ISSUE 74

focus

ON COMMERCIAL AVIATION SAFETY

SPRING 09

The official publication of the United Kingdom Flight Safety Committee

ISSN 1355-1523


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The Official Publication of THE UNITED KINGDOM FLIGHT SAFETY COMMITTEE ISSN: 1355-1523 SPRING 2009

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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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: Malaysia Airlines B747-400

What should Accountable Managers know about Aviation Safety?

by Rich Jones

Along with others, I was recently invited by the CAA to address a gathering of Airline Executives and Accountable Managers. The aim of the conference was to spend time reviewing the state of aviation safety in the UK and to highlight developments in regulation in Europe. As I approach the end of my first year at the UKFSC, preparation for the conference provided a welcome opportunity to take stock and generate an independent view of the industry.

I have learned a lot about commercial air transport, and much of it is very positive. For a start, the industry is incredibly dynamic, operationally focused and extremely flexible. It is also very responsive to change and adaptable to technology.

But what has the past year taught me as far as commercial aviation safety is concerned? It may be useful at this point to rehearse the sources of information from which I have been able to elicit my views. Our bi-monthly Safety Information Exchange Meetings are important thermometers with which to test the water. Sixty or seventy aviation safety professionals, both for the UK and overseas and from most sectors involved in the industry, regularly share the details of their companies' incidents and accidents in a confidential forum.

In addition, I represent the UKFSC at over 20 national and international safety meetings, through which the Membership are kept informed on safety issues and activities in most sectors across the industry. Briefings and summaries on the outcomes from each of these meetings are routinely posted on the UKFSC website. Through my regular attendance at these meetings, I have come to realise that there is a great deal of excellent and earnest aviation safety work going on – but that there is much duplication of effort and of resources being wasted. There would be much to be gained from better co-ordination and partnership in all safety initiatives by identifying regional centres of excellence, which could take the lead on co-ordinating and distributing safety knowledge and information and directing a more coherent approach; this is the major reason for the UKFSC becoming a partner in the SKYbrary aviation safety website.

Turning now to the accident statistics for the past year, the news, on the face of it, is good. The safety record of UK carriers stands up well in comparison to the worldwide situation, where the number of fatalities attributed to commercial aircraft accidents is down, although the number of accidents involving fatalities is up. But with no fatal accidents involving large public transport aircraft in the UK since 2001, our safety record looks impressive – but this could have been so different. Had the skill and luck of the British Airways 777 crew been any less on 17 January last year, or had the aircraft's approach profile been less forgiving, we could have been discussing a whole new safety situation!

But of equal concern, had the final outcomes from several incidents debated during our past year's Safety Information Exchanges Meetings been just a little less fortunate, we could have been dealing with a much more critical and catastrophic period for UK and European aviation. To my knowledge, an incorrect configuration event - not too dissimilar to the recent Spanair disaster - and several loading and performance calculation errors have put at least four airlines within seconds of serious accidents in the past year!

So, the apparently strong safety record that UK airlines continue to enjoy should not provide any excuse for self congratulation or complacency. Nevertheless, we should be extremely grateful that there is enough of a positive safety culture and willingness amongst our airline community to share the facts and circumstances surrounding these incidents, and thereby give others the invaluable opportunity to learn from these mistakes, rather than repeating them in ignorance!

Having aired some of my concerns about UK aviation safety gleaned from the past year at the UKFSC at the conference, I grasped the opportunity to highlight some of the new responsibilities which the regulatory introduction of SMS now lays at the door of Airline Directors and Accountable Managers. In the highly political, litigious and media-rich world in which today's airlines must operate, where the latest corporate manslaughter legislation awaits its day in court and where the buck can no longer be passed into the sole charge of safety and quality people, what is it that an Airline Board Director and the Accountable Manager need to know about the safety and risk management of their business. I suggest the following questions should be foremost in their mind:

- What could go wrong?
- What will stop it happening in their organisation – either today or tomorrow?
- What other things should and could be done?
- Is the company striving for continuous improvement ?

In response, the following strategy is offered for consideration:

Own and promote your company's safety policy and get it understood throughout the company.

Make sure your company's safety organisation is well trained, respected and influential at Board level and right across the company.

Develop a just safety culture which permeates the entire organisation.

Build a Safety Management System which encourages non-punitive reporting of all events and incidents - from which lessons can be learnt, hazards identified and risks managed effectively.

Integrate Safety Management into your business plan and give it the same attention as all other business risks.

Establish safety assurance arrangements which ensure that Flight Ops, Training, Engineering and Support Services communicate and co-ordinate with the Safety Department effectively.

Not learning the lessons can be hard and very expensive – if not business threatening!

Sharing Data, Keeping Safer

by Steve Hull, Baines Simmons

Often safety within aviation can come back and haunt you particularly after an accident. This normally results in you saying under your breath, or you hear others saying either "I knew that would happen" or "it was just a matter of time." Why? Well as I write this column the US Airways A340 that crash landed on the Hudson River is still major news and quite rightly so. It would be inappropriate of me to pre-empt the investigation, albeit to say that both the flight and cabin crew appear to have done a fantastic job.

Let me explain. During my airline career I was called "the Birdman of BA" and have spent the last 15 years trying to highlight the hazard that exists within the industry. So I believed in the inevitability of losing a passenger aircraft to a serious bird strike.

My bird strike involvement started after I noticed BA was experiencing a high number of bird strike events when operating in and out of Entebbe, Uganda. BA operated three times a week using a DC-10 aircraft and were suffering a bird strike every other arrival or departure. As a result I did what every safety manager should do and highlighted what I perceived to be a hazard. It then took me three months and several heated exchanges to get the hazard raised to a senior level. This included a visit to the airfield and meetings with the Airfield Operator and also the Ugandan Government. As a result of this minor victory, I began a crusade against our feathered friends and those that have heard me speak at bird strike conferences will know the passion I have on the subject.

So why do I believe for instance "it was just a matter of time?"

Let me further explain. Most airlines gather safety data through air safety reports or a similar medium and included in that data is bird strikes and near strikes. Airfield operators also collect information on bird strikes that occur at their airport. We all know the importance of safety data sharing, well we do within the UKFSC, but that cannot be said about our colleagues.

If safety data sharing is effective, then any serious aircraft incident or accident is a tragedy that should be shared by all, as the information that could have prevented the event would have been known to someone. This can be testified as immediately after the La Guardia event, I was reliably informed by one major airline, that La Guardia was the No.2 airport on their bird strike hazard list. Don't tell me, tell La Guardia, let your own airline know and then all airlines that operate into that airport.

So the sharing of data is still in its infancy and as we know three major US airlines have stopped their Aviation Safety Action Plan (ASAP) programmes altogether. This results in an increase in the risk of airlines experiencing events that may have occurred before. How can this be allowed to happen? The sharing of safety data is the only tool that can effectively prevent a repetition of an event, for airlines and airport authorities not to share this information is nothing short of criminal. As Bill Voss – CEO FSF, quite rightly stated 'safety should not be used as a bargaining tool,' I would go further and state that 'safety is not a commodity that should be used for commercial advantage.'

Those airlines that have scrapped their reporting programme must sit down with their pilots, engineers and ground workers and need to get together and thrash out an MOU (Memorandum of Understanding) with regard to the reporting of safety incidents. Most other international airlines have achieved this, so we are not talking about the impossible.

So where are we, well the world now knows that birds are a hazard to aviation and steps must be taken to reduce that hazard to an acceptable level, but once again it takes a hull loss to hammer that point home. Airport Operators must be responsible and accountable for what occurs on and around their airfield, airlines must ensure that the airports they operate to, maintain the highest bird strike awareness and avoidance programme. If they do not, then they must take steps to ensure they do, as it is the Airport Operators responsibility to ensure that their airfield is safe for aircraft to land at and take off from. There is no doubt that New York and New Jersey Port Authority are looking at their present procedures closely. They should do and they should hope they did everything possible to prevent the accident, as once the legal eagles get hold of it, they will have wished they had.

UK FLIGHT SAFETY COMMITTEE OBJECTIVES

- **To pursue the highest standards of aviation safety.**
- **To constitute a body of experienced aviation flight safety personnel available for consultation.**
- **To facilitate the free exchange of aviation safety data.**
- **To maintain an appropriate liaison with other bodies concerned with aviation safety.**
- **To provide assistance to operators establishing and maintaining a flight safety organisation.**

Don't eat into your margins – How to cope with wet runways and hydroplaning

An article from JETSETS – the flight safety news for BAE Systems Regional Aircraft customers

In 2005 an Embraer 145 overshot runway 27L at Hanover Airport. According to the German Federal Bureau of Aircraft Accident Investigation Report EX006-0/05 which can be read in full on their web site (http://www.bfuweb.de):

The weather forecast indicated thunderstorms and heavy showers of rain. The initial ATIS indicated a wind of 150/5 kt and a visibility of 8 km in light rain.

The weather deteriorated during the approach, and at the time of landing the wind was 100/5 kt (a 3 kt tailwind) with a visibility of 2000 m in heavy rain. The runway was wet and showed patches of standing water. Approximately 15 minutes after the occurrence the braking coefficients for the first third of the runway were between 0.4 and 0.7 and for the remainder of the runway were between 0.6 and 0.7 (good); however, it had stopped raining by this time, and so these coefficients were not considered by the Investigation to be relevant to the accident.

A Boeing 737 that landed prior to the Embraer subsequently reported to the Investigation that the braking action was medium – but this was not reported at the time to ATC. According to crew statements the aircraft crossed the threshold at 140 kt (Vref 131 kt) and touched down in the touchdown zone. The FDR showed a threshold crossing height of 62 feet as as opposed to the correct 50 feet. The crew did not experience any significant deceleration of the aircraft even though the ground spoilers had automatically deployed after touchdown.

Both pilots attempted to brake, and shortly before the aircraft overshot the runway the pilot in command activated the parking brake which is also the emergency brake. This resulted in deactivation of the anti-skid system, the wheels locked up and the ground spoilers retracted (because the wheels had locked). The aircraft came to a rest about 160m beyond the end of the runway, and suffered only minor damage.

Eyewitnesses stated that the aircraft touched down about 1000 m after the threshold, and this was later refined from FDR data to 849m.

Above: wet runways can affect braking

All four tyres showed traces of rubber reversion hydroplaning (Figure 1), and had left about 400m long bright traces on the runway which were definitely caused by rubber reversion hydroplaning (runway marks left following rubber reversion hydroplaning look like they might originate from steam blasting (Figure 2)).

Furthermore, melted away rubber was found on the runway (Figure 3).

The Investigation concluded that based on the slow deceleration after touchdown it was highly likely that dynamic aquaplaning occurred in the middle portion of the runway followed by rubber reversion hydroplaning which occurred when the emergency brake was activated, the anti-skid deactivated and the tyres locked.

The aircraft technical log did not show any irregularities regarding the brakes or tyres, and the tyres were inflated correctly.

The worst case RLW calculation, which the Investigation thought most likely to apply to this landing, gave a stopping distance with 150m runway remaining – there was a longer runway available but the crew chose 27L because of construction work on a taxiway and the shorter distance to the terminal.

Lessons that can be learnt

I would like to use this incident to illustrate 2 lessons: firstly the factors leading to an overrun, and secondly to discuss hydroplaning.

Left: Figure 1 – marks of rubber reversion hydroplaning on the tyre.

Lesson 1 – The overrun

The last issue of JETSETS also covered overruns and we found that all overruns had more than one contributory factor. From my reading of the report this overrun is no different in that there were several factors as listed below:

1. **Landed slightly long**. The ideal touchdown point is 300 m from the threshold - in this instance the touchdown was at 849 m. This shortened the LDA.

Above Left: *Figure 2 – marks of hydroplaning on the runway.* ***Above Right:*** *Figure 3 – Rubber dumped from tyre.*

2. **Landed slightly fast** - but only by a few knots.

3. **Runway condition**. The runway was wet, or even flooded, but it is not clear whether the crew were aware of this. The crew were notinformed of the runway condition by ATC.

4. **Wind**. There was a slight tailwind.

5. **Incorrect braking technique**. The Aircraft Operation Manual Part B included: When hydroplaning occurs, it causes a substantial loss of tire friction and wheel spin-up may not occur.

   - The approach must be flown with the target of minimising the landing distance.
   - The approach must be stabilized, and landing on centre line in the touchdown zone.
   - The touchdown should be firm to penetrate the contaminating fluid film, and ensure wheel spin-up and spoiler activation.
   - Immediately after touchdown, check the ground spoiler automatic deployment when thrust levers are reduced to IDLE.
   - Lower the nose wheel positively, with forward pressure to assist traction and directional stability.
   - **Apply brakes with moderate-to-firm pressure, smoothly and symmetrically, and let the anti-skid do its job.**
   - **If no braking action is felt, hydroplaning is probably occurring. Do not apply Emergency/Parking brake, as it will cause the spoilers to close and cut the anti-skid protection. Maintain runway centre line and keep braking until airplane is decelerated.**

The crew do not appear to have followed some of the above advice. BAE Systems have received reports of incidents occuring to BAe 146/ Avro RJ aircraft where the anti-skid system was not given a chance to adapt to the conditions because yellow, green and then emergency yellow were selected in quick succession. This does not allow the adaptive feature of the anti-skid to operate correctly. You should note from the above that locked wheels provide very little stopping assistance!

As can be seen, there were at least five contributing factors. This incident may have been inevitable because the LDR following the long touchdown might have been insufficient, but if the other factors had not been present it is possible that an overrun would not have occurred. As stated at the end of the JETSETS article in the previous issue dated February 2008:

Above: *an Embraer 145 similar to the aircraft that suffered a runway overshoot*

Don't eat into your margins, and if in doubt go around.

Lesson 2 – Hydroplaning

The other lesson from this accident has to do with hydroplaning. Control of your aircraft on the ground depends on the contact between the tyres and the surface, and on the friction provided by that surface. Whilst the above accident highlighted the braking problems caused by hydroplaning, directional control can be equally affected, especially in strong crosswinds before the rudder becomes fully effective. As a tyre rolls along the runway it is constantly squeezing water from the tread. This squeezing action generates pressure within the water that can lift part of the tyre off the runway and reduce the amount of friction that the tyre can develop. This squeezing action is called hydroplaning. Please note that icy runways are a totally separate issue.

Three basic modes of hydroplaning have been identified: dynamic, viscous and reverted rubber.

Dynamic hydroplaning, which is also called aquaplaning, is related to speed and tyre pressure. High speed and low tyre pressure are the worst combination, giving the lowest aquaplaning speeds. During total dynamic hydroplaning the tyre lifts off the surface and rides on a wedge of water like a water ski.

You have probably experienced this when driving through large puddles on the road, and felt the steering lighten. Dynamic hydroplaning will occur at speeds above 9 times the square root of your tyre pressure (in pounds per square inch). For instance the 146/RJ with tyres at 155 psi would hydroplane at speeds above 112 kt, the ATP (86 psi) above 84 kt, and the Jetstream 41 (100 psi) above 90 kt When dynamic hydroplaning occurs it may lift the wheel off the runway and prevent spin up or, if anti-skid is not being used, cause the wheel to stop spinning. Once started the hydroplaning could continue to much lower speeds.

Viscous hydroplaning occurs on all wet runways and describes the normal slipperiness or lubricating action of the water. Viscous hydroplaning reduces the friction, but not to such an extent the spin up on touch down is prevented. The most positive way to prevent viscous hydroplaning is to provide texture to the surface – hence grooved runways.

Above: wet runways contamination can cause hydroplanning

Reverted rubber hydroplaning is similar to viscous hydroplaning in that it occurs with a thin film of water and a smooth runway surface. It often follows dynamic or viscous hydroplaning where the wheels are locked. The locked wheel creates enough heat to vaporise the underlying water film thus forming a cushion of steam that eliminates tyre to surface contact, and begins to revert the rubber, on a portion of the tyre, back to its uncured state. Once started, reverted rubber hydroplaning will persist down to very low speeds – virtually until the aircraft comes to a stop. During the skid there is no steering ability. Indications of reverted rubber hydroplaning are distinctive white marks on the runway, and a patch of reverted rubber similar to the uncured state on the tyre. It is also likely that melted away rubber will be found on the runway.

The increase in stopping distance as a result of hydroplaning is impossible to predict accurately, but it has been estimated to increase it by as much as 700%. The reduced braking action on a wet runway may prevent the aircraft from decelerating normally with the anti-skid system operational. But the anti-skid system will provide optimum braking – switching it off will most likely lead to wheel lock up and burst tyres.

Conclusion

I hope that this article has provided some food for thought. Our northern winter will soon be here with wet weather and we will be faced with conditions similar, and worse to those described above. Of course other areas in the world suffer similar conditions in monsoons and heavy rain. I can do no better than reiterate the advice given in the previous issue:

- A good landing starts with a good approach.
- Think before accepting a downwind component.
- Land in the right place at the right speed.
- If in doubt go around.
- Trust the systems and brake for effect, not comfort.

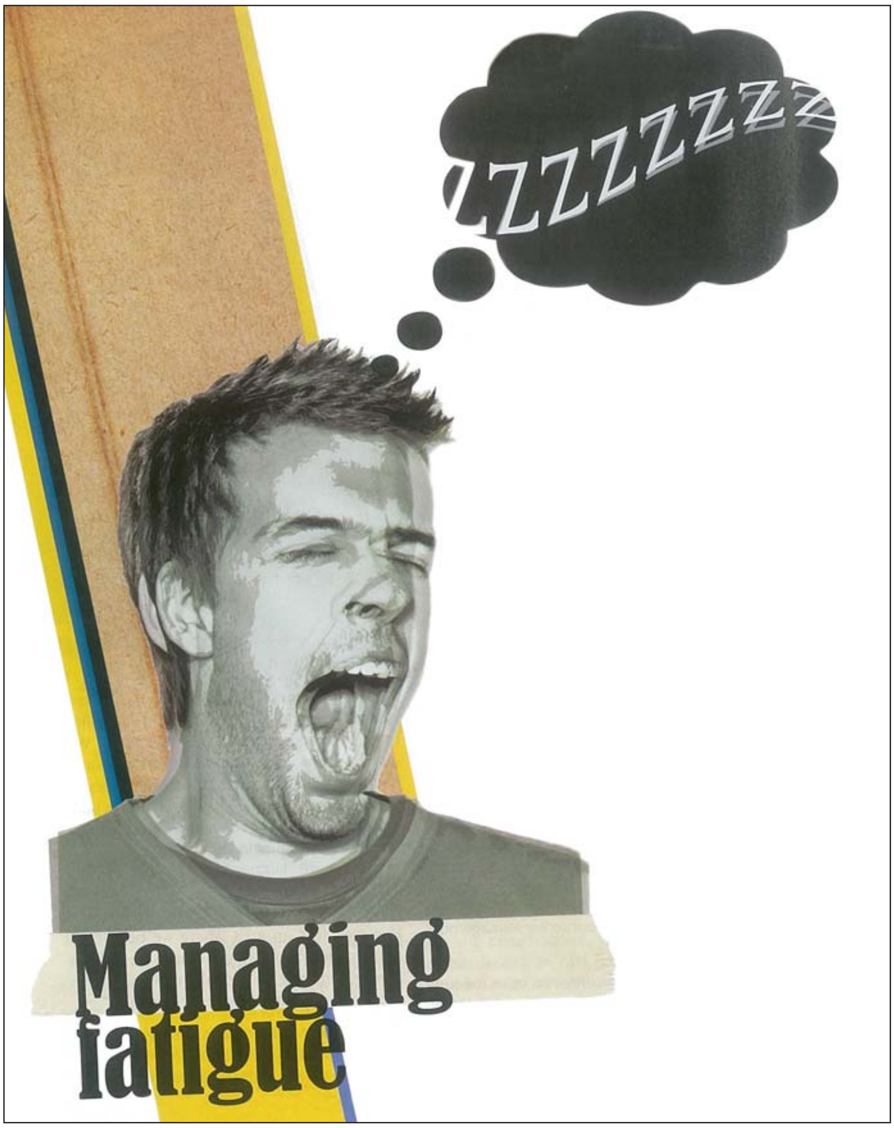
Don't eat into your margins

This article is reprinted from JETSETS Magazine with kind permission of BAE Systems Regional Aircraft.

Airline Fatigue Risk Management: purpose and benefits

by Simon Stewart and Derek Brown, easyJet

This article outlines the background for the establishment of a Fatigue Risk Management System (FRMS) in an airline. An FRMS was developed to enable fatigue risk to be managed in an evidence-based, dynamic and comprehensive manner. The purpose of the FRMS is to ensure that employees (initially flight crew, then cabin crew, ground operations, engineering and remaining employees) are sufficiently alert so that they can operate to a satisfactory level of performance and safety. The FRMS is based on scientific principles, including methods for data collection and analysis. Among other benefits, the system enables easyJet to monitor and understand the relationship between rostering, operational variables and crew fatigue and workload and to identify where controls need to be implemented or strengthened.



easyJet has attained significant market share within the competitive air transport industry through being dynamic, innovative and attaining maximum aircraft and crew utilisation. The airlines' success depends on the training, professionalism, and health of flight-crew to deliver a safe standard of operation for their customer base. Intensive short-haul flight schedules are a necessary element of Low Cost Carrier (LCC) operations to ensure profit margins and reflect specific challenges for safety management with regard to human factors considerations and crew fatigue alleviation. Regulatory differences across the EU and scheduling practices reflecting high duty hours, incorporating multiple sector duty days and minimum crew rest, have been proposed as contributing factors for crew fatigue (Rosekind et al, 1997; Goode, 2003; Caldwell, 2004). Current research suggests that there is a relationship between crew fatigue and an increased risk of incidents and accidents (Batelle Memorial Report, 1998). However, fatigue is a controversial issue that remains difficult to quantify within an airline operational environment. The Civil Aviation Authority (CAA) introduced the first comprehensive regulation in the form of an advisory document CAP 371 (The Avoidance of Fatigue in Aircrews) based on the provisions of the Bader report (1973). The fourth edition of this document was released in January 2004 however the guidance limits given by Hours of Service frameworks are largely unsupported by scientific field based research (Dawson & McCulloch, 2005; Cabon et al, 2002). The purpose of regulations, as proposed by the EU through the European Aviation Safety Agency (EASA) and Civil Aviation Authority (CAA), is to provide a fatigue-alleviating framework (Flight Time Limitations, FTL) for airlines. These FTL guidelines (Civil Aeronautical Publication, CAP 371) allow an airline rostering department to conduct rostering practices that minimise flight-crew operational fatigue. Current regulations have been principally designed around long-haul commercial flight operations and don't reflect the high aircraft and crew utilisation practices that reflect LCC operations (BALPA log, 2004; IATA Research Study, 2001).

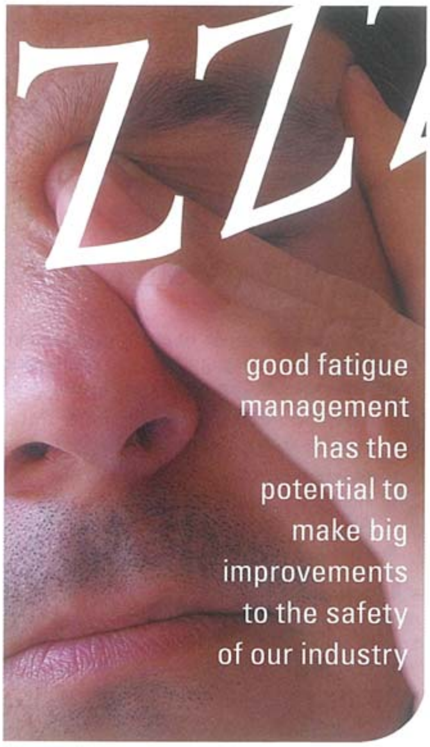
The IATA Research Study (2001) cited that crew fatigue may be affected by the following contributing factors:

"Increased flying hours;
Unsympathetic rostering practices; and
Absence of adequate JAA/EU rules on FTL.

The above factors in turn may be influenced by:
Shortage of experienced pilots;
High utilisation rates of crews; and
Lack of operations/ administration support.

These factors will be in turn influenced by:
The company organisational or corporate culture; and
The crew professional culture"

This review shows that fatigue within an airline must be managed at many levels and that detection capability for fatigue risk requires a proactive element and not simply focusing on active failures and retrospective investigation of



events. Within events the capability must extend to the ability to determine and evidence fatigue's influence on safe operation as a root cause or contributory factor.

The ICAO Fatigue Risk Management subgroup comprising leading fatigue research academics from across the industry cite a definition of fatigue as:

'A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness and/or physical activity that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety related duties' (ICAO FRMS sub group 2007 and EASA Draft regulations EASA Ops AMC 1 to MS.OPS.8.205(a)-2008).

This definition states that fatigue risk precursors (mental, physiological and emotional) interact with operational process to manifest fatigue performance decrements. Such performance changes need to be detected and assessed (safety reports, surveys, domain sleep deprivation studies, observational field studies) as operational risk and reported and managed to maintain an acceptable safe level of operation. Fatigue management requires both proactive and reactive capability within the risk management process. This definition of fatigue is used as the template for design of a Fatigue Risk Management System at easyJet. The next step is to evolve this relational framework into a process that can represent fatigue as a risk within a social-technical system such as an airline. The first step is to review the literature and summarise the use of controls, causes and consequences of fatigue.

Fatigue Risk Management at easyJet

In 2006 easyJet became the first European airline to implement an FRMS. The key benefit of managing fatigue risk is obviously the prevention of accidents, however it is simplistic to view fatigue risk management as merely a safety initiative. It is in the commercial interests of managers to understand the nature of fatigue risk and recognising this easyJet have incorporated the FRMS into their core business model. Knowing operational risk exposure enables managers to ensure that the short-term profitability is simultaneously considered with brand protection in mind.

easyJet have also implemented the FRMS in preparation for the ICAO SMS legislation that is due to become effective from January 2009. ICAO will require airlines to implement a continuous safety monitoring program with management accountability for operational risk. In a similar vein, in the EU the strengthening of the European Aviation Safety Agency (EASA) means that national regulatory bodies will have less oversight in the future and airlines will need to implement internal governance, or in other words risk awareness and ownership and a strong internal audit process (Hampton Report, 2005). In the UK, the CAA is already under pressure to cut resources and place more emphasis on internal self governance. Furthermore, corporate manslaughter legislation that becomes effective in the UK (2008), states that being unaware of a risk does not mean that managers are not accountable.

Insurers and underwriters are also promoting the application of proactive risk management strategies that demonstrate safety awareness and capability (Airline Business Risk Management Survey, 2007). They seek what distinguishes a company from regulatory baselines such as corporate management systems and enterprise risk management processes and will link airline premiums against risk signature (AeroSafety world, 2007).

easyJet FRMS Purpose

To maintain an acceptable level of safety, through the application of scientific principles based on human physiology and knowledge, determined from data collection, risk investigation and analysis. In doing so it allows greater operational flexibility of crew scheduling, in comparison with prescriptive limitations of flight and duty time. The FRMS forms an integral part of easyJet's established Safety Management System (SMS).

Fatigue Risk Management applies standard management control principles in order to mitigate fatigue risk in airline operations, through processes based on shared responsibility amongst management and crew members acting within a just culture.

Functioning

The objective of the FRMS team is to facilitate the airline's commercial success through enhanced productivity, delivered within a risk-controlled environment. The FRMS team also add financial value to the company, based on achieving a lowered risk profile, evidenced through a significant reduction of insurance premiums; together with lower levels of crew attrition and sickness costs through maintaining sustainable rostering practices, whilst minimising the risk of serious incidents.

In such a complex operating environment focussing on simple compliance with FTL requirements (i.e. 900 hours productivity per year) cannot be justified or assumed to provide adequate legal protection against safety risks for the easyJet business model as we have demonstrated through our previous experience. Operators are responsible and are accountable for their own risk with the overall requirement of achieving a level of risk as low as reasonably practicable.

The high levels of crew utilisation now being achieved has led to concerns that the degree of protection against fatigue offered by basic compliance with those quantitative FTL provisions specified in CAP 371 Annex A is no longer sufficient for larger companies.
CAA Draft FODCOM 2008

The FRMS team must establish a full and robust safety case, supported by scientific research, incident investigations, metrics, and reporting in order to identify risk,†prior to implementing each and every roster constraint to the business.

After identifying the risk, that safety case is put before the FRMS SAG made up of the relevant post-holders. It is these post-holders who own the risk and it is they who make the decision - not the FRMS team - to implement mitigating strategies in the form of roster constraints in order to maintain an acceptable level of safety.

Although a fully fledged FRMS is neither a cheap nor an easy option, it provides a systematic and objective process of managing fatigue risk and can add significant value to the business model. For this to happen it needs to be firmly embedded in the operational philosophy of the operator, have the full support and the visibility of the most senior management in the company, and will work only if it is continually nurtured through a 'just and open' culture.

The FRMS does not represent a 'bolt on' compliance system that acts a barrier to commercial viability. It represents operational flexibility and opportunity. It facilitates optimal performance and protection within evidenced safety criteria in pursuit of commercial opportunity.

In doing so it satisfies the corporate philosophy enshrined in the 5 values of easyJet - Safety, Teamwork, Pioneering, Passionate and Integrity.

The benefits of FRMS to easyJet

The benefits of managing fatigue like any other risk i.e. within a SMS are significant. Reasons for investing in an FRMS include not only avoiding pitfalls of FTL:

1) *Knowledge of fatigue risk exposure is a fundamental element of business model* - FRMS gives you measures of risk exposure. It is in the commercial interests of operators to understand the nature of fatigue risk and manage it effectively for continued safe operation and viability in the commercial environment. safety links to commercial via brand protection.

- Reduction in frequency of medium and high risk events
- Reduction in oversight from the regulating authority
- Reduction in attrition
- Reduction in Fatigue lost duty days and sickness incidence due fatigue related factors
- Increased crew morale and CRM performance

The quantification of the benefits a reduction in fatigue associated with altered work schedules has been demonstrated in the nuclear industry by Fleishman et al (2006) with the following benefits:

- Reduction in frequency of severe accidents
- Reduction in plant shutdown risk
- Improved security
- Reduction in frequency of lost and restricted work cases

2) *New ICAO SMS legislation* becoming effective from January (2009) requires airlines to implement a continuous safety monitoring program with management accountability of operational risk. EASA means that the CAA will have less oversight and airlines need internal governance (risk ownership), Within the EU, with the incremental transference of authority and responsibility to EASA, the CAA is under tremendous pressure to cut resource with more emphasis (and reliance) being placed on a strong internal company audit process (internal governance). An internal governance program based on accountability, transparency, predictability and participation (Gardiner, 2005) supports continuous oversight of operational risk by the Authority and allows them to focus regulatory resource against audit risk areas, maximising benefit to the business model.

3) *Risk signature*. Insurers and underwriters are seeking the application of proactive risk management strategies that demonstrate safety awareness and capability through mitigation of the risks of incidents & accidents against easyJet airline peers in the industry (Airline Business Risk Management Survey, 2007). They seek what distinguishes a company from regulatory baselines such as corporate management systems and enterprise risk management processes and will link the decrease in airline premiums commensurate with risk profile (Underwriter perspective-AeroSafety world, 2007).

4) *Corporate liability*. The message from the regulators is clear: legal duty hour limits do not necessarily ensure safety and risk ownership and accountability lie squarely on the shoulders of the operator (CAA presentation Crew Management Conference, Brussels 2007). Corporate Manslaughter legislation (effective UK Ministry of Justice, 2008) informs us that not knowing or being unaware of the risk does not mean that you are not accountable.

Unless the FRMS system is provided with accurate and timely information regarding the system state (that can be processed and assimilated into a fatigue risk format for analysis) the program will at worst be ineffectual (box ticking exercise) and at best provide senior management with an inaccurate system overview of a key risk indicator on which operational decisions are based. These decisions may directly impinge on system fatigue risk. Furthermore, the information sources for the FRMS system should be dynamic, in-effect 'real-time' so that a fatigue risk model can be developed, that provides a platform from which system projections on performance can be made. This allows the system to be employed proactively, to provide senior management with an accurate state of operational fatigue risk. The FRMS then forms part of the company commercial business plan that accounts for fatigue risk to maintain operational integrity during projected expansion activities. The FRMS system must encompass an accurate assessment of network fatigue tolerance levels combined with work-related fatigue determined from hours and patterns of work.

Battling Level Busts

by Peter Riley,

NATS tracks down why business jets figure prominently in altitude deviation in UK airspace.

Departing from your cleared flight level is never a good idea, especially in Europe's crowded skies, where a level bust could lead to a loss of separation with another aircraft. Business aviation, which accounts for about seven percent of flights in the United Kingdom, was responsible for almost 20 percent of the level busts recorded in that air space, and five of the eight most serious losses of separation following a level bust.

Between January and September 2008 in the airspace in which NATS, the U.K. air navigation service provider, provides the air traffic control (ATC) service, there were 356 incidents involving business jet aircraft. Fourteen of these incidents were within the higher risk category and involved a loss of separation, mainly due to level busts.

Responding to this trend, NATS has looked more closely at the specific issues posed by business aviation with regards to level busts.

As part of its efforts to reduce the number and severity of level bust events, the NATS Level Bust Workstream, a working group of representatives from across the company, has become increasingly concerned about the prominence of business aviation aircraft, in particular non-U.K. registered, non-commercial operators, in the statistics. Of concern not only are the numbers but the severity of the busts; business jets caused 5 of the 8 most serious losses of separation resulting from level busts in the 6-month period that ended in June, 2008 (see Table 1).

The NATS Level Bust Workstream determined that the evidence of a problem is compelling. Going back to January, 2007, the business aviation community accounted for 10 out of the 19 most serious level busts recorded, 52% of the number of serious bust events. Eight of those ten events involved non-U.K.-registered aircraft. Given this disproportionate involvement in the higher severity events, it is clear there was a need to focus effort on working in partnership with the business aviation community.

NATS believes that there are many reasons for the unwelcome prominence of corporate jets in the level bust event data. The nature of business flying is such that crews often find themselves flying into airports and associated airspace for the first time. As infrequent visitors, a lack of familiarity with some of the more challenging procedures in U.K. airspace is probably a major factor. Among these challenging procedures are step-climb standard instrument departures (SID), a feature at many of the London region's outer airports, where business aircraft are frequent visitors.

There have been many instances recorded, and not only among the business aviation community, of crews "falling up the stairs" on a stepped profile. For business aviation, if the aircraft is flown by a single pilot, or if the crew is distracted from briefing the profile correctly – perhaps by having to perform functions carried out by other staff such as cabin crew on the airlines – the possibility of an incorrect or incomplete brief is increased. Throw into the mix the fact that many of the business aviation crews may not have the level of flight operations support available to airline crews, and the very high performance of the aircraft that are being flown, especially in the climb, and the reasons behind the prominence of corporate jet aircraft in the data become more obvious.

NATS has made great efforts to reduce the level bust threat, having introduced Mode S radars that display each aircraft's selected flight level (SFL) on the radar workstations within the Manchester Area Control Centre and in the London Terminal Control Operations Room at Swanwick Centre. Although this has had a very positive effect on reducing level busts, with controllers now able to see the flight level dialled into the mode control panel/flight control unit (MCP/FCU) by pilots following an instruction to climb or descend, it has not been the complete solution.

For example, the displayed SFL will not take into account any altimeter setting error made by the pilot. This is a common causal factor of level busts in the U.K., where the transition altitude to change altimeter settings from local pressure readings (QNH) to 1013.2mb (29.92 inches) is 6,000 ft in controlled airspace and 3,000 ft outside it.

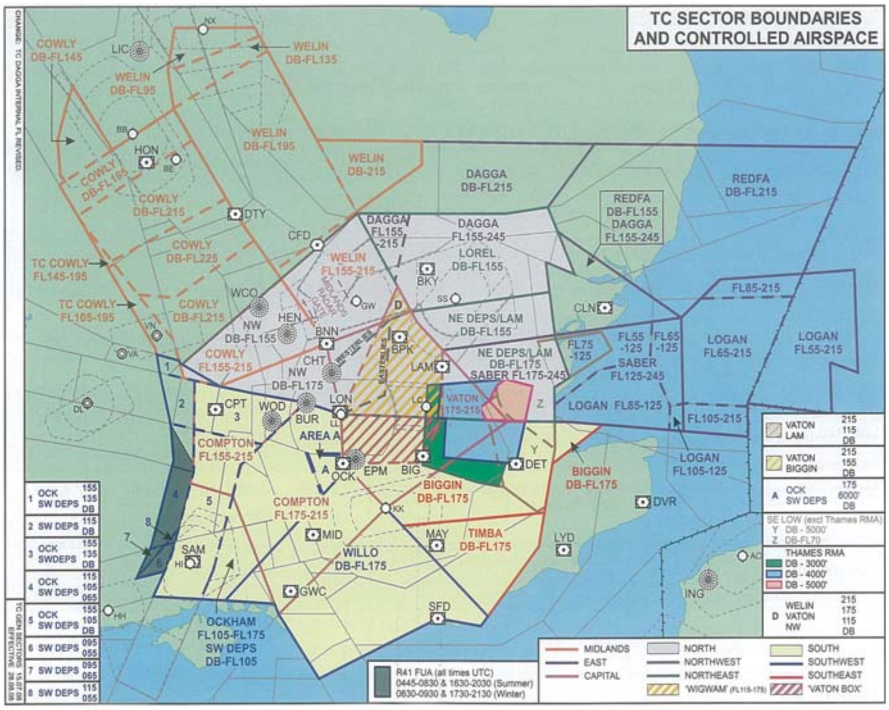
It is appreciated that particular standard operating procedures (SOP) are chosen to

SERIOUS LEVEL BUST EVENTS (Safety Significant Events 1-3) in airspace in which NATS provided a service – 01 Jan 08 – 30 Jun 08		
Date and Aircraft	**Summary**	**Primary Causal Factors**
14/01/2008 AVANT FA10	The FA10 descended below its cleared level and came into confliction with a B738 which was under the control of a different sector. Slow TCAS response was to 'maintain passenger comfort'.	Incorrect response to TCAS Rate of turn/climb/descent
07/03/2008 BPK F2TH	The F2TH was instructed to climb to FL140 but climbed to FL144 and into conflict with other traffic. The F2TH had a very high rate of climb and may have mis-interpreted a TCAS RA.	Incorrect response to TCAS Rate of turn/climb/descent
10/03/2008 DET FA50	An FA50 was instructed to climb FL120, and approaching FL110 was given traffic information on an aircraft 1000ft above. The FA50 climbed to FL127.	Incomplete readback by correct aircraft Not Heard
11/03/2008 LAM F50	On departure the F50 was instructed to climb to FL80. The aircraft was later observed at FL87. This level bust was as a result of the pilot climbing on the QNH.	Altimeter setting error Not seen
01/04/2008 BPK C560	An inbound aircraft was descended to FL120. An outbound C560 was climbed to FL110. Both aircraft approached BPK at the same time. The C560 was observed climbing to FL117 - before descending again. The inbound aircraft received a TCAS RA.	Incorrect response to TCAS Poor manual handling
11/04/2008 BKY LJ45	An LJ45 was instructed to climb to FL80 against traffic descending to FL90. The descending traffic reported a TCAS Climb. The LJ45 reported that it had also received a TCAS Climb. It had climbed at 2500fpm with less than 1000ft to go.	Incorrect response to TCAS Responded to TCAS/GPWS
26/05/2008 HON B733	On climb out the student pilot exceeded the cleared level by 600ft before the training captain could intervene.	Correct pilot readback followed by incorrect action Pilot under training
03/06/2008 ABBOT B738	Traffic in the hold was descended to FL 70. The readback from the pilot was garbled by another inbound aircraft. The cleared levels were not clarified by controller and an incorrect callsign descended to FL70, losing separation.	Pilot readback by incorrect aircraft Not Heard
Reporting period Jan. 1, 2008–June 30, 2008. Source: NATS		

enhance operational effectiveness according to the nature of the operation. However, where a pilot has programmed a step climb profile into the flight management system (FMS), unless there is an additional SOP to set the profile restrictions in the MCP, there can be a disparity between the aircraft's SFL and the programmed SID, which can cause increased controller workload as they try to ascertain whether or not there is a level bust developing.

While there is little possibility that step-climb SIDs will be eliminated in the short term, avoidance of this procedure now is enshrined as a basic design principle for all future NATS airspace changes. In the interim, there have been some successful mitigation measures applied at some NATS units; for example, providing with the departure clearance an explicit warning of the existence of a step-climb SID.

While helpful, Mode S SFL capabilities may create new hazards, data is beginning to indicate: When the SFL displays the correct level to which an aircraft is cleared, controllers have a level of confidence in the crew's correct handling of the climb or descent that



Above: London's complex airspace can trip up infrequent visitors may turn out to be misplaced if the pilots do not adhere to sound airmanship principles of reducing the rate of climb or descent approaching the assigned level.

Further, a high rate of climb or descent can trigger a traffic alert and collision avoidance system (TCAS) warning on one or more aircraft under these circumstances, and the resolution advisory (RA) often is to continue the ongoing climb or descent. When this occurs, the SFL indication quickly becomes meaningless, and a situation the controller had every reason to believe was under control can quickly become a level bust. This is one of the reasons an "incorrect response to TCAS" might be attributed to a level bust, even though the actual response to the RA may have been correct.

In fact, an incorrect response to TCAS is recorded in half the level bust events.

Analyses of TCAS-related events by the NATS TCAS Working Group have found three major contributory factors. The most numerous by far were aircraft with high rates of climb or descent approaching the cleared level; around 75 percent of recorded TCAS events involve aircraft cleared to vertically separated levels generating 'nuisance' TCAS RA manoeuvres. Incorrect responses to TCAS RAs were less frequent, but often had far more serious consequences.

The causes behind an incorrect TCAS response varied. In some, crews reported choosing not to follow the RA to maintain passenger comfort or because they had visually acquired the other aircraft in the encounter. A more common cause was misinterpreting an RA, in particular misunderstanding an "adjust vertical speed" RA, an instruction to reduce the rate of climb or descent.

A normal TCAS response also can cause pilots to fail to maintain their ATC-cleared level when correctly following an RA; for example, an aircraft is climbed to a level with 1000 ft standard separation below another aircraft and receives an "adjust vertical speed" RA. While staying within the green arc of the TCAS climb/descent guidance, the aircraft can level at 600' beneath the traffic, preventing a collision but eroding standard ATC separation.

The increased risk of non-response, late response or incorrect response to TCAS – as well as possible pilot slow reporting of a deviation in response to a TCAS RA – are some of the many issues that have been identified as being more common in single-pilot operations. The introduction of Very Light Jets (VLJs), particularly when operating with one pilot, complicates this picture. Although low performance VLJs are likely to be treated from a controlling perspective much the same way as current turboprops, mid performance VLJs will have higher cruising levels combined with slower speeds than other aircraft at those levels. This is likely to add to controller workload, and, given the evidence of incorrect response to TCAS already identified, NATS will need to monitor closely the level bust performance of single pilot aircraft.

For NATS, having identified the level bust trend in the business aviation sector, the greatest challenge is to reach the correct audience with its mitigations. NATS has a very successful safety partnership agreement with many commercial operators in which it exchanges data and discusses issues in an open and frank forum. It also provides on a quarterly basis specific data on level bust performance to nearly 50 operators, including some business jet fleet operators such as Netjets.

However, for the business aviation community beyond the U.K. Air Operator's Certificate-holder sector, it has proven very difficult to reach the crews in an effective way. Small operators are too numerous, transitory, dispersed and infrequent U.K. airspace visitors to develop the longer-term relationship necessary to bring down level bust numbers. NATS has worked to develop ties with trade associations and simulator service providers, and has taken advantage of relationships with local handling agents to provide publicity and awareness initiatives. Ultimately, however, these strategies do not address the fundamental issue of directly engaging the target audience.

AVOIDING LEVEL BUSTS

NATS has identified that there are a number of things that aircrew, especially business aviation crews, can do to minimise their chances of being involved in a level bust:

Crew Preparation

- Ensure departure and arrival briefs are complete and include Transition Altitude (low in the UK), first stop altitudes on stepped-climb SIDs and the impact of low QNHs when transitioning from altitudes to flight levels (FL) and vice versa.
- Understand the profile, brief the profile, fly the profile. Do not "fall up the stairs" on stepped climbs. Carry out a specific review of the SID to be flown with both pilots participating.

Communications

- Both pilots should wear headsets, monitor the frequencies and listen to the clearance.
- Use standard phraseology and avoid unnecessary radio chatter. When not sure, do not repeat clearances as a question; ask ATC to say again.
- When changing radio frequency, listen after the change before transmitting; be alert for similar call signs on your frequency; if you hear a readback error, let ATC know.
- Beware of confusing heading and level numbers; do not confuse 2s and 3s — e.g. FL230 / FL330; beware of a non-existent first digit, e.g. FL90 not FL190.
- On first contact, always pass to ATC your current cleared level.

Operational good habits

- One pilot programs the FMS, another checks it; crosscheck every MCP/FCU change, visually and verbally; crosscheck altimeter settings.
- Apply CRM skills, e.g. pilot monitoring standard call for altimeter setting on passing a set flight level; call out altitudes passing and feet to go approaching the level off.
- Avoid high rates of climb or descent approaching the level-off point to prevent unnecessary TCAS alerts; consider limits of 3000 fpm with 3000ft to go; 2000fpm with 2000ft to go; 1000fpm with 1000ft to go.
- Understand how TCAS works and all TCAS RA warnings, including those not frequently practiced in the simulator.
- Set the clearance given, not the clearance expected.
- Maintain a sterile cockpit below FL100.

Pete Riley, a controller now working at NATS Corporate and Technical Centre in the UK, is NATS Level Bust Workstream Lead

– NATS

In an attempt to go further in addressing this issue, NATS has created a new workstream whose focus is on business aviation, as well as cooperating with the Business Aviation Safety Partnership. The work of these groups will consider the following areas:

Training Establishments

- Pilot training for global airspace and not just the country within which they are learning; and,
- Pilots training for a variety of conditions, e.g. emergencies, poor weather, etc.

Regulation

- Promoting carriage of specific avionic equipment, such as Mode S and, in some air space, airborne collision avoidance systems
- Adequate licensing, training and competency arrangements to expand knowledge of TCAS responses and airspace, airports and poor weather operations.

Briefing

- Facilitate access to adequate briefing material through handling agents, etc.
- Encourage correct briefing by the operators.

The focus of these groups is supported by the recent publication of the Business Jet Safety Research Report, a Statistical Review and Questionnaire Study of Safety Issues connected with Business Jets in the UK (15 Aug 08). This, in turn, has resulted in the formulation of a U.K. Civil Aviation Authority-led Safety Action Plan for Business Aviation.

Although the work is not yet finalised in this area, it is clear that the need for specific attention to be given to this sector of the aviation industry is greater than ever.

The SKYbrary Project – A Single Source of Aviation Safety Knowledge

by Tzvetomir Blajev, John Barrass, Eurocontrol

Accessible and Comprehensive Safety Knowledge

How often do we hear people say in the aftermath of an accident, "This is a known problem"? If a pilot, a controller or a safety manager in an airline or air navigation service provider wants to find out information about a specific problem or issue that he is encountering, where can he go to find knowledge, examples of incident and accident reports, advice on best practice, solutions to his needs, training material and links to other sources of information?

Most organizations in the flight safety world publish their own journals and documents on their websites but don't link very well to other sources. There are numerous amateur websites devoted to aspects of flight safety, some of which are an excellent source of best practice, but how can the visitor be sure that the advice is correct?

How can we ensure that our collective knowledge and experience is shared and accessible to all in the business? Furthermore, how can we ensure that the knowledge provided helps to shape behavior, and promote best practice?

The SKYbrary Project – Creating a "One Stop Shop" for Aviation Safety Knowledge

Eurocontrol's Safety Improvement Sub-Group (SISG), which comprises safety representatives from Europe's air navigation service providers, is a consultation group that acts as a forum for safety lesson dissemination, particularly in relation to ATC significant events and safety monitoring in general in order to advise on safety improvement in the ECAC[1] area.

The SISG was interested in creating a wiki-like knowledge base, combining the power of Wikipedia whilst ensuring quality of information to serve the needs of aviation professionals worldwide, with the aim of providing safety managers with solutions to the problems they were encountering in their day-to-day work. Eurocontrol's *HindSight* magazine was launched at this time, and it was also the intention that this would evolve to become some form of online knowledgebase to meet the needs identified by the SISG. Work began in

2005-2006 on the development of the concept, design and subsequently the population of an aviation safety knowledgebase, which acquired the name of SKYbrary. This initiative soon gained the support of both Flight Safety Foundation and ICAO, support considered crucial for the project to have credibility and access to existing knowledge.

Collecting and then organizing and delivering aviation safety knowledge in such a way that it does not remain static is an enormous challenge.

It quickly became obvious that any knowledgebase would need to extend beyond the needs of the air traffic control community and must also address the needs of the operators. The focus of the project is therefore, for now, on commercial air transport operators since the potential safety benefit of addressing the needs of that community will also improve the overall safety of the whole aviation system for the benefit of all.

What is SKYbrary?

The SKYbrary knowledgebase is built on a mediawiki platform and is a network of hyperlinked articles, similar to Wikipedia, but with more restrictive control over the authorship rights, and is available free of charge to the aviation community via the Internet. Substantial bespoke work has been done to the look-and-feel as well as content management logic, to meet the requirements of Eurocontrol and its partners.

The Article is the prime content item in SKYbrary and it can contain links to related articles, Bookshelf documents, or external documents and sources. Articles follow the semantics and style of classic encyclopedia entries – precise, concise and concept-related.

It is important to note that SKYbrary's aim is not to reproduce the entire domain of aviation safety, but to provide an umbrella for easy search, reference and links to the credible resources.

Visitors can browse selected categories of information, look at recent Safety Alerts issued by Eurocontrol, or access a growing Bookshelf of reference documents, including Accident and Serious Incident Reports. SKYbrary also gives to the user a unique opportunity to search in ICAO documents. SKYbrary provides a coherent link from knowledge articles to direct behavior-influencing applications like e-learning modules, videos, posters and presentations.

Accessibility

Although in the pre-launch stage the author and editor role have been merged, it is envisaged that the author population of SKYbrary will eventually be built up from the SKYbrary user population.

Each of the authors can draft articles in a special area of SKYbrary (the "work in progress" area).

The editorial team discusses to which categories the drafted articles belong. Per category, an editor oversees the quality of contributions and can edit contributions. The editor not only looks at the content of the articles, but to the references provided as well. SKYbrary is not only a compendium of aviation safety articles, but a portal to the wider network of aviation safety knowledge. It is the task of the editor to ensure that outward links from SKYbrary equally represent high quality content.

If a (registered) user does not want to draft an article, they have the option to voice ideas for articles to be written, using the "Request an Article" facility. If an article meets the editorial standards of SKYbrary, the SKYbrary content manager can move the article onto the main SKYbrary space. As indicated earlier, the content manager also manages user rights in SKYbrary.

It is important to emphasize that the SKYbrary partners (ICAO and Flight Safey Foundation) provide their content to the SKYbrary platform as well, thereby greatly enhancing the breadth and depth of the subject matter provided to the user population.

Defining the Scope

Initially, the project concentrated on operational issues of concern to the SISG and which were the subject of Eurocontrol safety improvement initiatives. This has since been extended to cover 14 principal categories: CFIT, Runway Incursions, Runway Excursions, Loss of Control, Level Bust, Fire, Ground Operations, Human Factors, Airspace Infringement, Bird Strike, Air-Ground Communications, Loss of Separation, Wake Vortex Turbulence and Weather.
In addition to Operational Issues, two further portals were created: the Enhancing Safety portal, which includes the categories Airworthiness, Flight Technical, Safety Management, Safety Nets and Theory of Flight, and the Safety Regulations portal, which includes the categories Certification, ESARRs, Licensing and Regulation. The concept envisaged that every category should be kind of "tool kit", providing users with easy access to background knowledge and solutions, and contain no more than 30 articles. Secondary articles, and articles of a more encyclopedic nature, or articles which do not fit neatly into any particular category are stored under a General heading.

Articles are linked together, as in Wikipedia, and a separate database, a Bookshelf, of documents is slowly being built to provide further reading. This includes accident and serious incident reports which are covered by a basic article within SKYbrary, linked to appropriate categories and articles, and a copy of the associated official report is included on the Bookshelf.

The organization and structure of SKYbrary is subject to constant review as the volume of knowledge grows and feedback is received from users.

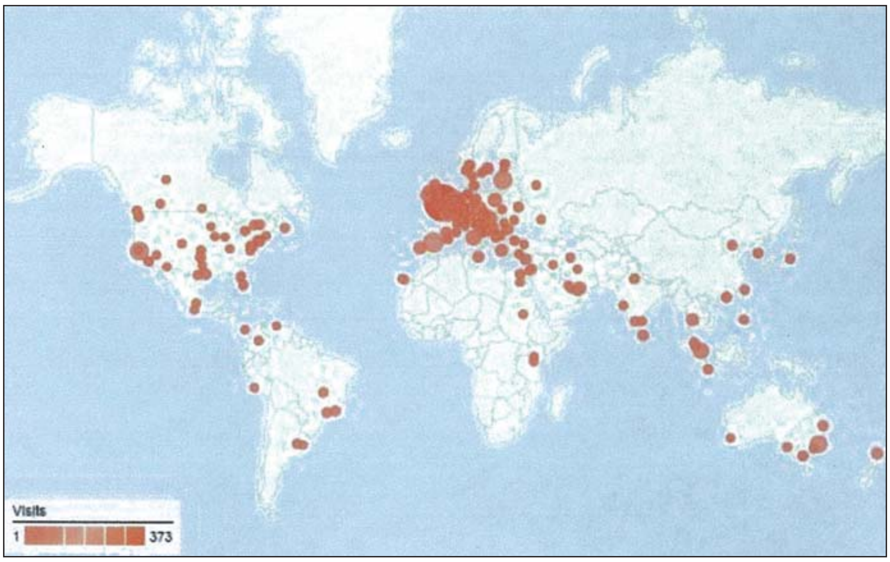
Who is the Target Audience?

SKYbrary is aimed at anyone interested in aviation safety. The production process is, however, targeted at explicitly bringing value to three groups of stakeholders:

- Safety – Safety Managers, Incident Investigators, Flight Safety Officers, Safety Experts, Safety Regulators.
- Operations – Air Traffic Controllers, Pilots, ATC Operations line mangers, Chief pilots, Operations experts.
- Training – Training Experts, Instructors.

Priorities

While the framework of the SKYbrary knowledgebase is becoming mature, the subject coverage is in places quite thin. The priority for content development is targeted at the major killers in the aviation industry:



Above: 9,232 visits came from 1,762 cities

- Loss of Control (LOC)
- Controlled Flight Into Terrain (CFIT)
- Runway Excursion (RE)
- Runway Incursion (RI)
- Loss of Separation (LOS)

Within these specific categories, the target is to achieve 100 percent of subject coverage by June 2009. Achievement of that target is of course a subjective assessment, and the knowledgebase will and must continue to grow. Over the same time frame, it is hoped that coverage of all other categories within SKYbrary will be at least 60 percent of subject coverage.

Measuring Success?

SKYbrary currently has over 1,200 articles and 500 documents stored, including nearly 100 official accident/serious incident reports linked to operational safety issues.

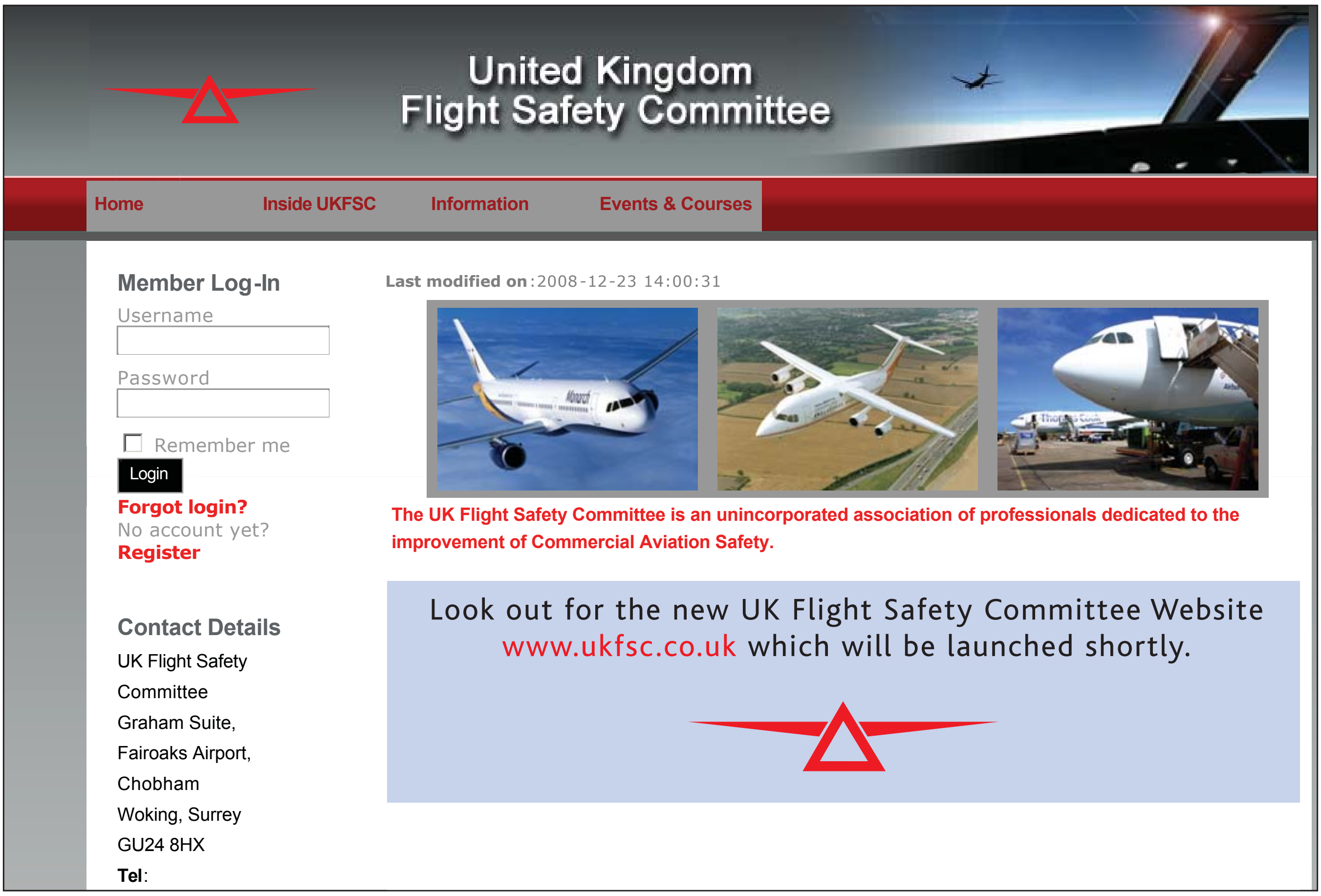
Visitor numbers passed 10,000 per month in August 2008 and analysis shows that while the majority of visitors are based in Europe, SKYbrary is attracting visitors from all over the world.

Help Wanted

It has taken two years of considerable effort to get SKYbrary ready for launch. A great deal has been achieved in this me but for the project to go forward, we need greater engagement from the community in order to build the depth and breadth of knowledge that we aspire to.

[1] *ECAC: European Civil Aviation Conference, consiting of 42 member states*

COMING SOON



Safer Skies

by Hazel Courtney, CAA Research

Previously specialising in research relating to rule making initiatives, CAA Research now focuses on safety risk projects funded by industry. HAZEL COURTENEY* highlights some of the main drivers for research, examines what is delivered and asks whether it achieves value for money for its industry sponsors.

The UK Civil Aviation Authority (CAA) research programme is much reduced in areas that support rule-making, as this is largely now the responsibility of the European Aviation Safety Agency (EASA). However, there are still good reasons to do research. The most common categories are as follows.

Reduce restrictions: Research can produce information that allows regulations to be made less restrictive or more flexible, resulting in greater freedom for industry. Restrictions can be reduced because research has shown where this can be done safely, e.g. SAFE pilot fatigue model, pilot's colour vision and helideck landing (wind-shear criterion).

Safety improvements: Research develops solutions that target safety directly, in areas where risks are known. Examples include new type rating training syllabus for highly automated aircraft, fire training improvements for cabin crew, health and usage monitoring systems, helideck landing (lighting, and moving decks), carburettor icing and gyroplane design projects.

Safety investigations: Safety risks may be suspected or rumoured but before CAA can take action or raise the issue with EASA, the nature and extent of the problem has to be investigated. The measurement of manual flying skills and data analysis of maintenance error are examples of this.

Safe introduction of new technology: Safe introduction of new technology sometimes needs support from research. Examples include the required navigation performance (RNP) terminology database, fire foam testing, inspection reliability of composite materials, and projects related to global navigation satellite system (GNSS)/global positioning system (GPS) approaches, both in mainland airports and offshore.

Regulatory actions: Policy decisions are supported with information, such as research on runway incursions technology interventions, ground fire fighting technology interventions, risk based oversight, inadvertent instrument meteorological conditions (IMC) and occurrence reporting by ground handlers. There is also a need to find ways to demonstrate compliance with new European regulations and this sometimes requires research, for example the target level of safety (TLS) compliance research.

Above: Beechcraft King Air. CAA Research's work include studies measuring pilot performance, pilot fatigue and colour vision.

Safety – CAA or EASA?

CAA continues to have a responsibility for oversight of safety for the UK industry which includes ensuring that safety risks are identified and addressed – with the exception of aircraft certification where CAA acts on behalf of EASA.

The emerging situation is that EASA will create the requirements but national authorities such as the UK CAA will continue to interpret and implement them nationally – guided and monitored by a standardisation function from EASA. In time, EASA will conduct research to support its rule making activity but CAA research is generally not for rule making purposes. It does, however, provide information that is independent from commercial interests.

What to research?

Safety risks are identified systematically. Fatal accidents to large public transport aeroplanes world-wide are analysed to identify the most frequent types of accident and the common causal factors. A full ten-year update of this work (up to the end of 2006) will be published soon as CAP 776 on the CAA website. This is supplemented by a detailed review of all highrisk events involving the UK large public transport aircraft fleet (reportable accidents, serious incidents or A or B grade mandatory occurrence reporting scheme (MORS) affecting UK-registered or operated large public transport aircraft anywhere in the world).

The MORS records almost 13,000 events per year and these are used to monitor the frequency of any known precursors to these major events for the UK in general.

The most prominent risks emerging from the analysis are then subjected to a rigorous group process where a multidisciplinary team works through potential contributors to that risk, from any source.

Pilot performance issues are prominent in CAA research. In the past ten years, the most common type of fatal accident to large public

Other studies include incident occurrence reporting by ground handlers on the ramp.

Ground fire fighting technology has been studied by CAA Research.

transport aeroplanes world-wide is 'loss of control'. Pilot performance is the primary causal factor in two thirds of fatal accidents, and the most prevalent pilot errors to feature in these events are flight handling, and also inappropriate action (potentially related to a range of causes such as fatigue or training)

The UK is not immune. For example, in 2007 there were 72 stall related events in commercial aircraft reported to CAA as MORS; 60 triggered stick shakers/stall warnings, seven were classified as serious, including an occurrence where the airliner appeared to stall at a pitch angle of 44° (based on preliminary data, subject to change following full investigation) during a go-around following an unstable approach and another where there was a stall warning during climb out with difficulty re-engaging autopilot.

In addition, many authoritative sources such as UK Air Accident Investigation Board (AAIB) and the US Federal Aviation Administration (FAA) currentiy cite pilot interaction with automation as a priority risk. There is also research requested by regulating departments directly, often to support policy decisions or find ways to comply with new requirements.

Recent research projects

The activities below highlight some milestones within the CAA Research programme during the financial year 07/08, including achievement of a number of 'world firsts'.
Projects are externally contracted, and the complete programme is managed by three research project managers who also drive the safety planning process and provide much of the matenal for the CAA's Safety Regulation Group (SRG) safety plan.

Pilot performance – manual flying skills measure and trial (joint funded with the Guild of Air Pilots and Air Navigators (GAPAN)) – For the first time an objective, fully validated method of measuring pilot's manual flying skills has been developed. This moves far beyond the early attempts to measure root mean squares (RMS) of path deviation. The method has been applied to pilots flying with a major UK operator (short haul) and early results show that manual skills do reduce with service in highly automated aircraft, particularly airspeed management. Airspeed management is important in avoiding risks related to stall and also runway excursions or overruns.

Type rating syllabus for highly automated aircraft – A new type rating syllabus for highly automated aeroplanes has been developed using robust research into training principles and differs from the traditional syllabus: (i) moving away from the ability to state how the automation works, toward the ability to know how to use it, and (ii) a change in sequencing to learn first how to achieve the task manually, and so understanding what the automation is trying to achieve and thus becoming better able to monitor it. A trial is in progress with a major UK operator and their training provider. As part of this work a simulation package of 'human factors faults' has been developed. This causes the simulator to fail as if either the pilot or co-pilot has made an undetected error. The simulated error is introduced to evaluate the flight crew's performance in recognising and dealing with the effects of the error. This is important since 'pilot error' is the single most frequent accident cause.

Runway incursions technology interventions study – An evaluation of the various technologies potentially available to reduce the risk of runway incursions was delivered to the CAA Runway Incursions Steering Group.

Pilot fatigue SAFE model – Following several years in development, a fully mature (Version V) computerised model of pilot fatigue that includes crossing time zones has been produced, validated and trialled in an airline roster. This was developed so that flight operations regulators could assess industry applications to vary their roster outside the normal guidelines, and it is used two to three times per month on average for that task. Without the model it would be difficult to have confidence to approve variations and so more rigid rules would be used. The system for aircrew fatigue evaluation (SAFE) is now being trialled for incorporation into commercial rostering software.

Pilot colour vision test – For the first time an accurate, repeatable, computerised colour vision test has been produced, that is tailored to the pilot flying task and will allow more pilots to fly (up to 35% of pilots currently excluded due to defective colour vision may be able to obtain a licence). As a side benefit, it was shown that by placing a filter in front of lights, such as PAPI (precision approach path indicator) lights, it is possible to reduce the human error rate among normally sighted pilots as well as those with marginal colour deficiency. The new system is currently with the CAA Medical Department for evaluation.

RNP terminology database (joint funded by GAPAN) – RNAV (area navigation) atld RNP (required navigation performance) approach implementation is imminent in the UK and there was concern voiced by operators that terminology was proliferating out of control, with multiple definitions for the same term and multiple terms for the same definition. This could result in confusion on the flight deck (subtle differences in 'definitions' have already contributed to fatal accident causal chains). An interactive, web based terminology database has been produced and populated, and implemented by key groups conducting rule making and procedure design.

Aircraft maintenance – data analysis of maintenance error – A subject matter expert conducted a full analysis of MORS related to errors in aircraft maintenance. This showed clearly which systems are most at risk (e.g. equipment and furnishings (especially escape slides), power-plant, flight controls and landing gear) but did not reveal any systemic error pattern or indicate a particular intervention. It did show a marked effect of the human factors education programme on reducing certain kinds of maintenance error.

GNSS/GPS approaches – signal reliability and integrity – A computerised model of GPS performance has been produced. It is able to predict GPS performance for non-precision approaches in terms of the key RNP-RNAV navigation parameters of accuracy, integrity, continuity and availability, and it can identify the points on the approach that could suffer from GPS outages. Also, a method has been developed and implemented to provide effective performance monitoring of the GPS signal in the UK, as recommended by ICAO.

Support to implementation of RNAV (GNSS) instrument approach procedures
A successful trial of GPS non-precision, or RNAV (GNSS), approaches was conducted at six UK airports, prior to CAA accepting applications for such approaches from suitable UK airports. A website for reporting issues associated with GPS during these early stages of implementation and its use in general, is now being created.

Helideck lighting – before

Helideck lighting – after

Cabin safety, fire and evacuation – cabin crew fire training – Simulated cabin evacuations were filmed at Cranfield University and the footage contributed to an international cabin crew fire training package, launched at an international conference and now being prepared as a webbased version. In a separate exercise, over 2,000 current cabin crew responded to a website contributing opinions on fire training. This will now be used for a full training needs analysis.

Ground fire fighting technology interventions study – The technical ability to fight cabin fires on the ground has not advanced significantly since the catastrophe at Manchester in 1985. A range of available fire fighting technologies was compared for their potential to enhance fire fighting on the ground and specifically for their life saving capability. This showed that one particular technology had substantial advantage over others available, and this information is now being used in policy decisions.

Report on passenger experiences during evacuations: A report detailing real passenger evacuation experiences has been produced, containing information collected over several years. This will provide insight for instruction cards, cabin crew training and cabin design issues.

Large public transport helicopters offshore – HUMS (joint funded with FAA, CAA Norway, Oil & Gas UK and Shell Aircraft)
Health and usage monitoring systems (HUMS) capability has been improved with vibration health monitoring (VHM) analysis capability. A six-month in-service trial of the enhanced capability produced excellent results and a second in-service trial is underway. A study investigating the potential for HUMS for rotors showed potential benefits in this area.

Offshore helicopter use of GPS (joint funded with CAA Norway and the EU)
Safety assessments for the use of GPS for *en route* navigation, weather radar approaches and weather radar approaches enhanced by existing GPS equipment fits have been completed. The *en route* safety assessment was translated into a CAA Specification and implemented by operators. A GPS-assisted, or 'hybrid' weather radar approach was developed and tested and will be implemented later this year.

Helideck landings (joint funded with CAA Norway and HSE) – Lighting: Night landings on offshore helidecks have been previously described as landing in a 'black hole'. A prototype system of enhanced helideck lighting was designed and installed on a North Sea oil platform and evaluated during a demonstration flight. Following evaluation, changes were made and a modified system has been installed, to be tested next winter. Status lights on helidecks have been a separate issue – a correct procedure to test these lights has now been ascertained and changes to the CAA specification recommended.

Wind shear: Data analysis and wind-tunnel testing has allowed the wind-shear criterion in CAP 437 to be deleted, allowing less restriction on industry with science to support the safety of this decision.

Moving decks: Substantial analysis and mathematical research has produced landing criteria for moving decks (e.g. small ships offshore) and prelirninary limits derived for some helicopter types. An in-service trial is planned.

General aviation – Small helicopters: inadvertent flight into IMC – A study into visual cues and inadvertent entry to IMC has contributed to changes in the Air Navigation Order (ANO).

Small Aeroplanes: Carburettor icing (in response to AAIB recommendations, e.g. 2004/01) – A mechanism to solve this perennial problem was developed and tested on a ground rig. (It will now be tested on an aircraft to validate the laboratory data.)

Gyroplane design requirements – A computer model and flight trial of rotor teeter behaviour has confirmed the benefits of a change to the gyroplane design requirements, which are still a UK CAA responsibility.

Regulatory activity – compliance support
There have been methods developed to help determine whether UK service providers comply with new standards from Europe.

Risk based oversight – Current methods used by flight operations inspectors to informally adjust oversight according to ask were surveyed and documented. This formed an input to development of key performance indicators for risk based oversight across all areas of safety oversight.

Occurrence reporting by ground handlers – Ramp events can have serious safety implications, but very few ground handlers report to the MOR scheme. Reporting is being explored and promoted.

Limited budget

Since industry funds this research through fees and charges, is it good value? The annual research budget is currently £600,000, as published in the CAA accounts. In addition, there is a similar sum contributed between a range of external bodies, including Oil & Gas UK, Shell Aircraft, UKOOA (UK Offshore Operators Association), EPSRC (Engineering & Physical Sciences Research Council), HSE (Health & Safety Executive), GAPAN, Transport Canada Civil Aviation, Norway Civil Aviation Authority and US Federal Aviation Administration.

While £600,000 is a significant sum, it must be put in context with other industry operating costs such as IT projects, accommodation changes, fuel, cabin modifications or the interest charges on finance arrangements. In the aviation environment, a single diversion may cost £150,000 (including the sub leased replacement aeroplane and additional crew, passenger hotel bill, fuel and ground support), one FMGS data entry keypad for a simulator can cost £100,000, training for one pilot £60,000, a single baggage truck dent £50,000 £160,000 (depending on where on the aircraft the damage occurs). An accident that causes injuries or a small drop in passenger confidence frequently leads to lost revenue and a complete re-branding exercise for an airline that can run into many millions.

The manufacturing industry is supported by widespread research in universities and air traffic management research has fabulous budgets from Europe (Single European Skies research is funded at £47m for the definition phase alone). The flight operations industry has no such research infrastructure and the majority of airlines do not conduct safety research. Those that do may not necessarily share it with the industry as a whole (or it may not be applicable) and there is no co-ordinated programme.

Yet flight operations is the 'sharp end' where most safety risks emerge and where any risks that have entered the system at another stage – for example at the aircraft design stage – will become apparent and have to be addressed. While not all GA research is aimed at flight operations, the operators do not pay all of the CAA funds either. UK operators share the benefits of CAA flight operations research. The price is equivalent to one diversion plus one occurrence of ramp damage that hit an expensive part of the aircraft, shared between all UK AOC holders. Benefits include more operational flexibility and less accident risk. It could be argued that this is quite good value.

Conclusion

Research for UK CAA still has a useful role to play, alongside EASA. While safety levels are high, it is easy to forget that this good safety record has been achieved through continuous work from many sources including CAA. For all of these reasons the CAA conducts research that is systematic and focused and provides a worthwhile contribution to safe aviation. Your comments would be most welcome to SafetyResearch@caa.co.uk.

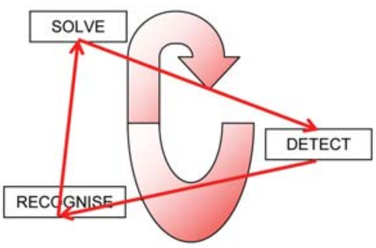
**Dr Hazel Courteney, FRAeS, is head of research & strategic analysis at the UK CAA. She worked in aircraft design and manufacture for 12 years before joining CAA in 1994 to work in type certification, particularly crew related issues, and chairs the CAA Accident Analysis Group.*

Avoiding the Conflict

by Anne Isaac and Vicky Brooks of NATS

It would seem strange to an outsider that ANSPs spend an enormous amount of time and resources on selecting and training professionals to separate aircraft, only to have increasing numbers of incidents which involve short-term conflict alert (STCA) and TCAS intervention. This is not unique to Europe and it is almost impossible to calculate how many conflicts are not resolved in a timely manner, but the estimate is somewhere in the region of 10 for every 100,000 movements. This is exactly why the air traffic control system finds it so difficult to implement further safety strategies and often struggles to find the balance between safety and service. If controllers got it wrong more often we would be in a better position to implement more robust safety nets. But why do controllers get it wrong at all? The answer in some part lies in the often difficult balance between conflict resolution and conflict avoidance. Conflict resolution, which is the most obvious skill of controllers, is demonstrated when measures are taken in order to prevent the further development of a conflict situation. Conflict avoidance, is used to prevent the situation in the first place by using pro-active control actions such as heading or level assignments.

When analysing these two strategies it is easy to recognise how complex avoiding the conflict can be. Conflict resolution can be described simply as a three-stage activity, although at each stage there are several things that may go wrong.

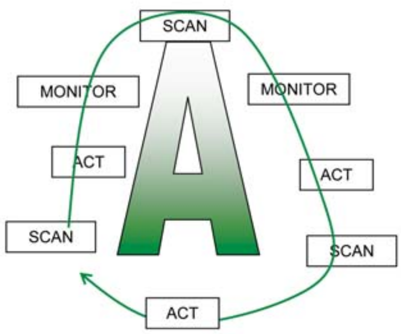


Conflict resolution firstly relies on detection, which means the controller must know what to look at and for, when to look and actively 'see' what is being searched. Here we have the first problem, since incident statistics demonstrate that one of the highest number of errors in ATC incidents is to 'not see' the information at all. There are many reasons for this: firstly if the technology does not display the relevant information in an intuitive way, controllers may fail to scan the most relevant data. Secondly, controllers may fail to recognise the important information.

If the relevant information is detected the controller then needs to recognise it as a problem or risk. The main problem with these activities for experienced controllers is the issue of time; often requiring tasks to be prioritised. High workload also increases the risk of reacting to situations instead of anticipating them.

The existence of conflict resolution tools, such as STCA and medium-term conflict alert (MTCA), also invite controllers to not actively scan for conflicts but depend on the tools to warn them; which must be avoided.

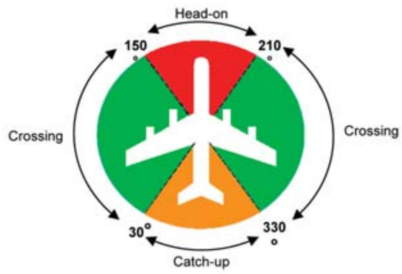
Conflict avoidance, on the other hand, is potentially a more robust technique, however it does require the controller to control defensively and pro-actively; that is set up the traffic in such a way that should a plan fail, separation would be maintained. This technique is illustrated in the following figure.



Comparing this with the conflict resolution model, it can be seen that controllers would be expected to invest more time in monitoring the situation, which of course means a trade-off with other activities or in some cases deferring other activities until the original task is complete. However if a clear set of roles and responsibilities are given and practiced by the controlling team, the investment would ultimately mean less risky and more pro active controlling.

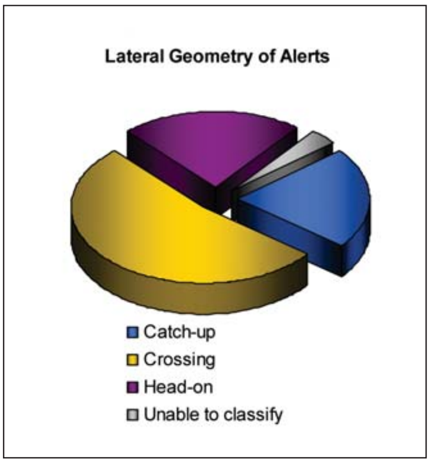
One challenging factor is the year on year increase of traffic. It is not surprising that this increase in demand decreases the possibilities of using conflict avoidance techniques. Another area that hampers the use of conflict avoidance is the complexity of airspace, one of the leading contextual factors in ATM incidents. This is a highly challenging area to tackle and demands highly collaborative decision-making, learned over a lengthy period of time.

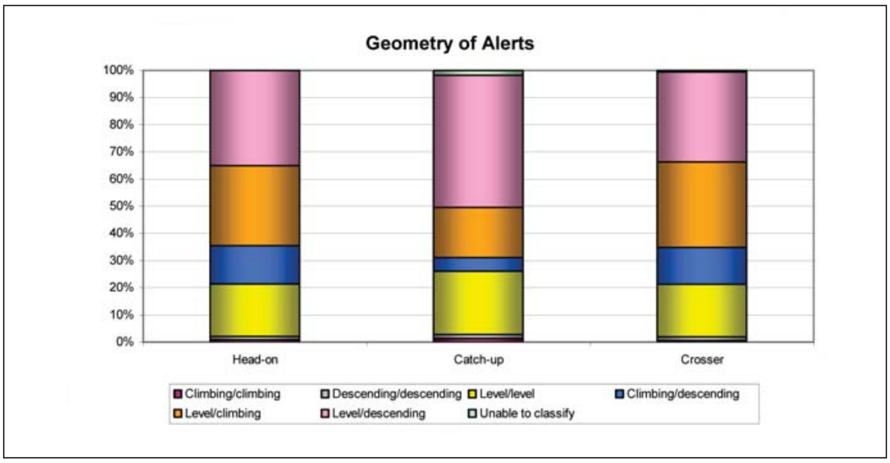
So what do we know about conflict resolution at the moment? Recent work with regard to STCA has revealed some interesting trends, although how robust these are and how they can be generalised is too early yet to assess. The analysis of STCA alerts requires the lateral and vertical geometries to be defined. The lateral geometry in this work is based on the relative heading of two aircraft; the alert is then classified as head on, crossing or catch up as the following diagram indicates.



The vertical geometry is based on the altitude change over the last 5 radar cycles before an alert. The geometry of each aircraft is then classified as climbing, descending or level.

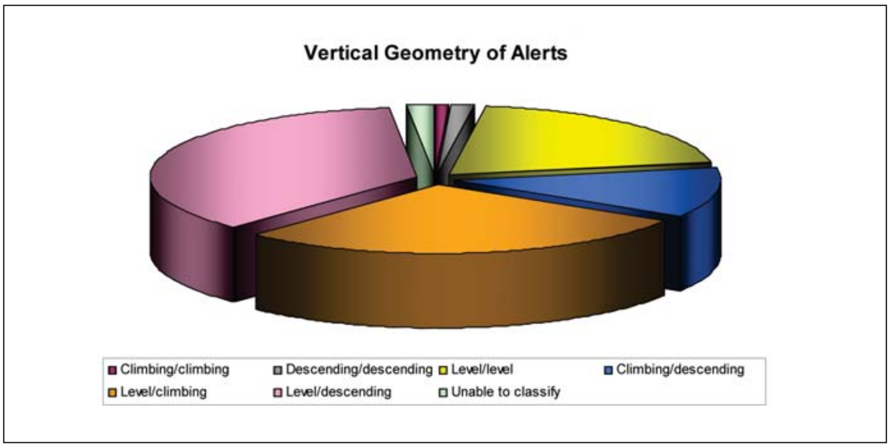
In terms of the lateral geometries of the alerts studied, 55% were crossing, 22% were catch up and 23% were head on.





In terms of the vertical geometries of the alerts; 65% of encounters are where one aircraft is level and the other is either climbing or descending.

Combining the lateral and vertical geometries of the alerts shows that approximately 80% of crossing encounters involve one or both aircraft that were climbing or descending. The following figure illustrates the findings of these geometries.



The version of STCA used in this study uses a two-stage alert, changing from white (low severity) to red (high severity). It is assumed that in the first stage of the alert, white, controllers will acknowledge the alert and act to resolve the potential conflict as required; indeed 97% of alerts that were white, remained white until they were resolved. A small percentage of alerts went straight to red, which meant there was little pre-warning, possibly the result of a 'pop-up', for example, either a fast moving military encounter, an encounter with a sudden change in lateral or vertical geometry, or an airspace infringement. And the remainder of the alerts began white before becoming red.

It is difficult to make any substantial claims from one set of data, but further analysis will add to the understanding about what controllers do, particularly when the alert goes white and what, if anything, changes their strategy when the alert becomes red.

If we return to the original discussion of conflict resolution versus conflict avoidance, it would seem that developing techniques to allow controllers to exploit conflict avoidance strategies within their time constraints would be a more pro-active approach to ATM safety. How we do this of course is another story – watch this space!

Wake Turbulence – Progress at Last

by David Booth, Eurocontrol

Wake vortices are generated by all aircraft in flight. Their generation begins when the nose wheel lifts off the runway on take off and ends when the nose wheel touches down again on landing. These vortices are in the form of two counter-rotating air masses trailing behind the aircraft. The vortices generally sink and when they are close to the ground tend to move outwards from the track of the aircraft. Vortex strength increases with weight and therefore is at its greatest when generated by heavy aircraft.

While the term wake vortex describes the nature of the air masses, the term wake turbulence is used to describe the effect of the masses. Because wake turbulence is invisible and its presence and location are dependant on a number of factors (e.g. wind speed and direction, proximity to the ground etc.), it is difficult to determine precisely where they are. It is for this reason that ICAO introduced wake turbulence separations in the 1970s.

When these separations were introduced aircraft were categorised solely on weight and expert opinion at the time. Although the separation requirements were adequate at the time they were introduced, over the years many changes and modifications to the original criteria have been made – in Europe alone there at least 15 variations! Since their introduction a huge amount of research has been carried out in the study of wake vortex. This research has shown that factors other than aircraft weight (e.g. wingspan, wing loading, speed etc.) need to be taken into account when determining into which category aircraft are placed. This increased knowledge has increased our ability to effectively model and predict the behaviours of vortices. However, no changes would ever be possible until real time data could be obtained to supplement the output from models and to prove beyond any doubt that the vortex wake is behaving precisely as predicted. The collection of this real time data is now, at last, possible due to the availability of advanced measuring equipment such as LIDAR. At last, after many years, the present criteria can be updated and new procedures that take account of the effects of strong winds on vortex wake can be developed.

The recent introduction of the Airbus A380 into operational service demonstrates this very well. For the first time the wake turbulence separations were defined prior to an aircraft entering service and for the first time they were defined using scientific analysis. An interesting spin off from this project, using this new measuring technology was the discovery that on many occasions when aircraft had been carefully separated by the air traffic controllers, the vortex wake generated by the lead aircraft simply was not there – it had either been blown away from the flight path of the following aircraft or more often it had decayed to virtually zero strength.

This has clearly demonstrated that further changes to wake turbulence separations will be possible in certain circumstances. EUROCONTROL has identified four areas of interest:

- The need to apply wake turbulence separations between aircraft operating from closely spaced parallel runways (CSPR)
- The application of wake turbulence separations in crosswind conditions
- The development of a time based final approach separation procedure (TBS)

- Updating the present ICAO aircraft wake turbulence categories into a single globally accepted set of categories (RECAT)

In order to build on the common interest in these concepts, to avoid any duplication of effort and to facilitate the approach to ICAO for rule changes, EUROCONTROL are co-operating very closely with the FAA. Together they have established a common Wake Vortex (WV) Coordination Group to oversee the development of these concepts. Representatives of all sectors of the aviation community have been invited to participate and to contribute to the work.

Closely Spaced Parallel Runways (CSPR)

In today's operations, parallel runways spaced less than 760m apart are classed as dependant in terms of wake turbulence. The CSPR project aims to introduce procedures to reduce or eliminate this dependency. It will do this by demonstrating;

1) That in certain crosswind situations the vortices generated by an aircraft on one runway are transported away from the other runway.

2) In a zero wind or headwind situation vortices are either not transported from one runway to the other or are of sufficiently low strength not to be a factor – and by low strength it is meant considerably less strength that those vortices that are routinely encountered when flying directly behind aircraft on final approach today.

This project is currently being developed at Paris, Charles de Gaulle airport and the first phase of implementation took place in November 2008.

While addressing the particular case of Paris, CDG airport, the work will be of benefit to other airports with closely spaced parallel runways in Europe – and generic procedures will be developed that can be adapted to those other airports. At the same time the data and analysis will be used to expedite the development of single runway crosswind procedures.

Because the CSPR procedures are not weather dependant they will offer an increase in capacity to already constrained airports.

Crosswind Procedures

This project is weather dependant and therefore cannot claim to increase capacity; however it is seen as one possible solution to reduce delays at airports. It is investigating the possibilities of safe conditional reduction of wake turbulence separation minima between successive arrivals or departures.

Recent research has shown that a crosswind of as little as 7 knots will transport any wake vortex away from a runway. Therefore, if there is no wake turbulence then there is no requirement for wake turbulence separation. This would then allow the possibility of suspension of the 2 minutes wake turbulence runway separation when Medium and Light aircraft depart behind Heavy. For arriving aircraft ATC would only need to provide radar separation.

Time Based Separation (TBS)

The objective of this project is to validate a concept substituting distance based separation with minima based on time leading to a recovery of some of the runway capacity lost during periods of strong headwinds. The fact that controllers still need to apply standard wake turbulence separations in these strong headwind conditions is one of the biggest causes of delay in Europe. In terms of applying this concept, controllers use marker lines that are generated and displayed on the radar screens. EUROCONTROL have already conducted a real time simulation at their experimental facility involving controllers from Germany. The result of that simulation demonstrated that the TBS concept is viable, was easily understood and applied by controllers and, in strong wind conditions, TBS operations recovers most of the lost runway throughput.

Re-categorisation of the ICAO Wake Turbulence Categories (RECAT)

Concerns over the viability of the existing ICAO wake turbulence separation criteria have led many Civil Aviation Authorities around the world to introduce modifications to the scheme. These local variations are not co-ordinated and have significant implications for both safety and capacity. In the light of these considerations it is now apparent that the current ICAO Wake Turbulence categories are outdated and a major update is needed. The RECAT project is being conducted in close co-operation with the FAA. The objective is simply to produce a globally accepted set of criteria that take account of all relevant factors. If successful this criteria will be adopted by ICAO.

Other Issues?

While the four projects mentioned above form the basis of the current EUROCONTROL work in wake turbulence there are other areas that we need to, and indeed our stakeholders are insisting that we address.

One of the most important of these areas is the question "What is a safe encounter?" At the present time opinion on this subject varies greatly and, in truth, there appears to be little consensus on the matter. We know that aircraft are experiencing encounters today but many are considered by aircrew to be "just mild turbulence" or "a bit bumpy". Even some of the more serious encounters go unreported because the situation has been controlled swiftly and professionally by the crew.

In the future it could be argued that an acceptable encounter would be one which would be no worse than that experienced by aircraft following a B747-400 using today's ICAO wake turbulence separations.

However, in order to investigate this subject more we will require pilots to file wake turbulence encounter reports. Currently there is an ICAO Wake Encounter Report Form and the UK's Safety Regulation Group has developed its own version which is more comprehensive. Whilst it is appreciated that pilots are very busy and would prefer to avoid time spent filling forms the information contained in them is vital to the ongoing research into wake turbulence.

Other areas of concern are:

- en-route wake turbulence separations. Currently ICAO provides no guidance in this area.
- The separations needed for Very Light Jets (VLJs)
- Helicopters

These areas will be developed as part of a longer term work plan.

Finally let us reiterate that we are now in a position where revisions to the current ICAO wake turbulence separations can and will be made in the short term. These will be implemented with the development of new practices and procedures, the results of which will be developed and implemented within the next three years.