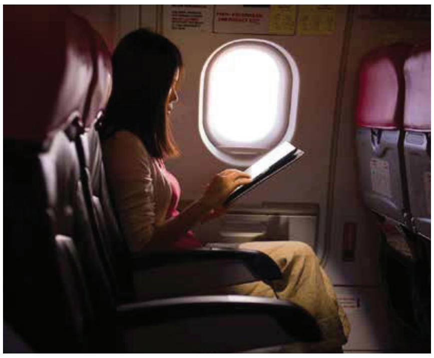
- The State of destination has regulations allowing the expanded use of PEDs which differ from those of the State of the Operator

- The State of destination does not allow the expanded use of PEDs

The FAA's guidance material recommends that U.S. operators comply with any restrictions established by the State of destination (i.e. refrain from allowing the expanded use of PEDs when in States which do not allow it for their operators). This in turn means that operators should verify PED regulations in each State they operate to and from, and apply restrictions as needed. A consensus could not be reached on adopting this approach into ICAO guidance. The issue was left more open-ended, but States and operators are asked to give it consideration. The circular notes that, if the State of the Operator allows the expanded use of PEDs but the State of destination does not, the operator should include this aspect in its policy (and decide how to address it). The operator should have procedures to comply with any restrictions when applicable.

Raising passenger awareness

As part of the transition process, the State should pay special attention to raising passenger awareness regarding the expanded use of PEDs. A key step in the process is conveying information to passengers on the operator's new PED use policy, any safety implications of expanded PED use, and any passenger responsibilities associated with the provision of this service.



Therefore, precise and clear information should be given to passengers regarding the types of PEDs that can or cannot be used during various phases of the flight, the requirement to secure and stow devices during certain phases of flights, and PED size and weight limitations.

The circular provides guidance to States and operators to assist them in defining key messages for passengers – to raise awareness on the importance of the safety-related aspects of expanded PED use during various phases of flight. Multiple methods for dissemination of information are recommended, such as the use of the operator's website. Well-coordinated dissemination of information is an integral part of the process and will facilitate the appropriate use of devices by the travelling public.

The ICAO Guidelines for the expanded use of portable electronic devices (Circular 340) are now available to States in English on the ICAO-NET at http://portal.icao.int/ and can be obtained via the ICAO online store at http://store1.icao.int. More information on ICAO's Cabin Safety Programme can be found at www.icao.int/cabinsafety.

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Colgan Air 3407 - Bombardier DHC-8-400 12 February 2009 – Buffalo, New York

by Dai Whittingham, Chief Executive UKFSC

On 12 February 2009 the crew of a Colgan Air Q400 lost control and crashed during a night approach to Buffalo-Niagara International Airport, killing all 49 on board and one person on the ground. The NTSB report identified flight crew monitoring failures, issues with pilot professionalism, remedial training, pilot training records, airspeed selection procedures, stall training, FAA oversight, flight operational quality assurance programs, use of personal portable electronic devices on the flight deck, the FAA's use of safety alerts for operators to transmit safety-critical information, and deficiencies in weather information provided to pilots. Fatigue was also identified as a potential factor.

The crew

The captain had 3379 flight hours, of which 111 were on the Q400. He had failed 4 check flights during FAA Airline Transport Pilot licensing, one as a Colgan Air first officer, but two earlier failures were not mentioned in the recruitment process. He also failed 3 proficiency checks on his previous type. The first officer held a Commercial Pilot Certificate and had 2,244 hours, with 774 on the Q400. Both pilots were based at Newark (EWR). The captain, who lived near Tampa Bay, had just completed a 2-day duty, with the final leg arriving at 1544; the first officer began her commute from Seattle, at 1951 PST, arriving at EWR on the day of the accident at 0623. Both were observed in Colgan's crew room before their report time of 1330. Their first two scheduled flights were cancelled.

The accident

Flight 3407 pushed back at 1945. There were considerable ground delays but the departure at 2118 and climb to 16,000 feet msl were uneventful. In the cruise the crew engaged in an almost continuous conversation, albeit without breaching the sterile cockpit rule. Ten minutes prior to the approach, the first officer briefed the flaps 15 Vref as 118 knots. They descended through 10,000 feet at 2206 - from that point on, the crew was required to observe the sterile cockpit rule. At 2210, they discussed the presence of ice on the windshield; shortly after that they began a conversation unrelated to the flight which continued after ATC clearance to 2,300 feet. One minute later, the captain called for the descent and approach checklists.

The captain began to slow from 180 knots within 3 miles of the outer marker; the engine power lever angles were reduced to about 42° (flight idle 35°) and both engines' torque values were at minimum thrust. Twenty seconds later, the landing gear was down, propeller condition levers were at max RPM and the airspeed had reduced to 145 knots. About the same time, the captain called for the flaps to be set to 15° and asked for the before landing checklist; airspeed was about 135 knots. Five seconds later the CVR recorded sounds of the stick shaker and the AP disconnect horn, which repeated until the end of the recording.

The AP disengaged at 131 knots. The captain responded by applying a 17 kg pull force to the control column and increasing power. The AOA increased to 13°, pitch attitude increased to about 18°, load factor increased from 1.0 to about 1.4 Gs, and the aircraft stalled at 125 knots, pitching up and rolling to 45° left wing down, and then rolling right. As it rolled through wings level, the stick pusher activated and the captain applied a 19 kg pull force. The flaps were selected up by the first officer; airspeed was about 100 knots. The roll angle reached 105° right wing down before the aircraft began to roll back left and the stick pusher activated for a second time; the captain's response was a 40 kg pull force. The roll angle reached 35° left wing down before the aircraft rolled right again to 100° and pitched to 25° nose down in a steep descent. The stick pusher activated for a third time at 2216:50, whereon the captain applied a 73 kg pull force. The CVR recording ended on impact at 2216:54.

Stall protection

The aircraft has a conventional stick shaker. The ice protection panel includes a "REF SPEEDS" switch - when set to the INCR position it advances the stall warning so that the stick shaker activates at a lower AOA, giving the aircraft the same margins as it would have clean (no ice). With INCR set, the crew would need to increase landing airspeeds between 15 and 25 knots to remain above the new stall warning threshold.

The Q400 has a stick pusher that is designed to remain engaged until the AOA decreases below the stick shaker activation angle, but it can be overpowered or disengaged by flight crew action. Overpowering requires a nose-up break out force of 37 kg followed by a sustained force of 30 kg.

Performance

Calculation of landing performance data was done via datalink. If the keyword "icing" was included in the request, it would cause the Vref speed to increase by 15-20 knots (flaps 35 or flaps 15). The keyword "eice" (en route icing), would add 40 kg to the calculated landing weight to compensate for the accumulated ice. The crew did not enter "icing" or "eice" and the system therefore produced a Vref of 118 knots rather than 138 knots. The REF SPEEDS switch was found in the INCR position but icing did not affect the crew's ability to control the aircraft.

NTSB Findings

There were 46 findings and 24 new safety recommendations in the report. The impending stick shaker onset could have been recognised from the decreasing margin between IAS and the low-speed cue, the airspeed trend vector, the changing colour (to red) of the IAS, and the excessive nose-up pitch attitude. Colgan's SOPs did not promote effective monitoring, and the crew's failure to adhere to sterile cockpit requirements further degraded their performance. Also, Colgan's approach-to-stall training did not fully prepare the crew for an unexpected stall in the Q400 and did not address recovery from a fully developed stall.

Colgan had no FDM (FOQA) scheme for the Q400 fleet at the time. Industry participation in FDM/FOQA was and remains voluntary despite an earlier NTSB recommendation on mandated FOQA participation for Part-121, 135 and 92K operators. There were recommendations concerning provision of standards for pilot professionalism, leadership training as part of captain upgrade programmes, and a review of all operator SOPs to ensure they were consistent with FAA advice on pilot monitoring. Following the Pinnacle accident of October 2004, NTSB had recommended that all Part 121 operators should establish a safety management system (SMS); Colgan intended to implement an SMS but had not done so.

Fatigue

The investigation examined commuting and its effect on crews. It was probable that both pilots were impaired by fatigue, but the extent of this impairment and its contribution to the accident was undetermined. The NTSB found that Colgan had not proactively addressed the fatigue hazard at EWR, a predominantly commuter base: of 136 pilots, 49 were living more than 400 miles away, 29 of whom commuted more than 1000 miles. The FAA was recommended to require all Part 121, 135, and 91K operators "to address fatigue risks associated with commuting, including identifying pilots who commute, establishing policy and guidance to mitigate fatigue risks for commuting pilots, using scheduling practices to minimize opportunities for fatigue in commuting pilots, and developing or identifying rest facilities for commuting pilots."

Oversight

Recommendations associated with FAA oversight included the need to "document and retain electronic and/or paper records of pilot training and checking events in sufficient detail so that the carrier and its principal operations inspector can fully assess a pilot's entire training performance" and for the FAA to "develop a process for verifying, validating, auditing, and amending pilot training records". Additional recommendations concerned: the dissemination of critical weather and other safety information to operators and crews; improved stall and stick-pusher training for pilots; and improvements in simulator fidelity at and near the full aerodynamic stall.

Follow-up action

Political pressure culminated in the Airline Safety and Federal Aviation Administration Extension Act of 2010, which required Part 121 co-pilots to hold an Airline Transport Pilot certificate and have 1500 flight hours before being allowed to operate without restriction. The FAA published its final rule on Flightcrew Member Duty and Rest Requirements on 21 December 2011; the new rule only covers commercial air transport and not cargo operations. The FAA published AC 120-100, Stall and Stick Pusher Training, in August 2012, though it was cancelled in November 2015. The 2010 Act also mandated SMS for all Part 121 operators; an FAA final rule came into force in March 2015, though operators have until 2018 to comply.

Epilogue

On 1 December 2015, the final report on Air Asia Indonesia Flight 8501 revealed that, just as with AF447 in June 2009, startle and inappropriate pilot response to autopilot disconnect and stall warning contributed to the loss of the aircraft.

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