ISSUE 98

focus

ON COMMERCIAL AVIATION SAFETY

SPRING 15

The official publication of the United Kingdom Flight Safety Committee

ISSN 1355-1523

Contents

The Official Publication of THE UNITED KINGDOM FLIGHT SAFETY COMMITTEE ISSN: 1355-1523 SPRING 2015

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.

Editorial Office:
The Graham Suite, Fairoaks Airport, Chobham, Woking, Surrey. GU24 8HU
Tel: 01276 855193 Fax: 01276 855195
e-mail: admin@ukfsc.co.uk
Web Site: www.ukfsc.co.uk
Office Hours: 0900 - 1630 Monday - Friday

Advertisement Sales Office:
UKFSC
The Graham Suite, Fairoaks Airport, Chobham, Woking, Surrey GU24 8HU
Tel: 01276 855193 Fax: 01276 855195
email: admin@ukfsc.co.uk
Web Site: www.ukfsc.co.uk
Office Hours: 0900 - 1630 Monday - Friday

Printed by:
Woking Print & Publicity Ltd
The Print Works, St. Johns Lye, St. Johns, Woking, Surrey GU21 1RS
Tel: 01483 884884 Fax: 01483 884880
e-mail: sales@wokingprint.com
Web: www.wokingprint.com

Front Cover Picture: Boeing Field Seattle the first 5 of 180 737 NG's on order by Ryanair are prepared for test flight prior to delivery. Ryanair currently have another 100 737 MAX on order with an option on a further 100 as part of a total $22 BN purchase programme.

Modern Threats

by Dai Whittingham, Chief Executive UKFSC

Despite the loss of the AirAsia Indonesia A320-200 in the final days of December, it seems that 2014 was the safest year on record for commercial aviation. The Flight International data shows just 19 airline accidents for the year. Sadly, the casualty figure of 671 is right on the 10-year average and well above last year's all-time low of 281.

The 239 people who are now presumed to have lost their lives in MH370 have had a significant impact on the statistics but their relatives may derive some comfort from the fact that they have also had an impact on the way the industry operates, as their loss is leading to a new ICAO 15-minute standard for flight tracking. While we have yet to see the possible security implications of this accident emerge fully, MH17 has been excluded from the statistics on the grounds that it was a war risk loss, though as the Chairman notes in his column, the effect on relatives is the same regardless of cause. If the MH17 figures are included, 2014 would stand as the 4th worst year for casualties since the start of the millennium. But if MH370 turns out to be security related and not accidental, 2014 would be remembered for 18 accidents and just 432 fatalities.

For the sake of argument, let us stay with the position of MH17 being a war-related act. We are then left with a global airline fatal accident rate of 1 per 2.38 million sectors, which would in most other circumstances have been celebrated. Unfortunately the AirAsia accident and most recently the TransAsia ATR accident in Taiwan have been more news-worthy than a significant achievement in global aviation safety, which as a result has gone largely un-remarked by the media; the decision by the Malaysian Government to formally declare MH370 an accident has served to further suppress discussion of the positives. So where do we go from here? Do we simply become complacent in the knowledge that the travelling public will still travel? Or does complacency, as the easy option, help us to drive the statistics in the opposite direction again?

We know there is plenty of work going on to prevent more LOC accidents, the FAA in particular having undertaken some thorough research into automation and flightpath management. Upset Prevention and Recovery Training (UPRT) is becoming more widely included in the syllabus from basic training to ATQP, and yet it seems as if LOC may have been a feature in both the most recent accidents. Despite the best efforts of the designers, automation will not be able to prevent every single situation becoming unmanageable if pilots lack awareness of automation modes or use the systems inappropriately. Training would appear to be required in this area.

Continuing on the LOC theme, there would seem to have been an upsurge in accidents where weather has been at least a factor. AF447 and QZ8501 spring immediately to mind, both events having occurred in the ICTZ. A colleague has suggested that there has also been an increase in encounters with extreme weather events. Without getting into the global warming debate, we need to understand if such events are indeed becoming more prevalent or extreme, or if it is the encounters themselves that are more common. It may even be that we are simply more aware of them now because they have featured in some high-profile accidents.

Time will tell on the global warming question but in the meantime we need to do something about the threat from an apparent increase in extreme weather encounters. Again, the implication is that there is something missing in flight crew training. Why do people not give thunderstorms the widest possible berth? Do pilots know how to properly manipulate radar tilt and gain to give themselves the best understanding of the weather around them? Research by one US manufacturer suggests that many pilots do not get the best out of their radar and simply leave a standard tilt/gain setting on throughout a flight, with weather remaining undetected until a late stage as a result. And if we are confident that crews are up to the job, have we got the design and certification process right? Are all aircraft capable of withstanding the forces present in some extreme weather systems? Could automation do more to help?

As can be seen from the history of warfare, as soon as one threat has been neutralised there will be another to take its place. We need look no further than unmanned systems to see that the operational environment has shifted. Whether we like it or not, UAS are here to stay. The technology is already mature with the arguable exception of sense and avoid, the proliferation of UAS is already out-stripping predictions at the commercial level and the hobby and toy markets are exploding. Regulators globally are struggling and usually failing to keep pace with the demand – all indications are that the FAA's regulations for full UAS integration into Class A-D airspace will be delayed until 2017 at least, despite a 2015 target and sustained pressure from Congress and the White House.

Leaving aside the security threat from UAS, the risk to CAT is principally MAC and is most likely to stem from the hobby market. Operators of larger UAS have made a sizeable investment in their platforms and are either on military or commercial business, in which case they can be expected to know and operate within the regulations as currently framed. You can expect these operations to be segregated or properly notified. The real danger lies with the casual hobbyist and those who buy small UAS as toys. In between lie the responsible aero-modellers who belong to clubs and understand that airspace is a shared asset for which there are rules. Others do not have the same knowledge and there is no mechanism for ensuring they are even made aware of the existence of the Air Navigation Order, the Rules of the Air, the dimensions of an ATZ etc. Why would they know? And if they do know, why would they bother to comply when enforcement is well-nigh impossible? In this case, ignorance is bliss.

As an example of ignorance (in the strict sense of the word), last year a pilot friend had an interesting discussion with a plumber who was keen to tell him about his new quadcopter and its 2 cameras. The plumber was describing how he had been able to image the Thames and the Isle of Wight at the same time. Gentle questioning by the pilot revealed that the small UAS concerned had been flown at around 4000ft in the MAYFIELD hold for Gatwick. The plumber had no idea there was a hold in that location, nor that he had been flying his pride and joy in controlled airspace, nor that the ANO applied to him as well. There was no information with his internet-purchased UAS to suggest there might be some restrictions on where and how he could fly it. Ignorance of the law is not generally an excuse but a court might have some sympathy with someone who genuinely thought there was no risk of harm; the same sentiment would be unlikely to apply if our plumber had been operating his UAS within the airport boundaries or on the approach to Gatwick itself, as he could reasonably be expected to know that proximity to aircraft was both likely and hazardous. The more pertinent question is why imports are permitted without the requirement to include at least broad guidance on the widespread existence of national airspace regulations.

There are three modern threats worthy of closer attention. The first is perhaps not new but seems to be increasing year on year, namely disruptive or uncooperative passengers. The refusal to obey crew instructions, and other misbehaviours, are perhaps symptomatic of modern society but there is little doubt that lives will eventually be lost or injuries caused during ground evacuations when free escape is compromised by cabin baggage. However, the corporate drive to reduce costs means crews are having to deal with increasing volumes of bags in the cabin and the lack of appropriate stowage serves only to increase the likelihood of bad behaviour.

Next is Lithium batteries and specifically e-cigarettes. Much has already been written about batteries and the threat of airborne fire, and the industry is well aware of the Asiana and UPS 747F losses and the implication of Lithium battery carriage. Good advice is available from the Royal Aeronautical Society.[1] E-cigarettes pose a more interesting threat because they not only contain Lithium batteries but they can be linked to passenger behaviour issues. It is now common for people to see 'vaping' as being wholly different to smoking and they therefore feel able to use these devices in areas where smoking is prohibited. This will include their use on board aircraft unless operators put suitable procedures in place. Many airport operators ban their use airside not just because of the fire risk but because of their potential effect on enforcement of the smoking prohibition.

Last but not least, it is time that operators gave serious consideration to the cyber threat. The ability of bad people to get into sophisticated organisations and disrupt their IT systems is now well known, and there have been some recent high-profile examples of this. A cyber attack involving a 3rd party taking control of an aircraft is currently very unlikely, but it is far more probable that an attack would be aimed at operational planning systems. Manuals and performance planning tools are now held on laptops or tablets and updates are typically issued via un-encrypted means. How would your operation fare if your EFB was contaminated? And when was the last time you did a manual performance calculation? Do you even have a secondary means of getting to the data you need? Cyber is a real threat and most businesses are taking it seriously. Our industry needs to put some thought into quantifying the threat and responding to it before it is too late.

1. http://aerosociety.com/Assets/Docs/Publications/SpecialistPapers/SAFITA__2013.pdf and http://aerosociety.com/Assets/Docs/Publications/SpecialistPapers/SAFITA%20Part%202_Training_1st%20Edition.pdf

Is Security part of Safety?

by Chris Brady, Chairman UKFSC

The air accident data for 2014 shows that it was the safest year ever by both number and rate of accidents, with just one fatal accident per 2.38 million flights.

If you told this statistic to a member of public, or possibly many people in the aviation industry, they would be surprised because of the two very high profile hull losses of MH370 and MH17. These two events took a total of 537 lives and probably got more media coverage than any previous accidents because of the unusual circumstances of their loss. Interestingly, MH17 is not included in the air accident data because it was an act of war. Presumably this distinction is made because it is considered either that there is little that can be done to mitigate against threats associated with war or that safety and security are separate issues.

I would challenge this position. As I have said in a previous column there needs to be an independent global body, such as ICAO, who can use their resources to gather intelligence and advise airlines of any unsafe airspace, or airports so that they can flight-plan accordingly.

Such a service is unlikely to be established anytime soon. Fortunately for UK operators the DfT, drawing upon information from intelligence sources, have implemented a system of 'early warnings' to airlines regarding airspace threats.

Aside from the avoidance of overflying warzones, there are many other ways that an operator can protect against security threats. The obvious ones we may see as crew may be more effective (ie relevant and up to date) security training, not just for aircrew but for engineers and other ground staff, all of whom have access to the aircraft. Security training for operations or call-centre staff who may receive a phone call with a threat regarding a specific flight. Training and advice for airline management who need to make informed decisions about operating to or over or night-stopping in destinations of concern; not just for planned operations but for diversions too. There is also the science of profiling passengers, not only at the airports but at the time of booking by analysing suspicious booking habits; smart use of Advanced Passenger Information and liaising with both local airport police and the national security authorities about general or specific passengers who may be a known risk.

Many airlines may already have some or all of these measures in place, those that don't, need to consider them. The bottom line is that, we cannot continue to keep safety and security separate and delegate responsibility for security to a few security specialists in each airline/handling agent/MRO; this task needs everybody to be informed and alert. These days, security has to be an integral part of flight safety and part of how business is done.

I would suggest that to the families of the passengers and crew, the staff at the airline, the people of Malaysia and all of the other nations who lost citizens on MH17, it matters little whether it was due to an act of war or a conventional flight safety issue. A hull loss is a hull loss and the impact on all concerned is the same regardless of how it happened.

ACAS X – The reinvention of ACAS II/TCAS II cloaks major advances in a familiar interface and enables rapid upgrades

by Wayne Rosenkrans

Editor's Note: This is the first of 2 articles on ACAS X. They are viewed from slightly different perspectives and have been included to give the reader a fuller understanding of ACAS X and its implications.

Outside the software engineering teams conducting research and development of ACAS X — i.e., airborne collision avoidance system X — aircraft operators, pilots and other stakeholders seem most interested in its safety enhancements and user interface, one team member says. Details will continue to be refined by an RTCA special committee, EUROCAE working group and others[1] until the final approval of a minimum operational performance standard, anticipated by the U.S. Federal Aviation Administration (FAA) in 2018.

Michael Castle, a systems engineer at Aurora Sciences and a contracted subject matter expert for the FAA, describes ACAS X essentially as the agency's "solution going forward for how we are going to conduct collision avoidance." His overview of the nine year project was part of the Airborne Conflict Safety Forum held on June 10–11 in Brussels, Belgium (*ASW*, 9/14, p. 38). At that time, prototype testing had focused on the new system's capability to avoid issuing non-safety-critical (nuisance) alerts and to demonstrate a risk ratio[2] significantly better than that of the traffic-alert and collision avoidance system known as TCAS II (or ACAS II) Version 7.1.

"TCAS II has been a fantastic system in terms of providing a safety margin for the airspace," Castle said. "Since 1990, when it was mandated, there's been no commercial [air transport] midair collision, and it's been noted by many people that TCAS has saved situations and encounters.... We're not here to bury TCAS, we're here to evolve it." In comparisons, computer simulations suggest a future probability of near midair collision (NMAC) avoidance 10 to 20 times better than TCAS II if an ACAS X–equipped *ownship* experiences an encounter in which separation from the intruder has been lost, he said.[3]

Circumventing Limitations

An extensively studied limitation of TCAS II is that more than 80 percent of its alerts are triggered by situations in which the ownship and the intruder actually are intentionally, safely separated. "We want to try to reduce those while also maintaining the safety factor. This is the central idea," Castle said. "TCAS II [is] a less flexible system than what we'd like. The [software logic] changes seemed like very simple procedure changes, but it took a lot longer to do them than what we would have liked. ... Accounting for new surveillance systems, new users of airspace [i.e., unmanned aircraft systems, known internationally as *remotely piloted aircraft systems*] and new procedures [by further upgrading would have been] a challenge, and the challenges are rooted in the structure of TCAS II."

Technically speaking, TCAS II has relied on a *rule-based pseudocode* — a combination of deterministic rules and heuristics (essentially, a trial-and-error process that compares stored rules to predictable encounter geometries) — that specifies the threat logic. "Legacy TCAS first... projects the time of closest approach," Castle said. "[The logic] decides what sense it wants to provide the alert in. Is it a climb sense or a descend [sense]? Then it tries to choose the rate that is the least disruptive [climb/descend maneuver] that also meets the thresholds."

Overall, TCAS II functions by using highly complex logical interdependencies, and it requires uncommon expertise to modify safely. "A small set of people really understand the pseudocode… and those are the people that we have to rely upon to improve [it with] changes," he said. Collision avoidance experts in recent years agreed to move beyond pseudocode to a more flexible decision-making structure. Many years of peer-reviewed academic papers vetted the basic concepts, followed in 2009 by the FAA's launch of formal research on ACAS X.

ACAS X (or more precisely, its *ACAS Xo* variant) has been designed to look like TCAS II in its interface and functionality so that pilots will get, for example, identical resolution advisories (RAs) on the same flight deck displays and apply the same general training to respond to them.

Expected benefits of the flexible structure include implementing reduced minimum aircraft separation, driving down the unnecessary alerts, adding new airspace-user classes as noted, and dynamically adapting future U.S. airspace to traffic.

Different Logic

Advanced algorithms and analytical methods today enable robust systems to make critical decisions in uncertain, dynamic environments while maintaining safety and efficiency. Forum attendees learned from Castle how that theoretical underpinning has influenced ACAS X.

"We have an uncertain situation in the airspace," Castle said. "[We] never have perfect information. What is the best choice to be made? That's what ACAS X was founded on. So it uses decision-theoretic safety logic and a flexible surveillance tracker."

Three major challenges have to be addressed when designing threat logic into software that will choose among alternative ways that a collision avoidance system should respond. "The first [challenge] is that you have imperfect sensor information, and so there's uncertainty associated with the position and the velocity of the aircraft," Castle said. "[Secondly,] you have dynamic uncertainty of 'How is the pilot going to respond?' and 'How will the encounter develop?' Then, the third challenge is that the system not only has to be safe, but it also has to be operationally suitable.

"We could design a perfectly safe system that just alerted [pilots] all the time — well in advance of the encounter — and, in theory, the aircraft would never come close to each other. … ACAS X tries to answer each of those by using a probabilistic sensor model, a probabilistic dynamic model and … a multi-objective utility tool … in a way that balances all these things."

Intruder Threats

ACAS X software logic estimates the *state* of the ownship every second. "It's looking at… what the ownship 'thinks' the world looks like," he said. "So [it 'asks'] 'Where are all the intruders? Where are all the threats?' We reduce what the world looks like down to a set of state variables.

"In the current design, we have five state variables … to define what choices we're going to make in terms of [pilot] alerting …. A special data structure, that we call the lookup table, is pre-encoded and loaded into the avionics. And so when [the ownship has] a certain set of state variables, [ACAS X will] index into that *lookup table* and try to determine for each action that is possible, 'What is the cost?' So these lookup tables are sets of costs, and then [we] basically do a comparison. In [the third] step, [the software logic will] choose the action that has the lowest cost."

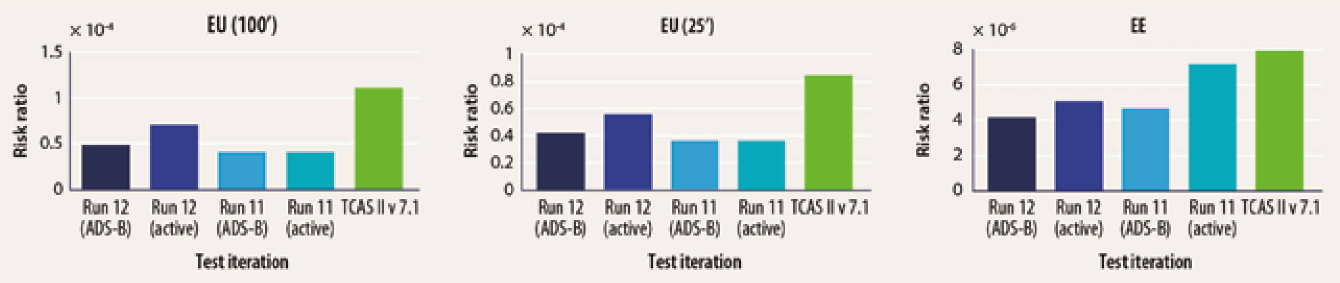
As one example, the cost of "not alerting" the pilot was 0.8 and the cost of the pilot "leveling off " was 0.1. Because leveling off entailed the lowest cost, ACAS X selected that action. "These costs are recomputed every second by looking up the values in the lookup table," Castle said.

Simplifying Upgrades

Ease of upgrade was an important factor in the clean-slate design of ACAS X software logic, influenced by engineering teams' difficulty with TCAS II changes. "With legacy TCAS, we would have [had] to change either some of the assumptions about [how] the models interoperate in terms of ownship or intruder aircraft," he said. "We could change some of the thresholds that are embedded into TCAS II design or we could change the existing pseudocode. Each of these [choices] has different levels of complexity associated with it."

In contrast, changing the system behavior of ACAS X is analogous to turning three knobs to tune a radio, with many combinations possible. Castle said, "One [method changes] the belief states and the state transitions. …. We would possibly modify [the dynamic model] to try to change the behavior. And we could [also adjust] the off-line costs … embedded in the cost table."

ACAS X vs. TCAS II Test Results for Risk Ratio, June 2014



EU (100′) = Equipped-Unequipped, a test scenario in which an ACAS X/TCAS II–equipped ownship encounters an ACAS X/TCAS II–unequipped intruder that carries an operating transponder encoding its altitude into 100-ft (30-m) quantization

EU (25′) = Equipped-Unequipped, a test scenario in which an ACAS X/TCAS II–equipped ownship encounters an ACAS X/TCAS II–unequipped intruder that carries an operating transponder encoding its altitude into 25-ft (8-m) quantization

EE = Equipped-Equipped, a test scenario in which an ACAS X/TCAS II–equipped ownship encounters an ACAS X/TCAS II–equipped intruder

NMAC = near midair collision

Run = ACAS X test run in computer simulation using the same ownship-intruder encounter dataset (scenario) as TCAS II

TCAS = traffic-alert and collision avoidance system test results

v = version of TCAS II software logic tested (latest)

Notes: The ACAS X software engineering team, by this development stage, had conducted 12 computer-simulation test cycles (iterations) of the design to adjust the costs (risks) assigned to the possible alerting actions stored in a data structure called the *lookup tables*, which are loaded into ACAS X avionics. Lower bars show better performance, so all ACAS X results were well below the corresponding probability of NMAC when using the latest TCAS II. (Risk ratio is the probability of an NMAC with a collision avoidance system divided by the probability without the system.)

Source: U.S. Federal Aviation Administration

Figure 1

The most costly off-line event — an NMAC — could be assigned a weight (value) of minus 1 in the cost table.

"Then we would have the relative weights of the other events determine the behavior of the system," he said. "[If] an alert is [weighted as] minus 0.01, it's 1/100th of the importance of the NMAC. We can play with these relative weights to try to tune the system to the behavior that we desire. … We give a small benefit, a small reward, for the 'clear of conflict' [alert, weighted as 0.0001]."

ACAS X also compares factors — such as the relative costs of strengthening an RA versus issuing a climb/descend reversal RA or changing vertical rate — to replicate the functionality of TCAS that is already familiar to today's pilots but with fewer non-safety critical alerts as noted, he said.

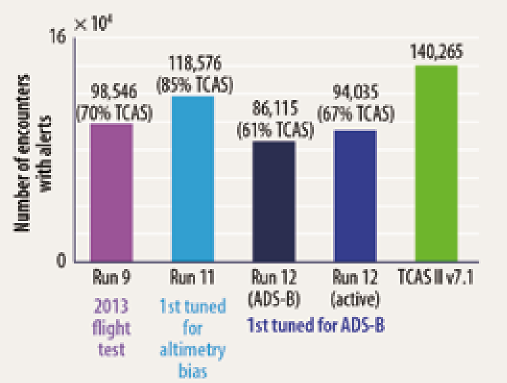
Some costs cannot be computed in advance or loaded into a lookup table, however, Castle said, referring to dynamic changes of state as the aircraft flies. For example, the altitude at which the ownship actually is flying during a given second cannot be precomputed by the ACAS X to establish the *inhibit altitude*. "As the system flies, if it's below that inhibit altitude, it won't issue RAs," he said.

Results-Based Optimism

Castle's first metric to demonstrate ACAS X versus TCAS II performance was the probability of an NMAC for a specific ownship-intruder encounter dataset. Simulator test scenarios include combinations of ownship equipped with TCAS II or ACAS X; and the intruder equipped with TCAS II, or ACAS X, or equipped with neither but carrying a transponder. "We have formal cycles; [as of June we're] on Run 12," he said. "The green bars on the right side of each graph (Figure 1) represent TCAS II 7.1 performance." Four differently colored bars on the left side of each graph show the corresponding ACAS X performance.

In the encounter dataset discussed at the safety forum, Castle said, "In each of these cases, we're well below the probability of NMAC with TCAS [II alone]." With ACAS X combining different surveillance sources, however, "We're something on the order of 40 [percent] to 60 percent of the probability of NMAC of TCAS II 7.1," he said.

ACAS X vs. TCAS II Test Results for Non-Safety-Critical RAs, June 2014



__% TCAS = fraction of TCAS II v7.1 test result (i.e., 70 percent is 30 percent better)

active = active surveillance of transponder data (i.e., not ADS-B)

ADS-B = surveillance using automatic dependent surveillance–broadcast data

RAs = resolution advisories (alerts)

Run = ACAS X test run in computer simulation (or flight test if indicated) using the same ownship-intruder encounter dataset (scenario) as TCAS II; runs include closely spaced parallel operations, military aircraft and formation flying

TCAS = traffic-alert and collision avoidance system test results

Notes: Lower bars show relatively better performance in rate of non-safety-critical (nuisance) RAs.

Source: U.S. Federal Aviation Administration

Figure 2

Another metric (Figure 2) enabled a comparison of the overall non-safety critical alert proportion from legacy TCAS versus ACAS X. Castle said, "We reduced the [ACAS X RA rates to] between 30 and 40 percent [below] TCAS II 7.1 alert rates. [Run 12] was our first attempt to do the tuning with ADS-B [automatic dependent surveillance–broadcast] surveillance data. … We didn't have it in the earlier runs. But there's a trend here, which is [that] we're getting to the point where the results are quite promising."

Computer Advantages

A basic working principle within ACAS X engineering teams is to harness the power of computers to the extent that the computers produce optimum conflict resolutions, yet the engineers must oversee the processing and final results. "Computers are quite good at optimizing, given a set of assumptions and a set of parameters," Castle said. "The human effort [then] is really focused on the performance metrics and evaluating how the system looks. [Humans will ask,] 'What scenarios and encounters are important? Did the ACAS X system respond in the way that we expected and wanted?"

As for its surveillance-source flexibility, the *front-end surveillance and tracking module* of ACAS X converts sensor data from proprietary formats into a generalized format that has a standard interface to the *threat side* of the system architecture. "The threat side is where all the logic tables reside and where the choice of what TA [traffic advisory] or RA to issue is made," he said. The significance is that ADS-B data, for example, is acceptable today and sensors not even invented yet should be compatible.

Notes

1. ACAS X is now being standardized through RTCA Special Committee 147, Traffic Alert and Collision Avoidance System, and the European Organisation for Civil Aviation Equipment (EUROCAE) Working Group-75, Traffic Collision Avoidance System.

2. Risk ratio is the probability of a near midair collision with a collision avoidance system divided by the probability without the system.

3. When describing in-flight collision scenarios and computing threshold times/distances at which pilots should be warned to respond to a collision threat, researchers and software engineers call the aircraft flown by the pilots who would receive the alert the *ownship* and the conflicting-traffic aircraft the *intruder*.

Reprinted with kind permission of Flight Safety Foundation AeroSafety World – October 2014

Future of Airborne Collision Avoidance Systems – Towards ACAS X

by Craig Foster – Future Safety Specialist, NATS

History

Flying by the 1950s had become a common occurrence and the skies across the world were becoming ever more crowded with aircraft. However, it took the mid-air collision which occurred over the Grand Canyon in 1956 to underline the safety challenges of managing this growth in air traffic and spur on initiatives to keep the skies safe. The 1956 crash was, at the time, the worst commercial air disaster in history and ultimately resulted in the establishment of the FAA.

When faced with the challenge of keeping aircraft safely apart an obvious solution is to strategically design the airspace so that it keeps aircraft separated. For example, depending on your direction of travel aircraft are separated by flying at different altitudes. This principle works well in the cruising phases of flight but is insufficient nearer to busy airfields as aircraft are all trying to get to the same point, and so there is a need for air traffic control.

These changes significantly improved the safety of the airspace but mid-air collisions still happened, notably two in California in 1978 and 1986. These highlighted that a further layer of protection was required to prevent mid-air collisions and would act as an independent safety net for failures of the air traffic control systems, pilot errors and inadequacies in the see-and-avoid principle.

Today we consider mid-air collisions as being prevented by three layers of protection:

- Strategic Conflict Management which limits the occurrence of conflicts, achieved by the design of the airspace, flight planning and airspace demand/capacity balancing operating on the scale of hours;
- Separation Assurance provided by the air traffic control system which operates over a timeframe of minutes and provides tactical conflict resolution and ensures that a target level of safety is met; and
- Collision Avoidance a final layer provided by an on-board capability and focussed on the last minute prior to a potential collision. This last layer should only be required when the previous two layers have failed.

In practice however, there is interaction between these layers due to operational procedures and airspace management. For example, it is common for the collision avoidance system to activate where there is no serious loss of separation.

TCAS

The collision avoidance layer is primarily provided by the Airborne Collision Avoidance System (ACAS) known as TCAS (Traffic alert & Collision Avoidance System). It should be noted that these terms are used interchangeably but TCAS (the system or equipment) is an ACAS (the concept and the international standard).

TCAS uses the principle of 'time-to-go' to collision known as "tau". The principle is relatively straightforward and states that by knowing the range to a target and how that range is changing (the range rate), it is possible to infer the collision threat that this target poses. This principle is used in the TCAS equipment carried by on-board aircraft today.

The development of TCAS started in the early 1960s and explored a number of technology options for the surveillance method required to provide the picture of the traffic surrounding an aircraft. By the 1970s, after a number of problems, a solution based on the transponder which aircraft carry to identify themselves to ground based radar systems was developed. This was followed by standardisation in the 1980s and 1990s. The development of TCAS spanned decades, indeed entire careers, and aircraft only started to carry TCAS in large numbers by the end of the 1990s with regional mandates for carriage occurring around the turn of the century.

Future Challenges – Why ACAS X?

TCAS has been very successful in preventing mid-air collisions in the years since its introduction and has saved many lives. However, TCAS has not reduced the risk of a mid-air collision to zero – some risk still remains due to limitations in the design of the system. For example, the requirement for carriage of a transponder presents a limit to the protection that TCAS can provide; aircraft without a transponder are invisible to TCAS.

In 2002, two aircraft collided over Uberlingen, Germany, even though both aircraft were carrying TCAS. TCAS instructed one aircraft to climb but the pilots descended leading to a collision with an aircraft whose pilots were following TCAS. In the Uberlingen scenario, it would have been preferable for TCAS to notice the non-compliance of one of the aircraft and to reverse the advisory from a descend to a climb manoeuvre. The TCAS logic has since been modified (TCAS II v7.1) to address this specific situation. However, the introduction of just this one change took 7 years of international work. To fundamentally improve the robustness of the logic requires a design change.

The TCAS logic is just one area for possible improvement. Globally, since the 1950s, the design of the airspace has been constantly changing. Over the next decade, across the world, there will be step changes in how air traffic is managed enabled by satellite based navigation, enhanced automation and new procedures. Unfortunately, TCAS cannot safely support the operational requirements of these new airspace concepts.

TCAS is also a system built around the 'pilot-in-the-loop' principle; it is a system with a human at its heart. The growth in unmanned air vehicles presents a new challenge for airborne collision avoidance.

New airspace requirements, new users and new surveillance technologies present a fundamental challenge to existing TCAS. As was seen with TCAS II version 7.1, a comparatively minor logic can take a disproportionate amount of effort and time to develop and agree internationally. Meeting these future requirements requires a complete overhaul of TCAS and, at the same time, the new system should be more adaptable so that future changes can be implemented far more easily.

ACAS X Overview

The future airborne collision avoidance system which is currently under development is known as ACAS X. It will be a family of systems which will be backwards compatible with TCAS. It will provide the same general role as TCAS: surveillance of nearby aircraft, Traffic Alert and Resolution Advisory generation and coordination with other aircraft collision avoidance systems.

ACAS X will support new capabilities. It can make use of new surveillance sources, such as Automatic Dependent Surveillance – Broadcast (ADS-B), it is intended for multiple types of aircraft (commercial, general aviation, UAS) and to be tuneable to different operational concepts i.e. closely-spaced parallel operations (CSPO) and reduced separation standards.

The four variants of ACAS X are: ACAS X_a which will replace current TCAS II equipment, ACAS X_o which will be designed for users of specific operations (e.g. CSPO), ACAS X_p which will use passive surveillance methods and be designed for general aviation and ACAS X_u for unmanned aircraft.

There are two major evolutions in ACAS X. Whereas TCAS uses only transponders to provide surveillance of nearby aircraft, ACAS X is being designed to exploit GPS-based technologies (although a threat aircraft will still need to be carrying a transponder for an RA to be generated) and to accommodate different sensor types, such as Electro-optical and Infra-red which are found on UAS. The second evolution is in how the TCAS logic is developed, maintained and deployed on aircraft.

The TCAS logic today is rule-based and held in state-tables and pseudo-code. The complexity of the logic is translated into complexity in the software of the on-board system. ACAS X takes a different approach. The logic, i.e. what action to take given a particular scenario, is developed using an off-line computer model. This takes into account the imperfections in surveillance technologies and the range of possible pilot responses to the alerts. A series of weighting factors are applied to the possible outcomes from alerts generated by the logic, for example, we want the logic to avoid near mid-air collisions, obviously, so collisions are very negatively weighted but we also don't want the logic to generate alerts that disrupt normal air traffic operations with excessive deviations, so these have to be carefully weighted. Finding the optimum balance of all of these weightings for all possible scenarios is undertaken by a powerful computer. The resulting logic is represented as a simple look-up table which describes what to do in any particular scenario and this table is implemented in the airborne equipment. The advantages of this approach are increased simplicity of implementation which also translates into far easier updates to the system in future: a new logic table is created, validated, approved and distributed for uploading onto the airborne equipment.

The pilot community, for whom Resolution Advisories are far from a daily occurrence, are unlikely to tell whether their aircraft is ACAS X or TCAS II equipped. Therefore considerable effort is being spent in ensuring that the flight deck experience with ACAS X is unchanged.

Next Steps

ACAS X is being actively progressed by the FAA TCAS Program Office supported by a number of companies and organisations, in particular the MIT Lincoln Laboratory where the logic is being developed and tuned. In addition, European organisations are contributing to this development through the Single European Skies ATM Research (SESAR) programme funded by the European Commission. The logic is under refinement and candidate versions have been developed and are being subjected to rigorous international testing. Flight tests of prototype equipment are planned for 2015. The international standardisation effort is gathering momentum and it is expected that a completed description of the new system will be available in 2018 with equipment becoming available shortly afterwards.

Concluding Remarks

The air traffic management system of the future will be radically different to the system of today. However, there will always be a role for an independent airborne layer of protection to act as a safety net in the unlikely event of a failure of the ground-based ATM system to prevent a risk of a mid-air collision. TCAS, the current system, has saved untold lives and its successor, ACAS X, ensures that collision avoidance protection will be available in the future.

This article was developed based on material provided by the FAA TCAS Program Office and MIT Lincoln Laboratory.

Scenario Training for Aircrew and Controllers [STAC] – viewpoint from controllers and a pilots

It has increasingly been realised that as a National Air Navigational Service Provider, NATS is not able to increase its safety performance when dealing with aircrew and airlines unless it considers both these groups [and several others within the aviation system] as part of the overall system to which we, as an ATM company, play a major safety role. In such a major safety role we can also detrimentally influence a flight when teams and crews in both domains are uncertain, unclear or do not follow the rules and protocols assumed in this complex area.

For the past 6 years, NATS has attempted to develop several joint training initiatives with pilots from all areas of the aviation community and some non pilot professionals who are key to safety in and around the ramp and airport environments.

As part of on going training undertaken throughout NATS, there is a desire to expand the syllabi of the Training for Unusual Circumstances and Emergencies [TRUCE] and the continuous professional development of operational staff. As part of this development SARG have approved the expansion of the licensing requirement for TRUCE to include more pilot/controller interface activities. This includes controllers joining with pilots to experience airline Line Oriented Flight Training [LOFT] and Line Oriented Evaluation [LOE], and a new workshop-based activity known as STAC or Scenario Training for Aircrew and Controllers.

STAC offers pilots and controllers a forum to jointly explore the risks and hazards inherent in emergency situations, and to promote mutual awareness of the protocols and options to be observed or considered.

The courses are facilitated by NATS TRM specialist facilitators and airline CRM instructors and include structured discussions relating to:

- Communication issues within the flight-deck and externally with ATC agencies
- Sharing situation awareness in an emergency scenario within and between the two groups
- Issues of overload and decision making for both parties
- Handover issues between controllers, and sharing the situation within and between the aircraft crews
- The use of SOPs, including emergency quick reference checklists by both groups

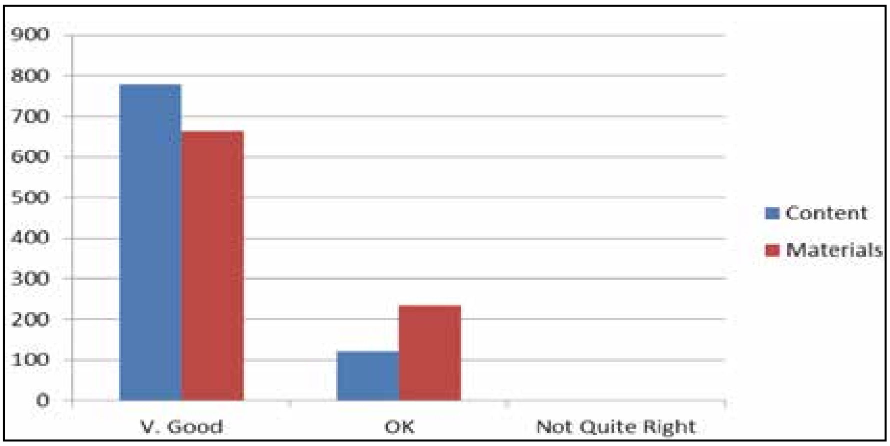
The courses use actual emergency scenarios to help promote increased awareness by all participants of the separate and often competing demands on attention and responses in unusual and emergency situations.

To date [3 years, from 2012 to 2014] there have been over 900 attendees to the Swanwick STAC courses. The approximate breakdown of participants is as follows:

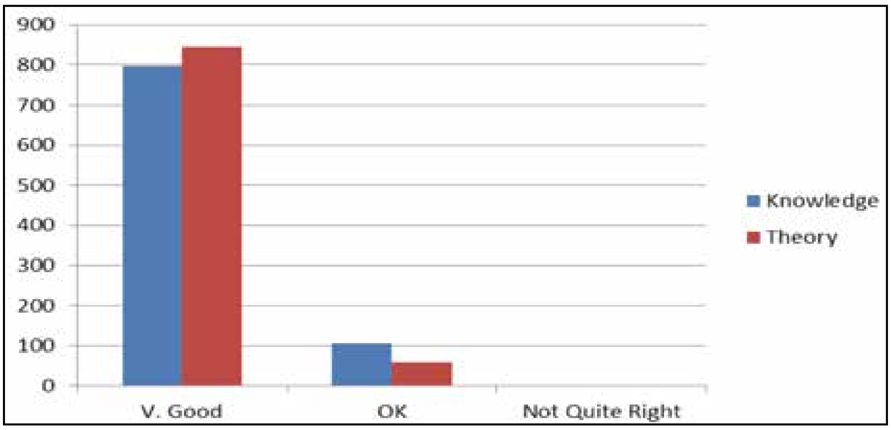
- Swanwick ATCO's – from both Area and Terminal Control – 702
- NATS Airport controllers – 7
- NATS training college staff - 5
- Non-NATS ATCO's - 8
- Military ATCO's from Swanwick - 3
- Airline Pilots - 138
- Business Pilots - 17
- Helicopter Pilots - 4
- Pilots from Training Organisations – 27
- AAIB - 2
- SARG ATC Inspector - 2

Feedback from the courses is recorded in different formats. The two main ways we have of evaluating the work and, more importantly, whether it is having an effect on our joint safety accountabilities are: through a simple feedback form relating to the effectiveness of the material and its delivery; and from monthly statistical analysis of the causal factors attributed to the pilot/controller interface.

A selection of the feedback from the STAC courses is graphed below.



Graph 1. Content and materials used in the courses



Graph 2. Knowledge and theory shared in the course

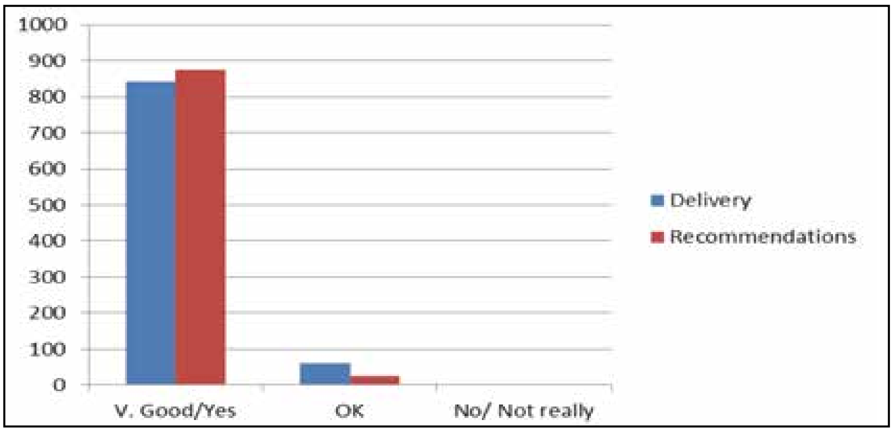
Graph 1

The graph indicates the value placed by the participants on the content and materials used during the courses. The materials are changed by the delivery team every six months and every year the course is completely re-written. In the present course there is more specific content about failures and unusual events found in the flight-deck, as well as how controllers cope with extreme weather conditions and with single pilot, high performance aircraft.

Graph 2

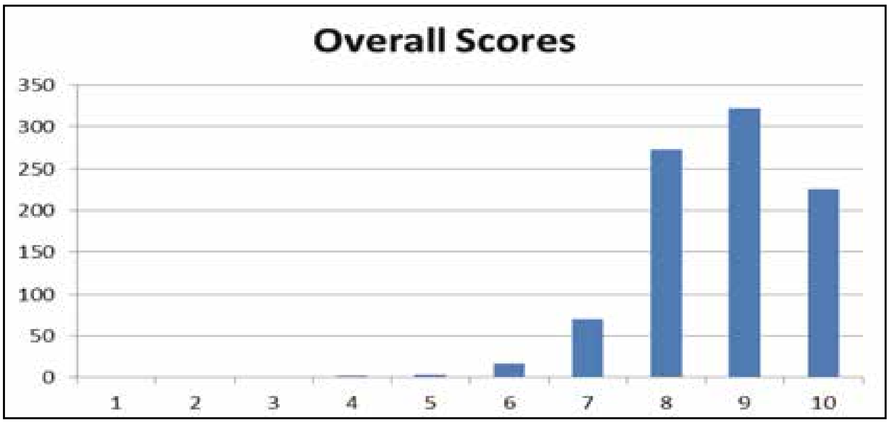
This graph indicates that the participants consider the knowledge and theory gained during the course to generally be very good. This has gained more and more positive feedback as the information is shared by the increasing number of pilots who attend STAC. Specific reference to the following issues is now part of the collective discussion and in some cases pilots and their airlines have changed protocols and procedures, both in training and in their flight-deck SOP's. These include:

- A better understanding and use of 7700, PAN and MAYDAY calls
- The use of NITS as a briefing protocol in an emergency for both flight-crew and controllers
- The issues of fuel management, minimum fuel and diversion rules and protocols
- The limitations of single frequency R/T
- The monitoring of 121.5 and the role of the Distress and Diversion cell at Swanwick
- The issues of workload, particularly in an emergency, and what is generally required by flight-crews in different types of emergency
- The issues of sterile runways and the expectations of the flight-crew in situations which require this support
- The various responses in an emergency to a single pilot, versus a multi-crew, general aviation or commercial aviation transport flight
- Assumptions made by both controllers and pilots in emergency or unusual situations and the ensuing problems of communication, planning and decision making



Graph 3. Delivery of the courses by CRMi's, TRM facilitators and human performance specialists and whether it is recommended to colleagues

Overall rating of the courses



Graph 4. Feedback from STAC courses 2012 - 2014

Graph 3
The graph indicates the high regard the participants have for those professionals, both CRMi's from the airlines, NATS operational controllers and human performance specialists who deliver the STAC workshops. NATS has worked hard to train a small group of operational staff to a high standard of facilitation delivery. These individuals are joined by CRMi's from several major UK airlines and flight training organisations which enhances the knowledge and professional delivery of the courses.

Graph 4
The graph indicates the total scores given by all the participants during the last three years.

The X axis indicates the score out of 10 [1 low – 10 high] as estimated by the participants. The Y axis indicates the total numbers in each category. The average score from the previous three years is 9.2.

When evaluating the impact of the work on the reduction of risk between controllers and pilots, it is complicated to clearly ascertain this link. However, Causal Factor data which is collected from all incidents in NATS, and which has been assigned to pilot/controller interaction, is reported on a monthly basis. During the past four years, the number of significant events included in this category have reduced from 78 in late 2010 to 60 in 2014; a reduction of approximately 18%.

Pilot perspectives:

Training Captain Wayne Parsons, from British Airways, is one of fifteen CRMi's[1] who joins the STAC courses on a voluntary basis to help facilitate and teach the material. These are his thoughts:

"As TRE/I[2], I have supported STAC in the capacity as CRMi, and have assisted in the development of material and in the delivery of several courses, since September 2012. This experience has allowed me to learn about ATC and also enables me to share my skills and knowledge with the controllers.

Initially I observed a lack of knowledge between pilots and controllers about each others' skills, procedures and difficulties faced, particularly in unusual and emergency situations. However, as a result of my work with the STAC delivery team and facilitating the courses, I have personally improved my knowledge of the ATC world which has empowered me to manage some of the difficulties faced in our industry – but this is a personal opinion. As well as adding to my knowledge which I can share as a training captain, I have also noticed quite a few changes which I have noticed from attending the courses which are now embedded in ATC procedures;

- NITS - which I believe, although simple, is a very powerful tool because it brings so much commonality to an emergency situation;

- Squawking - in an unusual or an emerging declaration of an emergency, is now better understood and many airlines will use 7700 as an initial indication of an aircraft problem;

- Turning in an emergency - was little understood by the controllers who believed all aircraft in emergencies requiring a descent would all chose the same plan. I believe we (as pilots) have now been able to explain the differences and problems encountered by the various emergency situations;

- The essential need of pilots to have the QNH confirmed, particularly in an emergency/ unusual situation, when their workload can be extreme;

- The understanding for pilots that announcing MAYDAY allows them to land on either end of the runway;

- Fuel states – which I believe has been generally misunderstood by the controllers, but which is clarified in STAC during discussions about fuel and fuel management;

- Weather avoidance – which I believe has been generally poorly understood by both pilots [the fact that controllers have no immediate reference on their radar of the weather[3]] and controllers [the fact that the weather radar on the aircraft has limitations and pilots do have Company and personal preferences when faced with extreme weather situations]"

Wayne went on to explain a recent situation in which his experience in STAC aided his instinct to re-think a routine situation.

"On a recent flight my experiences, with NATS ATC and in the delivery of the STAC courses, enabled me to make a decision which I may not have made had I not worked with the delivery team exploring materials and scenarios suitable for both pilots and controllers. Having evaluated the situation, which was in a flight from a non-UK destination, I spoke to my first officer about the clear inconsistencies surrounding the situation that was emerging. As a result we elected to hold our position until all parties had improved their situation awareness. My experience in STAC and the relentless discussions to 'ask if unsure' since anyone in the system can get it wrong, probably saved a potential incident on that day"

All enquiries about attending these courses should be directed to:-

Anne Isaac at anne.isaac@nats.co.uk

1. CRMi – Crew Resource Management instructor
2. TRE/I – Type Rating Examiner/Instructor
3. Weather radar is only available to the supervisor in the Operations room

Minimum Fuel and Fuel Shortage – Information for Controllers

Background:

In May 2012, the Manual of Air Traffic Services Part 1 was amended in the section 'Low Fuel, Holding Procedures and associated Radiotelephony Phraseology to include the response by controllers to a pilot's declaration of "minimum fuel", which ICAO had planned to introduce into PANS-ATM in October 2012.

Definitions:

Minimum Fuel is the term used to describe a situation in which an aircraft's fuel supply has reached a state where little or no delay can be accepted by the flight crew. It is not an emergency situation but indicates that an emergency situation is possible, should any undue delay occur [ICAO]. However, 'Minimum Fuel' RTF phraseology is not universally used by every aircraft operator and pilot.

A pilot's declaration of 'Minimum Fuel' indicates that no further fuel diversion options are available where the aircraft is committed to land at the pilot's nominated aerodrome of landing with not less than 'final reserve'[1] fuel.

Controller and Pilot Actions:

Controllers are not required to provide priority to pilots of aircraft that have declared 'Minimum Fuel' or that have indicated that they are becoming short of fuel. However, controllers shall respond to a pilot who has declared 'Minimum Fuel', by confirming the estimated delay they can expect to receive expressed in minutes if the pilot is en-route to, is joining, or is estimated in an airborne hold; or by expressing the remaining track mileage from touchdown if the aircraft is being vectored to an approach.

Once the pilots have this information, they will determine whether or not they can continue to the aerodrome with or without declaring a fuel emergency.

A pilot's world view

So what does this mean, practically, from a pilot's point of view? Let's consider a flight inbound to Heathrow via Lambourne. In this case it is being operated by an Airbus 320, but the general principles are applicable to any flight in any aircraft type.

The first point to note is that, in modern aircraft, the fuel-gauging is very accurate, and all the fuel on the gauges is usable – so the pilots are very well aware of how much fuel they actually have.

This is a picture of the Fuel page on the Electronic Centralized Aircraft Monitoring system of an Airbus 320: fuel is displayed to an accuracy of +/- 10 Kg. Fuel On Board was 3060 Kg when this picture was taken.

Committing to Land

The ICAO text talks about 'committing to land' at a specific aerodrome – what does that mean? EASA rules are quite clear in that regard: the aeroplane is required to land with (for a jet) fuel for 30 minutes of flying time. How the crew manages their flight to achieve that is outside the scope of this short discussion; nevertheless, it is perfectly acceptable, if the crew so decides, to dispense with an alternate and 'commit' to land at destination.

The Estimated Approach Time 'contact'

Our flight is now in the LAM hold, and expecting – when cleared for approach – a flight path which will look something like the picture above, for a landing on Runway 27L (albeit via radar vectors of course). It would typically require 300 – 400 Kg of fuel to fly that approach from the hold to landing. Holding fuel-flow is typically of the order of 30 Kg per minute for our flight.

When the pilots receive an Estimated Approach Time (EAT) they have at their fingertips all the information they need to assess whether they can accept it (and land with final reserve fuel) or whether they need to divert. In effect, the EAT has become an informal contract between the controller and the pilots.

If the pilots assess that they can continue to hold, but their landing fuel will be close to Final Reserve, they may declare Minimum Fuel at that point, even if they still have to hold for 20 minutes. In that sense a declaration of Minimum Fuel is an accurate indicator of a flight's fuel state without the pilots actually having to describe their endurance in minutes. Minimum Fuel should act as a warning to a controller that there is little scope to change the 'contract'. Unless the pilots have committed to a particular airport, and know they will land with less than Final Reserve fuel, they will not declare an emergency. Note too that the option of declaring a PAN for low fuel state has, in theory, disappeared (although, of course, it is always an option for the pilots). ICAO has dispensed with it. Thus Minimum Fuel is not a request for priority.

Now, we all know EATs are not set in stone; however, the most important thing to take away from this short discussion is the absolute imperative to tell the pilots if the plan, especially the EAT, changes. If the pilots have declared Minimum Fuel and the aircraft is broken off from the approach, or has to go around, it is very likely they may have to declare a MAYDAY.

This paper was written by Dr. Anne Isaac, NATS External Safety and Captain Tim Price, Manager Regulatory Affairs for British Airways, as a result of a request from, and in support of, the Safety Partnership Agreement [SPA].

1. Final Reserve Fuel is fuel for 30 minutes of flight for turbine powered aircraft or 45 minutes for piston powered aircraft [EASA Ops.]

An argument for Adopting True North for Air Navigation

by Dusty Miller

To adopt true navigation or to not adopt true navigation, that is the question. Here the BALPA ADO-AGE group summarises an argument for adopting change.

Accidents caused in whole or in part by errors in navigation using magnetic heading information are still occurring. On 20 August 2011, a B737-210C combi aircraft, C-CNWN, was being flown in daylight from Yellowknife, Northwest Territories (CYZF), to Resolute Bay, Nanavut (CYRB). Resolute Bay lies at 74.43ºN and at the time of the accident magnetic variation was 28ºW; it has now increased to 31.2ºW. During its approach the aircraft struck a hill about one mile east of the runway, killing eight passengers and all four crew; three passengers survived.

Conflicting Evidence

Prior to the approach the crew spent two minutes discussing conflicting evidence about navigation and the actual aircraft track. During the IMC approach the first officer became particularly concerned about lateral deviation from the intended track as indicated by GPS. The captain believed he had captured the localiser and continued the approach even though the first officer had also pointed out they were also unstable (configuration) at three nautical miles. After further discussion about their position the first officer called for a go-around. The captain called for go-around power shortly afterwards, 0.6 seconds before ground impact.

The investigation looked in detail at the compass systems in its analysis and determined that the heading reference was in error by minus eight degrees during the initial descent and drifted further to at least minus 17 degrees during the final approach. It was surmised that the captain probably made a control wheel steering input causing the autopilot to revert to MAN/HDG HOLD from VOR/LOC capture, and that this change was not detected by the crew. The effect of the large compass error would have been to confuse the crew as to its intercept angle and subsequent track. To add to the confusion, the flight directors were also believed to have reverted to AUTO APP intercept mode as the aircraft diverged from the localiser. Of note, the Resolute Bay approach plates and aerodrome chart indicated four different magnetic variation values.

Many public transports flying today still use INS as their principal navigation source. True north INS output has to be converted using a variation programme to give corrected magnetic heading. The USA has an agency that produces the variation programme every 10 years and when the sealed INS box is manufactured the most recent version is embedded into its firmware. Ten years later the INS units will be due for overhaul and update of, amongst other things, the variation programme, which of course attracts a fee. Reputable operators carry out this maintenance action but it is questionable whether the whole industry is fully compliant. During the 1990s with aircraft engines and systems becoming so reliable and monitoring comprehensive, 'on condition' maintenance was adopted to prevent needless and costly work. This principle was applied to INS (which rarely fails) but what was frequently overlooked was the embedded and restricted variation programme. The result now is that some boxes are more than 30 years old.

GPS is also a true navigation system but has a 28-day update cycle including new variation data to provide accurate data with which to navigate.

Deviations and Inaccuracies

As most licence holders will recall from their initial training, magnetic variation is only one part of the CDMVT (Compass Deviation Magnetic Variation True) heading puzzle. Compasses all suffer from deviation specific to the aircraft installation, which requires a compass swing to quantify and normally only results in a degree or so of correction. However, this procedure is expensive and time consuming, although necessary after a major component refit such as an engine change or maintenance; all engines have to be running, radios and other avionic systems switched on. But certain non-normal situations involve switching electrical components off or shutting engines down, whereon any compass deviation card becomes invalid. And how often do pilots actually apply deviation to compass headings in anger?

All modern aircraft have GPS, even in the GA sport and recreation sector. GPS is also a true navigation system but has a 28-day update cycle including new variation data to provide accurate data with which to navigate. Increasingly we see navigation into and out of airports relying on GNSS defined routes, and performance-based navigation (PBN) is an essential element of Single European Sky ATM (Air Traffic Management) Research (SESAR) and other programmes to increase airspace and aerodrome capacity. If aircraft systems are not regularly updated there will inevitably be inaccuracies. Agreed, these errors will be largest where variation is greatest or changing most quickly. But take variation out of the equation and the system is always in date.

Time for a Change?

In 2000, through the work of Arthur Creighton and others, a Royal Institute of Navigation (RIN) meeting discussed the idea of aviation changing to use true north as a reference instead of magnetic north. Canada also proposed such a move in 2013 – the Resolute Bay accident was not the first high altitude event of that nature. The most significant remark made at the RIN meeting was that the FAA would save enough in one year to pay for every worldwide flying craft – balloon, hang glider, light aircraft, etc. – to be issued with true north compasses, which are available in solid state with very small power requirements. The global saving to the industry from dispensing with variation changes, such as not repainting runway numbers and the reduction in associated route and airfield chart changes, would be enormous.

So should the industry stay with a navigation system datum simply because it has been used for hundreds of years? The magnetic compass provided an adequate approximation of true direction because there was no need for greater accuracy. Now the ability to navigate accurately using true direction is entirely possible but, paradoxically, today's more accurate systems are degraded by application of inaccurate and ever-changing degrees of magnetic variation.

It has been proposed that the evolution to true navigation would occur at a 28-day navigation data update day, and start with oceanic airspace as it would be a relatively easy procedure to initiate at the oceanic boundary. Many aircraft have a push-button on the flight deck to switch between true and magnetic already. By choosing a convenient starting line of longitude, for example 10 west at 0200 hours local time, and progressively as the world revolves, align VORs/radar heads and aircraft switches all to true. Discourage flight just before and after, and within 24 hours the industry would be aligned with a new and arguably safer protocol. An alternative would be to declare a fixed global changeover time based on a single time zone. CAT operators using electronic flight bags (EFBs) would be at an advantage as new plates and procedures could be pre-programmed, as would an alternate true north flight plan.

Industry has been slow to take the argument seriously, possibly because no case has been put forward based on satisfactory safety grounds. More probably, it is because the costs of the change have yet to be properly quantified and would have to be met as an investment rather than an ongoing cost. Consideration will also need to be given to fall-back options in case of GNSS (Global Navigation Satellite System) failures, for example, but these may be as simple as applying a gross error check by applying variation to a magnetic heading to derive the true value – a reverse of the present situation. What is clear is that the emerging ATM environment will demand increased navigational accuracy and it behoves us all to find a solution quickly. Changing to the use of true headings will go a long way towards satisfying the requirement.

Abridged by the ADO-AGE Group with thanks to Dusty Miller for the full paper. The ADO-AGE Group has given us its thoughts on true north but what are yours? If you have anything you would like to say, please contact BALPA's Flight Safety Specialist, Steve Landells, at stevelandells@balpa.org to put your thoughts forward.

Original article by Dusty Miller, abridged by the BALPA ADO-AGE Group. First published by BALPA in The Log Winter 2015

Missed Approaches and Simultaneous Departures aka "Piggy Back Go-Around"

A piggy back go-around is a situation where an inbound aircraft carries out a missed approach with another aircraft departing close ahead. This can be particularly hazardous when the inbound aircraft elects or is instructed to go-around from a very short final.

A piggy back go-around may result from a number of different scenarios

- Poor gap judgement by ATC (the distance between pairs of arrivals)
- Poor or non-compliant speed control on final approach by pilots
- A departing aircraft being slow to commence it's take-off roll
- An unstable approach – Resulting in Pilot electing to Go around
- Windshear
- Changes to weather conditions
- Runway incurrsions

A piggy back go-around will inevitably result in reduced separation between a pair of aircraft. Air traffic controllers may apply reduced separation in the vicinity of an aerodrome provided they can maintain visual reference to both aircraft; they may also issue essential traffic information until standard separation is achieved.

Controllers are aware of the dangers involved in cancelling a take-off clearance once a departing aircraft has commenced its take-off roll. Guidance is provided to controllers to assist them in judging when an aircraft is approaching V1 (this is normally in the form of a location from the threshold of the runway, but may vary). Controllers may elect to cancel a take-off clearance to prevent a piggy back go-around or may issue an early turn to a departing aircraft.

Air Traffic Controllers are taught various techniques to assist in resolving piggy back go-around scenarios, and the following guidance is published.

- Provide early traffic information to ensure aircraft are aware of potential conflictions before the scenario occurs – this applies to both arriving and departing aircraft.
- Use the phrase "immediate take-off" if the gap requires a departing aircraft to roll without delay.
- Whilst there may not be time for a departure to get airborne, there may be time for them to leave the runway. Consider vacating traffic to enable inbound aircraft to land.
- If the gap has been misjudged, make an early decision that your original plan is not going to work, instruct the inbound to execute a missed approach and arrange a suitable gap to enable the departure to clear the runway.

Air Traffic Controllers should be aware that a go-around, particularly during initiation, requires a number of vital configuration changes in the flight deck requiring the focus and physical action of both crew members. In the event of a piggy back go-around an acknowledgement of the instruction to go-around may be delayed as the priority is to execute the manoeuvre. In this scenario the controller would likely be in visual contact with the aircraft and thus see the initiation of the go-around. In a similar respect an instruction to reject a take-off may also receive a delayed response from the pilots as critical actions are completed. In summary the priority is for the pilots to control the aircraft.

To help reduce the possibility of finding yourself in a piggy back go-around situation, pilots are encouraged to:

- Fly speeds as allocated by ATC to assist approach in providing the necessary departure gaps for the tower controller.
- Do not accept a line up clearance unless you are fully ready for departure, and advise the controller if there may be a delay in commencing the departure roll, due to other checks(gust locks removal, etc)
- Commence take-off promptly if issued with an "immediate take-off" clearance.
- Pilots should be aware, in the event of a piggy back go-around an immediate turn may be requested by ATC and a revised go-around clearance may be issued to keep the two aircraft apart.
- If ATC instructs an aircraft to go-around the call will include the instruction to 'acknowledge'. Pilots should be aware that in a piggy back go-around scenario, separation between aircraft is reduced. Prompt initiation of the go-around and the associated configuration changes required must take priority. Acknowledgement of the ATC instruction may have to be deferred until workload permits; the tower controller will likely be able to see the go-around being commenced.

Left or Right? Kegworth revisited...

by Dai Whittingham

On 4 February 2015 a TransAsia ATR 72-600 crashed shortly after take-off in Taiwan, killing 43 of its 58 occupants. Initial investigations revealed there had been a loss of power from both engines following indications of a single engine failure. The investigation will amongst other issues consider whether the flight crew's actions contributed to the loss of power on the second engine.

On 8 January 1989 a British Midland Airways B737-400 crashed into a motorway embankment on the approach to East Midlands Airport, killing 47 of its 126 occupants; a further 74 people sustained serious injuries. The aircraft was making an emergency diversion after a single engine failure. During the approach the operating engine ceased producing sufficient power and the aircraft did not reach the runway. The following description is based on the AAIB accident report.[1]

Kegworth – the facts

G-OBME departed Heathrow Airport at 1952 on the third leg of a double shuttle to Belfast and was climbing through FL283 when a fan blade in the No1 (left) engine detached, causing a series of compressor stalls. This in turn led to heavy vibrations through the airframe, ingress of smoke and fumes to the flight deck and fluctuations of the No 1 engine parameters. The crew believed that the No 2 (right) engine had been damaged and reduced power to flight idle; the airframe shuddering caused by the surges in the No 1 ceased as soon as the No 2 power was reduced, thereby persuading the crew that they had dealt correctly with the emergency. The crew then shut

down the No 2. Thereafter the No 1 appeared to run normally during the subsequent descent.

The crew initiated a diversion to East Midlands and were vectored for an instrument approach to RWY 27. The approach was normal although there were high levels of vibration from the No 1 engine but at 2.4 miles from the runway there was an abrupt reduction of power followed by a fire warning. Efforts to restart the No 2 were unsuccessful and the aircraft struck a field prior to a second more severe impact with the western embankment of the M1 motorway.

At the initial onset of the vibrations the CVR area microphone had picked up an audible rattling sound and the FDR showed significant fluctuations in lateral and longitudinal accelerations but there were no fire or other visual or aural warnings on the flight deck. Both pilots recalled smelling smoke or burning through the air conditioning system. At this stage the FDR also recorded marked N1 and EGT fluctuations and a low, fluctuating fuel flow.

The commander took control of the aircraft and disengaged the autopilot. He looked at the engine instruments but did not gain any clear indication of the source of the problem. However, he stated that he thought the smoke and fumes were coming forwards from the passenger cabin which, from his knowledge if the air conditioning system, led him to suspect the No 2 engine.

The commander asked the FO which engine was causing the trouble. In response, he said: "It's the le... it's the right one", to which commander told him: "OK, throttle it back." The FO later had no recollection of what engine or other indications led him to this assessment.

Within 1-2 seconds of flight idle being selected on the No 2, the fluctuations in lateral and longitudinal accelerations ceased and the No 1 fan speed settled 3% below its previous stable speed and 50C above its pervious level. However, indicated vibration remained at a maximum and fuel flow was still erratic.

At this time, the FO advised London ATC that they had an emergency which believed to be an engine fire. 43 seconds after the vibration started, the commander then ordered the FO to shut down the No 2 but then told him to wait. The instruction was further delayed by the FO discussing options with London and suggesting they were heading to East Midlands. He told the commander he was about to run the 'Engine Failure and Shutdown' checklist but action was suspended while the commander advised company operations of the situation. During a short pause in the radio traffic with company operations the No 2 fuel cock (start lever) was closed and the APU started, 2 minutes and 7 seconds after the onset of the vibrations; the aircraft was in a descent 5 miles south of East Midlands. Shortly afterwards, the company asked the commander to divert to East Midlands.

The commander stated later that all evidence of smoke and fumes cleared from the flight deck as soon as the No 2 was shut down, convincing him that his actions were correct. The only flight deck symptoms of potential unserviceability of the No 1 was a higher than normal indicated vibration which persisted for 3 minutes before settling back towards 2 units[2] (only slightly higher than normal) and an increased fuel flow.

In the cabin the cabin crew and passengers had heard an unusual noise accompanied by moderate to severe vibration. Some were aware of smoke, described as smelling of burning rubber, oil or 'hot metal'. Many saw signs of fire from the left engine, including 3 members of the cabin crew, 2 of whom also saw light-coloured smoke in the cabin. Several of the cabin crew described the noise as a low repetitive thudding 'like a car backfiring' and one reported afterwards that the airframe shuddering was shaking the walls of the forward galley.

Shortly after the No 2 was shut down the commander called the CSM to the flight deck and asked whether there had been smoke in the cabin. On being told there had been, he instructed the CSM to secure the cabin. The CSM returned to the flight deck a short while later and informed the commander that some of the passengers were starting to panic. The commander then made a PA announcement, telling the passengers there had been a problem with the right engine which had generated the smoke in the cabin and that the engine was now shut down and they could expect to land at East Midlands in the next 10 minutes. The cabin crew who had seen evidence of fire in the left engine later stated that they did not hear the commander's reference to the right engine. By contrast, many of the passengers who had also seen signs of fire in the left engine were puzzled by the PA reference to the right engine but none brought this discrepancy to the attention of a crew member.

At this stage the aircraft was handed off to Manchester ATC who gave vectors for a descent to the north of East Midlands and an intercept for the RWY27 ILS. The commander flew manually while the FO dealt with the radio; flight deck workload remained high while the FO obtained the landing weather and attempted unsuccessfully to programme the FMS for the approach, the latter task occupying his full attention for 2 minutes. Some 14 minutes after the onset of the vibration the commander began to review the situation but his discussion with the FO was interrupted by further ATC messages with a new heading, a descent to FL40 and a change of frequency. Once contact was established the FO began to read the 'one-engine inoperative descent and approach checklist' but this was immediately interrupted by a request for a test transmission to the aerodrome fire service. The approach checklist was finally completed with the aircraft 15 nm from touchdown and descending through 6500 ft. One minute later the commander accepted a new vector south of the centreline to increase the distance from touchdown. Throughout the descent there were distractions from a small number of aircraft making radio calls on the same frequency.

At 13 nm from touchdown ATC advised a right turn to bring the aircraft back to the centreline and power was increased to level the aircraft briefly at 3000 ft, with maximum indicated vibration again being recorded on the FDR. The commander then began a slow descent to 2000ft and on gaining the centreline called for the landing gear; flap 15 was lowered as he passed the outer marker at 4.3 nm from touchdown.

One minute later, when the aircraft was at 2.3 nm from touchdown and passing 900 ft, there was an abrupt decrease in power from the No 1 engine. The commander immediately called for a relight on the other engine and the FO attempted to comply. The commander then raised the nose in an effort to reach the runway. 17 seconds after the power loss there was a fire warning on the No 1 engine and the GPWS started to warn of descent below the glidepath. The commander ordered the FO not to action the fire drill and then warned the cabin crew and passengers of the imminent crash landing. Some 2 seconds later, the airspeed fell below 125 kts and the stick–shaker operated until the aircraft hit the ground; the last reported FDR airspeed was 115 kts.

The aircraft contacted level ground in a nose-high attitude and then passed through trees before a second major impact on the upslope of the motorway embankment. The fuselage was extensively disrupted and only 14 passengers were able to make their own escape, the rest being trapped due to injury, seat failure or debris from the overhead lockers. There was no post-impact fire beyond a small fire at the front of the No 1 engine that was quickly extinguished by the rescue services. Both MLG legs had separated cleanly (as designed) when the trunnion fuse bolts failed during the initial impact. The engine pylon fuse pins had not operated but both engines separated in the second impact, without rupturing the wing fuel tanks, when the pylon structures failed approximately in line with the forward spar.

During the rescue operation a company engineer entered the fight deck and switched off the main battery and standby power switches. He later returned and switched off the engine start (ignition) switches and the fuel booster pumps. Both start levers were found in the cut-off position and no witness was found who could testify to having moved them.

The Investigation

Examination of the wreckage showed that damage to the No 2 engine was all explicable by the crash dynamics. Its internal condition was consistent with a low time, fully serviceable engine which had little or no rotational energy at impact, and there was no indication of pre-impact distress in the lubrication system filters and magnetic chip detectors.

The No 1 engine had suffered similar external mechanical damage but there was evidence of severe fire damage to the forward outboard region; the fire appeared to have emanated from the base of the fan casing and affected the entire left side of the casing. The fan blades were also severely damaged, with most fractured at a part-span position. The fan case abradable seal material was missing and the acoustic panels were either missing or badly scarred. Portions of fan blades and acoustic liner, liner attachment bolts and washers were recovered from an area 2 nm short of the accident site. Detailed analysis revealed a fatigue failure of a fan blade which generated a severe mechanical imbalance leading to blade rubbing and an eventual fire.

The investigation looked extensively at crew actions, including the speed of their response and the rationale behind the incorrect diagnosis of a failure or fire in the No 2 engine. The investigators noted that the commander's decision to disengage the autopilot and fly manually may have limited his ability to assimilate the available engine indications. In the event, both pilots reacted before they had positive evidence of which engine had malfunctioned and the FO reduced power on the No 2 engine without being positively directed to do so. The report included 31 separate safety recommendations; some of these related to training, including recurrent training and practice in re-programming of FMS, and improving knowledge of vibration monitoring systems. Significantly, the report also recommended the provision of training exercises to improve and facilitate the co-ordination and flow of information between the flight deck and the cabin crew.

Lastly, the type and severity of the injuries suffered by many of the passengers and crew prompted recommendations that a research programme be established into upper torso restraint for passengers, that the certification standards for passenger seats be increased, and that work be done to improve the integrity of cabin floor sections. The number of injuries caused by the early unlatching of the overhead bins and their failure during the accident sequence also led to a recommendation for improvements in airworthiness requirements that were accepted and are now in global use.

1. http://www.aaib.gov.uk/cms_resources.cfm?file=/4-1990%20G-OBME.pdf accessed 23 Feb 2015.

2. Vibration units are nominal on a scale of 0-5. A fault generating more than 5.25 units would be interpreted as an interface failure, for which the display pointer will be driven to the zero position for 2 seconds and then disappear.

Members List

Members of The United Kingdom Flight Safety Committee

FULL MEMBERS

Chairman
easyJet
Capt. Chris Brady

Vice-Chairman
Flight Data Services Ltd
Simon Searle

Treasurer
City University London
Pavan Johal

Executive Board CAA Rep
Rob Bishton

Non Executive Board Member
AIG Europe Ltd
Jonathan Woodrow

Acropolis Aviation
Nick Leach

A|D|S
Mick Sanders

Aegean Airlines
Capt. Stavros Christeas

Aer Lingus
Capt. Conor Nolan

AIG Europe Limited
Jonathan Woodrow

Airbus S.A.S
Harry Nelson

Air Contractors
Jack Durcan

Air Mauritius
Capt. Francois Marion

ALAE
Ian Tovey

Ascent Flight Training
Stewart Wallace

Atlantic Airlines
Alex Wood

AVISA
Phil Stuckle

BA Cityflyer
Alan Taylor

BAE SYSTEMS Reg. A/C
Alistair Scott

Baines Simmons
Chaz Counter

BALPA
Stephen Landells

Belfast Intl. Airport
Alan Whiteside

bmi regional
Martyn Sisson

Bond Offshore Helicopters
Richard Warren

Bristow Helicopters
Capt. Adrian Bateman

British International
Anthony O'Keefe

CAE Oxford
Andrew McFarlane

CargoLux Airlines
Mattias Pak

Cathay Pacific Airways
Rick Howell

Cello Aviation
Stephen Morris

Charles Taylor Adjusting
David Harvey

CHC Scotia
Mark Brosnan

CityJet
John Kirke

City University London
Cenqiz Turkoglu

Cobham Aviation Services
Scott Carmichael

Coventry University
Dr. Mike Bromfield

Cranfield Safety &
Accident Investigation Centre
Dr. Simon Place

CTC Aviation Services Ltd
Capt. Phillip Woodley

DHL Air
Shayne Broad

Dubai Air Wing
Rory Fagan

Eastern Airways UK Ltd
Ian Smith

easyJet
Capt. Chris Brady

flightdatapeople.com Ltd
Peter Clapp

Flight Data Services Ltd
Capt. Simon Searle

flybe.
Capt. Natalie Bush

Gael Ltd
Peter Cork

GAMA Aviation
Nick Mirehouse

GATCO
Shaneen Benson

Gatwick Airport Ltd
Jerry Barkley

GE Aviation
Mike Rimmer

Gulf Air Co
Capt. Khalil Radhi

Independent Pilots Association
Capt. James West

Irish Aviation Authority
Capt. Dermot McCarthy

Jet2.com
David Thombs

LHR Airports Ltd
Derek Provan

Loganair
Neil Heron

London's Air Ambulance
Dave Rolfe

London City Airport
Gary Hodgetts

Lufthansa Consulting GmbH
Panagiotis Poligenis

Manchester Airport plc
Rory McLoughlin

McLarens Aviation
John Bayley

Monarch Airlines
David Copse

National Police Air Service (NPAS)
David Taylor

Navtech
Harriet Dalby-Quenet

Panasonic Avionics
Bob Jeffrey

Pen Avia
Capt. John O'Connell

PrivatAir
Tom De Neve

RTI
Steve Hull

Rolls-Royce Plc
Phillip O'Dell

RVL Group
Michael Standen

Ryanair
Jim Lynott

Seaflight Aviation Ltd
Dimitris Kolias

Shell Aircraft Intl.
Keith Curtis

Stobart Air
Capt. Clive Martin

Superstructure Group
TBA

TAG Aviation (UK) Ltd
Malcolm Rusby

Teledyne Controls
Mark Collishaw

The Honourable Company of Air Pilots
Capt. Alex Fisher

Thomas Cook Airlines
Terry Spandley

Thomson Airways
Dimuthu Adikari

Titan Airways
Dominic Perrin

UTC Aerospace Systems
Gary Clinton

Vistair
Stuart Mckie-Smith

VLM Airlines
Steve Hull

GROUP MEMBERS

Air Tanker Services Ltd
Dale Grassby
Robert Luxton

MOD Representatives
Col. James Anderson - MAA Deputy Head Analysis & Plan
Wg Cdr Andrew "Errol" Flynn - MAA Engineering Oversight & Assurance
Cdr Ben Franklin - Royal Navy
Lt Col Gavin Spink - Army
Gp Capt Brian James - RAF

QinetiQ
Flt Lt Tim Burgess

QinetiQ Eng.
Rupert Lusty

RAeS
Peter Richards

RAeS Eng.
John Eagles

TAM Brazilian Airlines
Capt. Geraldo Costa de Meneses

TAM Executiva
Capt. Castro

CO-OPTED ADVISERS

AAIB
Capt. Margaret Dean

CAA
Brian Watt - Flight Operations

CHIRP
Air Cdre. Ian Dugmore

GASCo
Mike O'Donoghue

Legal Advisor
Edward Spencer
Holman Fenwick Willan LLP

NATS
Karen Bolton

Royal Met. Society
Robert Lunnon

UK Airprox Board
Air Cdre. Steve Forward