focus

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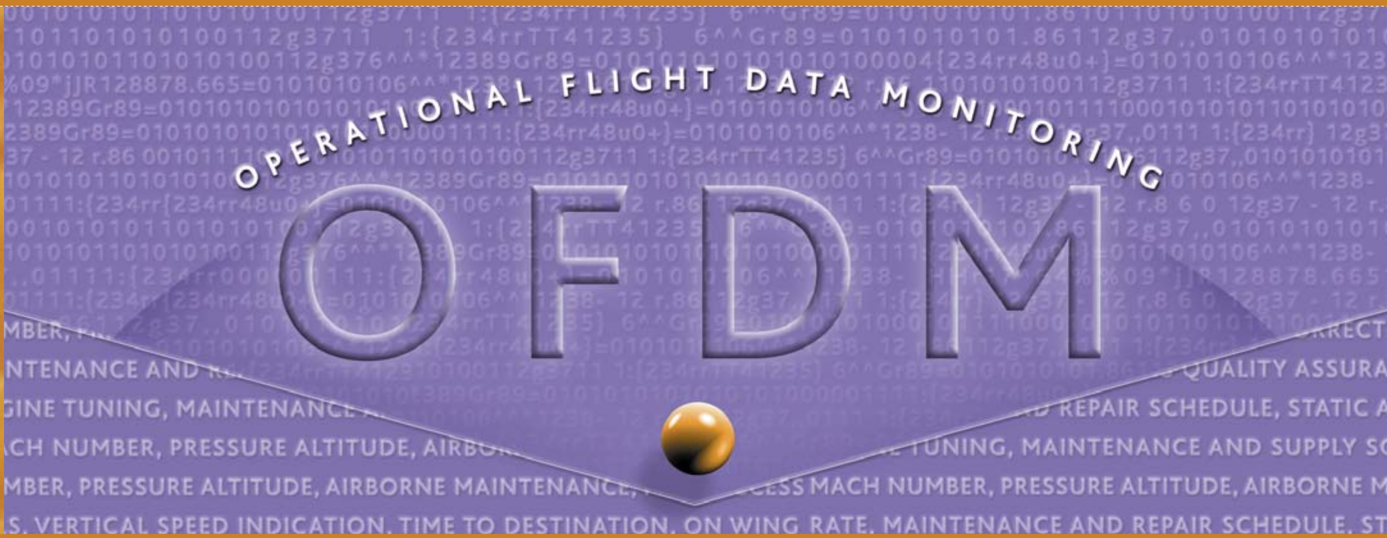
YOUR AIRCRAFT IS TALKING TO YOU IT'S TIME TO LISTEN



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SPIRENT Systems

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THE UNITED KINGDOM FLIGHT SAFETY COMMITTEE

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contents

Will cutbacks affect safety?

Before September 11th 2001, many air operators were aware of the signs of declining business. The events of September 11th acted as a catalyst precipitating the problem.

The immediate effect of the New York disaster was a reduction in the number of passengers, in particular the numbers flying across the North Atlantic. As a result operators were forced to take stock of their situation and implement plans to cut their costs as quickly as possible. These cutbacks took many forms; staff redundancies, route rationalisation and drastic cuts in all areas of expenditure. All of these make good sense from a business survival point of view. If, however, it is considered from an aviation viewpoint, it makes one sit back and cogitate the longer term influence that these cuts could have on aviation safety.

In some organisations, the quality and safety departments were combined; in others the number of staff were reduced. Logically the quality of the work might suffer as a result leading to quality audits being conducted less frequently, or less time being dedicated to incident investigation. This could consequently result in a lowering of the standard with the inevitable impact on safety.

Some may say that the aviation authority should, as the last resort, make sure that there is no increased safety risk by conducting more vigorous checks on the operators at times like these. It should be remembered that cuts in the national fleet size or any reduction in the amount of flying will have the effect of reducing the authorities financial resources. It is at times like this that their resources will become stretched to the limit. They are therefore unlikely to be in any position to increase the amount of monitoring that they do. However, we should not expect the regulator to do this. It is the responsibility of the operator to ensure that all the provisions of the regulations are met.

Managers and supervisors must ensure that morale is maintained. At times of redundancies staff morale is likely to be severely affected. A reduction in morale may lead to less attention being paid to a task with the resulting potential for an incident. Good management will go some way to preventing this from happening.

Robust attention to Systems Management and Standard Operating Procedures will assist in the maintenance of the safety standard. Managers and supervisors should ensure that all processes and procedures are strictly adhered to. Improving communication will help to ensure that all staff are made aware of any changes to processes and procedures and to motivate them to be ever vigilant for errors and omissions.

It has now become vital for operators to conduct risk assessments for all changes to the operation and to pay particular attention to doing a risk assessment on their reduction in staffing and any other critical reductions that they are planning. Hopefully this will be done before such actions are taken.

Working hours need careful monitoring to ensure that staff reductions do not precipitate fatigue. Committed staff may well offer to work additional hours in order to ensure that tasks are properly completed. In the longer term this will lead to fatigue and eventually to errors and consequently to erosion of the safety margin.

Event trend monitoring and incident investigation will need to be rigorous in order to immediately detect problems and ensure that defences are put in place to prevent them from re-occurring. It is at times like these that a good safety management system will provide benefit to the operator.

So the answer to the question "Will cutbacks affect safety?", has to be "Yes, unless we all take the necessary actions to restrict the effect of staff reductions on operational safety to a minimum."

UK FLIGHT SAFETY COMMITTEE OBJECTIVES

- To pursue the highest standards of flight safety for public transport operations.
- To constitute a body of experienced aviaition flight safety personnel available for advice and consultation.
- To facilitate the exchange of urgent or significant flight safety data.
- To maintain a liaison with all aviation authorities on matters affecting the safety of the flight-crew, ground-crew, the aircraft and passengers.
- To provide assistance to operators setting up a flight safety organisation.

2001 - A Year in Review

by Capt. Tom Croke

The year 2001 was one which irrevocably changed the aviation industry. As the high profile, highly visible business which receives extraordinary media attention it was perhaps inevitable that terrorism would return to our industry in an attempt to gain worldwide attention for its aims. However, the industry relies almost entirely on the agencies of the state and the intelligence community to provide the appropriate level of defence against these threats. On 11 September 2001 these defenses were breached and the aviation business and the whole world paid a terrible price. The industry can do little about such security threats, except to provide advice and guidance to the appropriate authorities, when it is requested to do so.

However, on the management of safety, the industry must always assess what the developing threats are and take appropriate action. To this end IATA, as the professional body of the industry, reviews all significant accidents involving hull loss and substantial damage to jet and turboprop commercial transport aircraft during commercial operation. This report gives a unique and professional review of the previous year and provides Flight Operations management a range of issues and topics which they may address in training to prevent recurrence.

This year there were twenty operational hull losses and thirty-six substantial damage accidents to jet public transport aircraft. A significant number of the twenty hull losses, six, were due to aircraft undershooting i.e. aircraft landing short of the runway but within the airfield boundary. They were not controlled flight into terrain (CFIT) accidents in the classic definition of CFIT. When the other approach and landing accidents are added in it becomes clear that the efforts of the Flight Safety Foundation Approach and Landing Accident Reduction Task Force are well directed since almost two thirds of all accidents happen in this phase of flight. What is regrettable is that in many cases these accidents represent a repeat of the last number of years and that a timely go around in most cases would have prevented the accident. In many cases the go around would have been required at a late stage in the approach, from two hundred feet to fifty feet, and the question I ask myself is whether we give adequate training in the recognition and execution of such manoeuvres.

There is an increasing threat to safety coming from outside the aviation industry. Political and environmental factors are now forcing airports and ATC to allocate inappropriate runways and flight paths, with little, if any, regard for the impact such allocations have on safety. All pilots should be aware that the ultimate decision to accept these inappropriate allocations rests with them. At the very least they should request a more appropriate runway or flight path and be prepared for any delays necessary to achieve the safer option. If this safer option is not offered then the crew must consider diversion. A fatal accident last year is attributable to such factors, even if only as contributory factors. It is unacceptable that the odds are being unnecessarily stacked against safety in this manner. Only the professionalism of the crews in refusing such options can mitigate this threat, but it also requires the support of senior management.

There is an industry trend to reduce technical training for flight crew to a minimum in order to reduce costs. This "need to know" level of training leaves crews with an inadequate level of system knowledge to carry out troubleshooting. It also leads to flawed decision making as the first requirement for decision making is an accurate "estimate of the situation".

The present financial difficulties of the industry will lead to an increased pressure on airlines to further reduce the training given. The result of such a decision may only appear in years to come when an accident has resulted from the poor level of system knowledge provided to crews. There are undoubtedly going to be repercussions on safety arising out of the tragic events of 11 September 2001. The need for regulators to be seen to be addressing the security deficiencies which in the first place caused these events is understandable. The safety concerns of the aviation industry have not generally been taken onboard. We will require a very careful examination of the measures now being put in place to identify the threats to safety to ensure adequate countermeasures are deployed.

This year, for the first time, the IATA Safety Report will be available not just to IATA members, but also to those wishing to purchase it. I would recommend that you obtain a copy when it is published and provide yourself with another potent safety tool with which to manage safety within your organisation.

Some thoughts on the future of airline safety

by Captain Bob Screen

From a paper given to 4th Annual Airline Conference on Aviation Safety Management, London, 31st May 2001, by Captain Bob Screen. (The views are entirely those of the author and do not necessarily represent company policy).

The improvement in the world accident record over recent decades has been made possible by the advance in technology, better training, improved procedures, the study of how humans interact, statistical analysis and much else besides. But the safety process must be an ongoing one to address any changes that may upset the safety balance. For relatively small airlines that do not have the resources to carry out safety research themselves, there exist organisations that actively promote safety initiatives, provide statistics and manage worldwide databases and these can provide airlines with a foundation for safety management.

A good safety record doesn't guarantee immunity, as we have seen in the last two years. Airlines with unblemished records need to address safety issues just as vigorously to identify and mitigate risk. It goes without saying that you can never sit back and assume all is well. Airline safety management is a bit like football management; these days you are only as good as your last game! Forget "no loss - no problem," safety management has to be effective both in reaction and prediction.

The margin of safety can be related to the difference between the minimum legal standards defined by the regulations and the self-imposed standards of airlines. An Air Operators' Certificate states that "The operator is deemed to secure the safe operation of aircraft", but is that all? Safety is about more than legislation; it is about a culture of safety within an airline, starting with management and extending to the workforce.

"Safety will be as good as senior managers desire or as bad as they let it be." [1] The challenge is to reduce the low but static accident rate of recent years.

"You can have a great safety department, but if it doesn't get to the people through culture, you're wasting your time!"

The safety department should be a living entity that is unique to the airline. One of its primary responsibilities is to facilitate communication and the safety awareness of all employees, who should be encouraged to question their activities from a safety perspective. The key safety managers within it have to be trusted, credible and articulate, to convince senior management that change and investment are necessary.

It is appropriate to look at the JAR prescribing Safety Management Systems. This states, "An operator shall establish an accident prevention and flight safety programme, which may be integrated with the Quality System, including programmes to achieve and maintain risk awareness by all persons involved in operations." This statement is based on an ICAO Annex 6 recommendation and it is as important to business survival as a financial management system.

What then, is a safety culture? It is the values, beliefs and behaviours of the group. Put simply, "the way we do things around here." I am reminded of an American airline training course on which the first slide on the first day said, " Safety begins here". A good start - it stuck in my memory.

Because culture is about people you have to get the right people through the door in the first place. Careful recruitment is a must, encapsulated by the aphorism "hire for attitude, train for skill." Modern aircraft require crew and system management skills that are far removed from the skills learned to go solo. A good personal attitude is a quality which is just as important as skill, but which cannot be wholly addressed through training.

Pilots want to join airlines that they perceive to be well run and in which the roster strikes a reasonable balance between productivity and time off. Recovery from fatigue should not be coincident with leisure time and it is well known that roster disruption can be a major source of discontent. It should not be forgotten that pilots exercise their skill and judgement, sometimes to the limit, and sometimes when most of us are tucked up in bed and we count on them to do this time and time again. " You can't park the jet while you make a decision, which is why pilot judgement and decision making is unique." [2]

Management style is an essential part of a safety culture because the attitudes and actions of management influence all within the company. Here, leading from the front can be very effective. Support, exercised from a distance, with operational decision making devolved to the experts on the spot, is probably better than a regime where crews are reluctant to make a decision for fear of getting it wrong. It is easy to criticise a bad decision with hindsight. An incident can be de-identified so that all can learn the lesson. Thus trust, respect and confidence can be established so that crews are not afraid to exercise their judgement on the day, in the best interests of the company. A safety culture is also a just and fair culture.

An internal system of detailed and open reporting of all minor incidents will complement mandatory reporting required by the CAA. With more data, we are able to address minor trends that may provide early warning of a more serious incident. Finally, we should provide avenues for crews to become involved in other company activities so that those who volunteer can derive satisfaction from contributing to the organisation as a whole.

It will be no surprise that training should be part of the culture and goes hand in hand with safety. Training programmes in some airlines are pared to reduce costs and this is a clear case of false economy. Training programmes should be more than just the bare minimum. Training might be expensive, but it is money well spent and the alternatives are unthinkable.

CRM scenarios can be usefully enacted between cabin and flight crews, preferably in a suitable environment such as a cabin simulator. A simulator observation programme provider for cabin crew instructors can give them exposure to emergencies such as depressurisation and engine malfunctions, so that they can speak with authority in the classroom.

I hope we have come a long way since captains were autocratic and unapproachable. Most airlines now regard crew interaction as Team Resource Management and conduct some of their training together with cabin crew. Nevertheless, 'social interaction deficit', mainly between pilots, has been recently identified as a greater threat to safety than human error, by diminishing a crew's capability to handle technical or operational problems successfully. Adequate training needs to ensure that two competent pilots operate as one competent crew.

LOFT exercises can be used to introduce the series of events that have preceded accidents in terms of malfunctions, communications and weather, requiring both manual and automatic skills. In other words, we should train for the perceived threat.

Although modern simulators have made an enormous difference to the scope of training that is possible, we now look to simulator manufacturers to provide significant improvement in the next generation. We need more realistic simulation in areas such as engine compressor stalls, engine failure, tail scrapes and weather, to eliminate negative training. Two areas need major improvement. Firstly, simulator reliability and secondly, more user-friendly instructor controls. Instructors should not have to scroll through pages of data to initiate simple system failures.

Airborne auditing of standard operating procedures, including R/T standards, is used to identify weaknesses that can be remedied by training. To be effective, standard procedures should reflect what is done in practice.

Most major airlines contribute to a safety database such as BASIS, which has facilitated the exchange of data worldwide. Databases are used in prediction, by examining incidents, which may combine to be the links in the chain, that lead to a major accident. A no-blame culture should facilitate the reporting of slips and errors, because all errors contribute to the big picture.

Human factors can be defined as "the interaction between people and machines, people and people, people and procedures and people and the environment," and are the most prominent cause of aviation accidents. One thing we can be sure of is that they will never go away. It is well known that minor slips and errors are made on every flight, because humans are intrinsically error prone. We must therefore build error management into our procedures so that the slips and errors are recognised and corrected. Because humans conceive, design, manufacture and operate machines, errors are just as likely to be made at the design stage as by the end user. If we are capable of designing failure into a system, it is not just the airline that should foster a safety culture. There is a danger that advanced automation makes the pilot a passive observer and pilots make poor monitors of automated systems. It is to be hoped that a new generation of aircraft will improve on the present shortcomings of automation and iron out the "what's it doing now?" syndrome. The pilot needs to be kept in the loop through shared control of automation. The man-machine interface needs careful design and yet we still get new machines of increasing complexity. To overcome this, industry now needs to define new standards of integrated cockpit design, to encompass, for example, ATM CNS requirements. Our past practice of technology add-ons will simply not be acceptable. We shouldn't have to put up with map shifts, FMSs that say "invalid entry" without offering a clue or any other shortcomings that require 'work around' solutions.

Complacency, especially when exacerbated by fatigue, is a human failing, which can be mitigated by the crew's attitude to procedures. A disciplined crew will use standard R/T phraseology and resolve ambiguity rather than assume or let it go. Cross-cockpit dialogue is vital, but workload needs to be prioritised to avoid distraction at critical times, using the "sterile cockpit" concept. Summarising techniques are an effective way of clarifying meaning and understanding.

The focus of human factors in maintenance is comparatively new, but mistakes in the hangar are not. Issues such as night shift working, shift changes, staff shortages, failure to use procedures, confusing manuals, all contribute to the cocktail. An increase in error reporting has helped identify where the problems are. A recent paper on safety, presented by the chemical industry, suggested that with appropriate managerial commitment, workforce participation, communication, responsibility, accountability and training, a zero accident rate is achievable.[3] However, there will always be risks in aviation and the greatest threat is the failure to recognise and manage them. Some, but not all can be eliminated and others need to be reduced to the point where they are acceptable - as low as reasonably practicable.

Decisions on risk are managerial and it is worth noting that the UK Turnbull Report on corporate governance has resulted in all companies being required to consider the nature and extent of the risks facing them. Furthermore, companies are required to establish a sound system of internal controls and review their effectiveness at least annually. The controls must be embedded within the operation and not treated as a separate exercise. Risk management should include transfer of risk to and from third parties and through joint ventures, contingency planning and evaluation of risk-taking decisions. In conclusion, it says that failure to identify a risk may be evidence of failure to meet required standards.

The reference to internal controls and review is worthy of review because it mirrors the JAR Safety Management System, which establishes the requirement for internal feedback and trend monitoring programmes, allowing managers to assess the risks in the operation and to determine logical strategies to counteract them. How do we go about risk assessment? There are various mathematical and procedural models in use, but I would submit that the most effective are practical ones. (On the subject of risk, it will be no surprise that aircraft operation whilst on the ground now carries a greater risk than when airborne).

Having discussed legislation and current safety challenges, what lies ahead? Most forecasts predict a doubling of air traffic by 2020. Coupled with increased passenger expectation and recent concerns about passenger health, airlines face consumer power as never before. Certainly in the UK, the public has learned to complain with a vengeance, whether the complaint is justified or not. At the moment, ticket prices are good value, but future proposals for fuel taxation and the clamour for more personal space can only increase costs and ultimately drive the price of air travel upwards. This is not to mention proposals for environmental and congestion pricing.

Crews will increasingly have to use their training in conflict management and breakaway techniques to combat disruptive passengers. Tighter control of alcohol consumption and denied boarding must be more rigorously imposed. Robust procedures introduced by DETR in the UK have evolved through the experience of the past five years and prosecutions, although still difficult to secure, increasingly serve as a deterrent, especially when reported in the tabloid press.

Acquisitions and mergers bring with them cultural differences that need expert management. Unfortunately there is no blueprint for success and managers are often faced with a unique set of circumstances. International partnerships using the common European licence means that increasingly we will be flying with crews of different nationalities. The organisational and occupational differences that go with them will influence safety culture and require careful management to maintain it.

It is fortunate for us that the use of English is accepted as the universal language in aviation. But we are probably the only monolinguals left in the business and professional world. “We should be alert to the difficulties that language poses for cockpit communication.”[4] Confusing communication with ATC is often a feature in the loss of situational awareness. The cockpit monitoring function can be undermined, for example, whilst obtaining a clearance from one ATC agency whilst still under the control of another. Technological advances in data link technology will help reduce the workload in this regard but all innovation brings the risk of introducing new problems. HF communication poses a risk, which may become unacceptable as traffic grows. Should HF have a place in the modern world?

To avoid staff shortages during this period of growth, manpower planning is crucial. We somehow have to entice a new generation who have grown up with aviation and regard it as commonplace that it is a rewarding and worthwhile industry to be in.

We must ensure that the environmental considerations do not undermine safe operation of the aircraft by dictating the use of limiting crosswinds and tailwinds. Crews should be firm in rejecting unacceptable clearances.

We have seen twin-engine transport become the norm, with over 400 Transatlantic ETOPS flights a day. The ETOPS threshold time has advanced in 15 years from 120 to 207 minutes, with 240 minutes in prospect, to cope with routes across remote areas of the globe. It is good to see that the regulators are currently reviewing the safety legislation, which was originally framed around engine failure.

NATS privatisation and the move to Swanwick have necessitated close attention to changed management. The granting of legal status to Eurocontrol is, in my view, the only way to solve the delay problem in the short term. The Single European Sky is a long-term solution, which will require unprecedented European cooperation to succeed. ECAC recently predicted that unless these reforms take place in the near future, Europe could face traffic gridlock in the air and on the ground by 2005.

I haven’t touched on FOQA or OFDM, as we prefer to call it in the UK. Quick Access Recorder data is a vital window into what’s going on out there, and will reveal both procedural and human factors issues. An OFDM programme should map the normal and crews encouraged to replay events that have caused them concern. Freedom of information is the issue here. All data, including safety reports, must remain the property of the airline, which must safeguard it from lawyers, the police and the press. Any breaches of confidentiality will seriously undermine the safety benefits.

Finally, I return to human factors. This is an area where we can make real progress. At present we only collect data on failed human performance in terms of accidents and incidents. Perhaps we should begin to look at the minor unreported errors which are made and from which we recover. We need to understand successful human performance as well as the unsuccessful.[5]

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1. Dr John Lauber
2. Capt.Stephen Luckey, ALPA
3. Jacques Berghmans, Dupont,2000
4. Ashleigh Merritt, NASA/University of Texas, 1986
5. Capt.Dan Maurino, ICAO, 1999

Operational use of Angle of Attack on Modern Commercial Jet Airplanes - Part 2

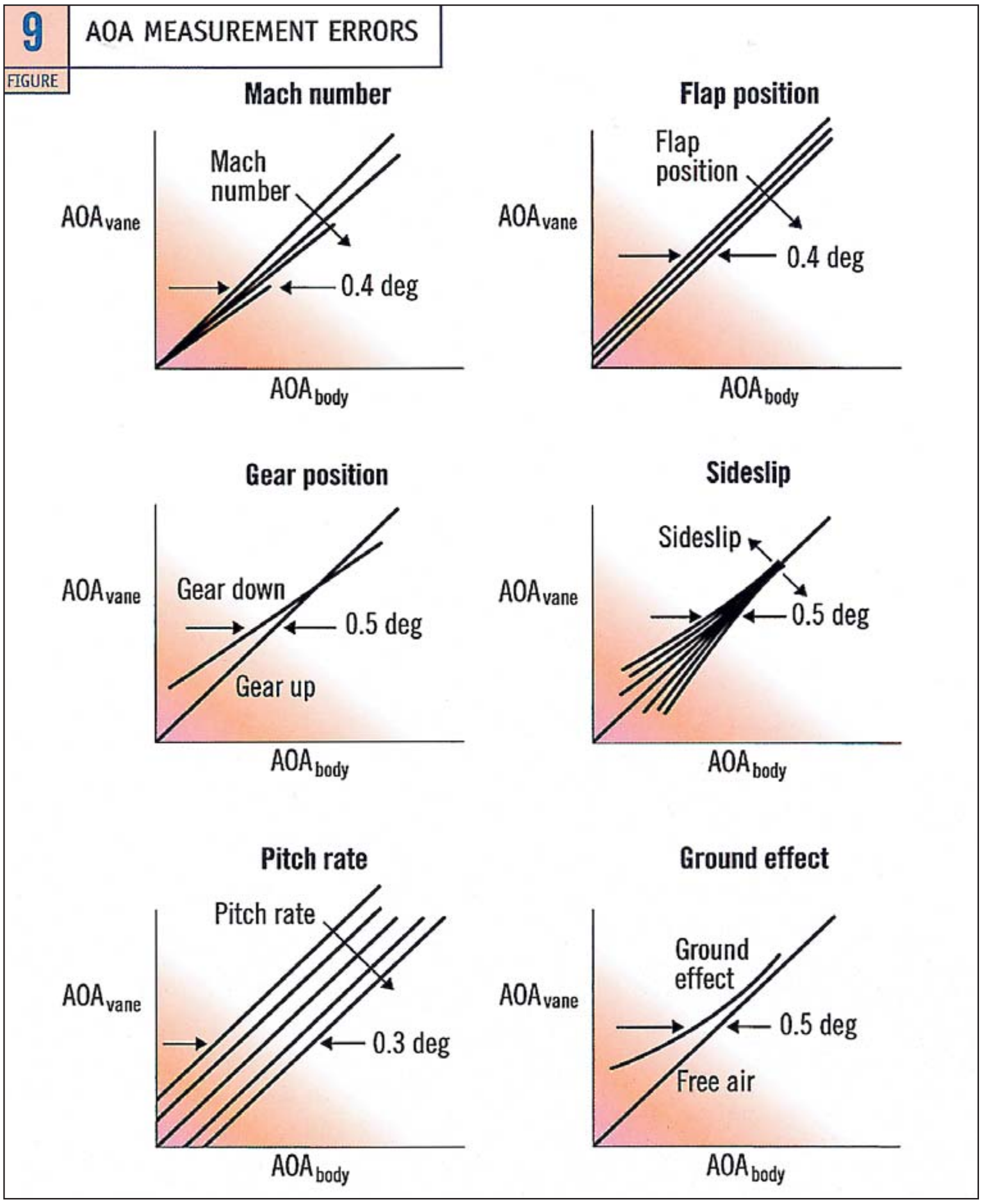
3. AOA MEASUREMENT

The previous section dealt with the relationship between the aerodynamics of the airplane and the true AOA of the wing. In practice, the true AOA of the wing is not known. It only can be estimated based on a measuring device mounted somewhere on the airplane. Any such device has inherent errors that must be addressed.

Wherever the device is located, it is measuring the flow angle in its own local vicinity, not at the wing. Stall warning devices have been mounted on the wing, but most modern commercial jet airplanes have movable leading edges that would interfere with such an installation. Most have the sensor located on the fuselage, far ahead of the wing, reducing the effect of changes in lift and configuration. Nearer to the nose of the airplane, the airflow is relatively clean and the boundary layer is thin, minimizing the required probe height.

Even at the nose, many factors can affect the relationship between the local AOA and true wing AOA (fig. 9). The angle of airflow around the nose is not the same as at the wing.

Also, the sensitivity to changes in AOA is greater, so a 1-deg change in true wing AOA causes a local flow change at the nose of 1.5 to 2 deg. The trailing-edge flap position has an influence on a typical AOA sensor calibration, as has landing gear position (in particular, that of the nose landing gear doors). Mach number affects the flow around the nose and therefore changes the sensor calibration.



Pitching the airplane can cause erroneous readings at the sensor. While the nose is pitching up (as in a turn), the local flow angle is reduced, causing the reading to be too low. Although the sensors are placed to minimize the effect of sideslip, it is not eliminated and can be quite significant at sideslip angles that may occur on short final approaches or with an engine out.

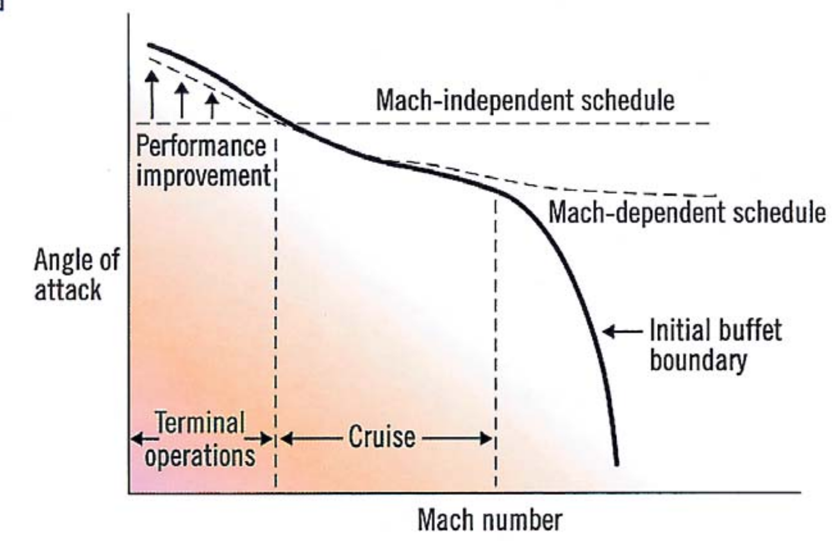
Even variations in the contour of the skin near the sensor can subtly affect the local flow angle. Many of these design challenges also affect pitot and static port installation and accuracy.

The sensor itself has potential for error. The combination of installation error, zero bias, and aerodynamic inaccuracy can total 0.5 deg or more. Contamination or damage can also affect the sensor's accuracy.

For the most part, the effects discussed above can be compensated for and, depending on the airplane, many have been. It should be noted, however, that each correction has its own inherent uncertainty and can also cause erroneous readings if the input data is incorrect.

In the philosophy of "keep it simple," the fewer dependencies on other data, the more robust the AOA system will be. For example, Mach number affects the sensor calibration. While this relationship could be compensated for, this would make the sensor output dependent on good Mach information. If the airspeed data were inaccurate, the calculated Mach number and therefore the calibrated AOA reading would be incorrect. This would affect the usefulness of AOA in the event of an airspeed system failure. Note that because the sensors are located near the nose and the air data probes, certain conditions, such as radome damage or loss, may cause erroneous measurement of AOA as well as airspeed.

FIGURE 10 STALL WARNING SCHEDULE



4. AOA INDICATIONS AND FLIGHT CREW PROCEDURES IN CURRENT BOEING PRODUCTION MODELS

AOA is most useful to the flight crew at high angles of attack to show the margin to stall or stall warning. All indications driven by AOA - stick shaker, PLI, and speed tape indications - are related to this important information.

Stick shaker. An artificial stall warning system is required for airplane certification if the natural prestall buffet characteristics of the airplane are insufficient to warn the flight crew of an impending stall. This warning must be in a form other than visual to be effective, even if the flight crew is not looking at the instrument panel. Beginning with early commercial jetliners, standard practice has been to equip these airplanes with a stick shaker as a means of stall warning. Some airplanes also have employed stick nudgers or stick pushers to improve stall avoidance and stall characteristics. All these indications have been driven by an AOA threshold, which is usually a function of flap configuration, landing gear configuration, or both.

Because of the effect of Mach number on stall AOA, the stall warning AOA typically was set at a conservative level to accommodate gross weight and altitude variations expected in the terminal area.

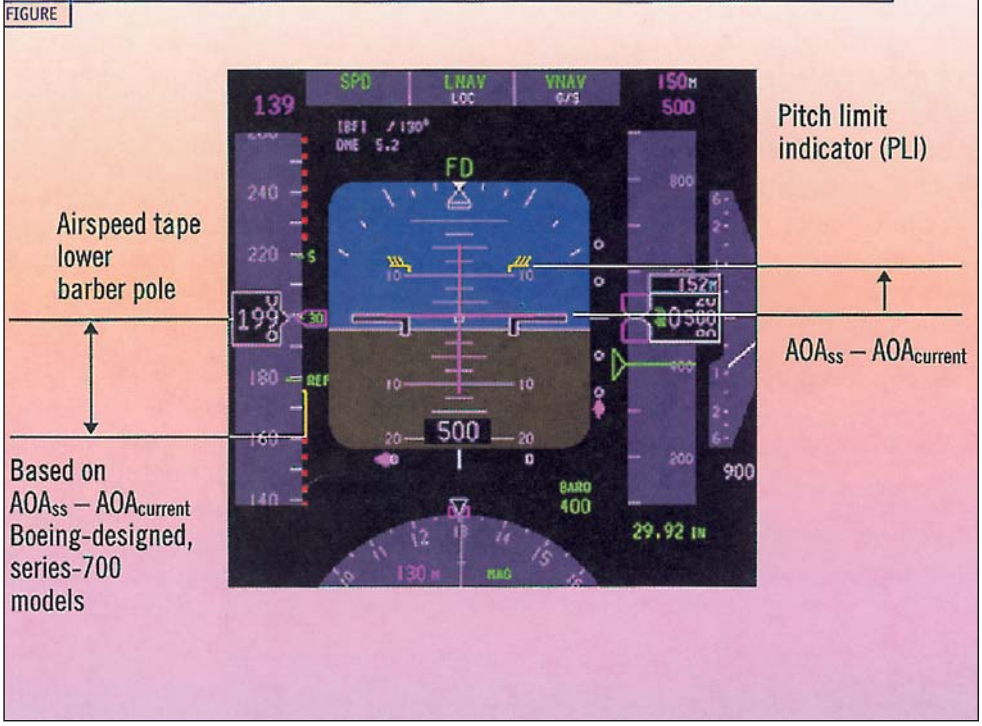
The early stall warning system thresholds were not set to be effective at cruise altitudes and speeds because they did not correct for Mach number (fig. 10). This kept the system simple. The stick shaker was set at an AOA effective for low altitudes but at too high a value for cruise. Natural stall buffet was found to give satisfactory warning at higher Mach numbers.

Later stall warning systems used Mach number from the pitot or static air data system to adjust the stall warning AOA threshold down as Mach number increased. This provided the flight crew with a stall warning related to the actual available performance. However, it also made the stall warning system dependent on good pitot and static data, a factor that will be considered in the next section on the dedicated AOA indicator.

It should be noted from figure 10 that the stall warning schedule does not follow the buffet boundary at very high Mach numbers. The buffet here is caused by Mach buffet, or too high a speed. Setting the stall warning system to activate at this point may lead the flight crew to believe the airplane is near stall and increase, rather than decrease, speed.

Pitch Limit Indicator. The PLI originally was developed as part of an industry effort to address windshear escape training. Because stall warning is primarily a function of AOA, the PLI shows AOA margin to stall warning, even though it is part of the pitch attitude display (fig. 11). The distance from the airplane symbol to the PLI is calculated from the difference between the AOA of the airplane and the AOA at which stall warning will occur. This provides the flight crew with good situational awareness, enabling them to monitor airplane attitude in pitch and roll relative to the horizon, while simultaneously showing whether the airplane is approaching its maximum AOA. In general, when the airplane symbol and the amber PLI bars meet, the stall warning system will activate.

FIGURE 11 PRIMARY FLIGHT DISPLAY STALL WARNING MARGIN INDICATIONS



However, the PLI also is limited to 30 deg of pitch attitude, regardless of AOA. If AOA or AOA margin to stick shaker were to be used as the first and primary focus of the flight crew during windshear escape or terrain avoidance procedures, extremely high pitch attitudes could be reached before stall warning if the maneuver is entered with sufficient speed. Therefore, the PLI shows the lesser of either margin to stick shaker, or 30 deg of pitch.

Because stall AOA is a function of Mach number, a PLI on airplanes with fixed stall warning schedules would display an excessively large margin at typical cruise Mach and altitude. To avoid this misleading display, PLI was available only with flaps extended when it was introduced in the mid-1980s. Later airplanes have employed stall warning schedules that adjust the stall warning threshold as a function of Mach number. The design of the 777, 717, and 767-400ER has taken advantage of this and will display the PLI full time when flaps are down, as well as when flaps are up if speed or load factor causes stall margin to decrease to an AOA within 1.3 g of stall warning.

Work is currently under way to introduce this type of PLI indication on other models. Recent changes to the 757 and 767 enable the PLI to be displayed with flaps up.

Speed tape indications. Soon after the introduction of the PLI, a vertical scale airspeed indicator was developed and added to electronic flight displays. This offered the opportunity to calculate and place airspeed-related data such as maximum, minimum, maneuvering, and reference speeds on the airspeed instrument (fig. 11). All Boeing models currently in production have this capability.

Of particular interest are the minimum speed amber and red bands, or barber pole. At low speeds on Boeing-designed airplanes currently in production, these indications are based on sensed AOA and the AOA margin to stick shaker. At higher Mach numbers, most airplanes with fixed AOA stall warning schedules show margins to stick shaker or margin to initial buffet, whichever corresponds to the highest speed. On these airplanes, the margin to buffet at higher Mach numbers is calculated by the FMC.

On newer models, such as the 777 and 767-400, the amber and red bands show margin to stall warning at all times because the stall warning schedule generally follows the initial buffet boundary at higher speeds up to cruise. The position of the amber and red bands is always a function of AOA margin to stall warning.

The speed tape is designed to provide the flight crew with situational awareness of the flight envelope. It shows the crew where the airplane speed is relative to the limits (i.e., maximum placard speeds or minimum stall warning speed, as well as the maneuvering capability available).

5. DESIGN AND USES OF A SEPARATE AOA INDICATOR

Boeing and several operators worked together to develop the display format for an optional AOA indicator (fig. 12). The upper right location was chosen as one that can be accomplished without significant rearrangement of the existing PFD or electronic flight display formats. The indicator itself consists of an analog scale and pointer, and digital representation similar to displays of many other parameters throughout the flight deck.

Stall warning AOA is shown with a red tick mark, which will change position as a function of Mach number for those airplanes with Mach-dependent stall warning schedules. A green approach reference band is shown whenever landing flaps are selected. The range of the approach reference band accounts for normally expected variations in CG, thrust, sideslip, and other considerations.

Many AOA indicators used in the past have been of the "normalized" type, where AOA is shown in arbitrary units and scaled so that zero load factor is shown as an AOA of zero and stall is shown as an AOA of one. Normalized AOA on a commercial jetliner would require that Mach number be introduced into the calculation of AOA because stall AOA and buffet margins are a function of Mach number.

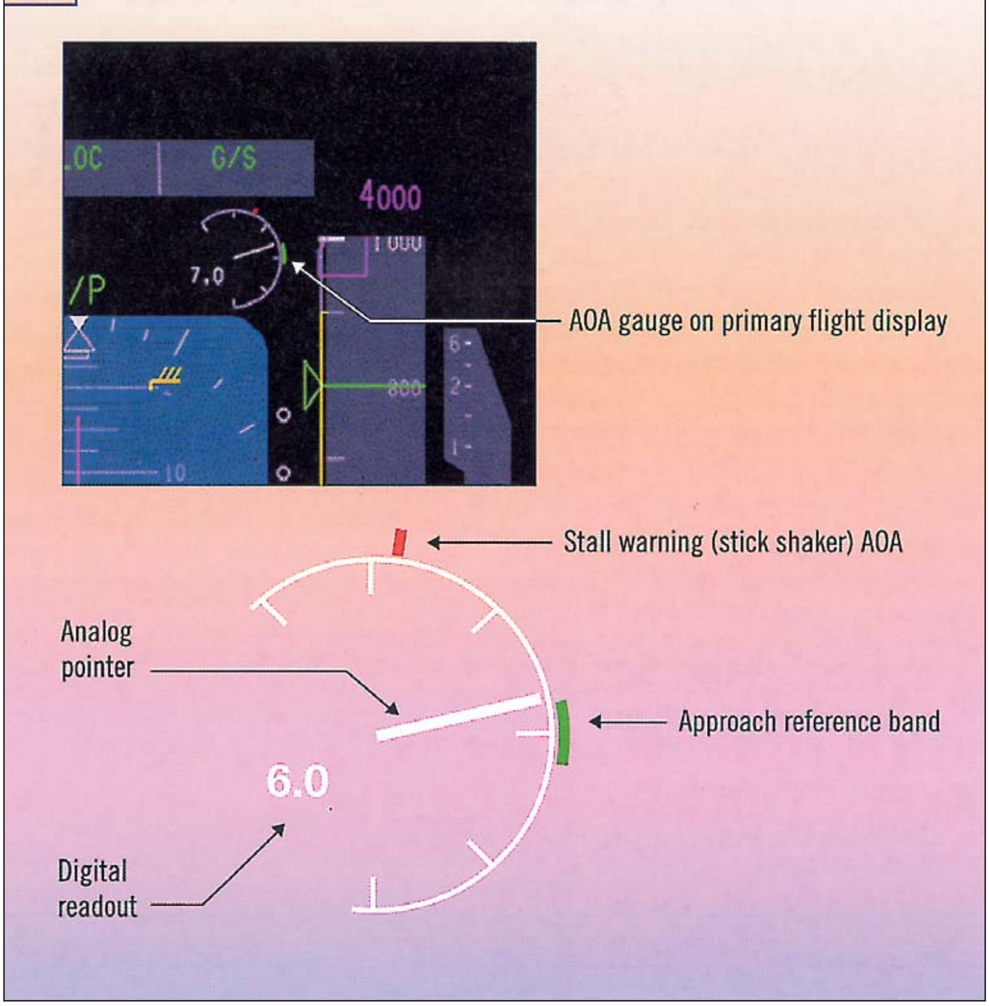
The indicator developed shows body AOA in degrees and is not normalized, which is related to the second objective above, that the indicator be useful when pitot or static data, and therefore Mach calculations, are unreliable because of blockage or a fault in the system. The pointer of a normalized indicator in this condition would behave erratically, making the indicator unusable.

With the non-normalized design, the position of the needle is a function only of sensed AOA. The red tick mark for stall warning may behave erratically in a pitot or static failure state, as may stick shaker, PLI, and speed tape amber and red bands. However, the AOA needle and digits will remain stable, and the indicator itself still will be useful as a backup for unreliable airspeed, provided the AOA vanes are undamaged.

A variety of potential uses for AOA were examined during the design of the new AOA indicator:

- Improved situational awareness and flight crew training.
- AOA backup indication following pitot or static system failures.
- Reference during upset recovery, windshear escape, and terrain avoidance maneuvers.
- Indication of maximum L/D or range, detection of weight errors, and a check of fuel consumption during cruise.
- Cross-check to detect weight or configuration errors on approach to reduce the probability of tail strikes on landing.

FIGURE 12 OPTIONAL AOA GAUGE FOR 737-600/-700/-800/-900, 767-400, 777



AOA can be used for some of these purposes, but it does not work as well for others. From the standpoint of flight operations, some of the goals can be met with certain caveats that take into account the principles and limitations of AOA measurement and aerodynamic performance of modern commercial jet airplanes.

Improved situational awareness and flight crew training. There is a desire to use AOA information to increase the flight crew's understanding of the physics of flight arid their general awareness of the state of the wing during normal and non-normal conditions. Within certain limitations, the display provides this indication in a clear, unambiguous format. The degree to which AOA can be used to increase knowledge and airmanship depends, of course, on the approach taken by the airline in training its flight crews and the use of the indicator in training scenarios for non-normal procedures. Some of the limitations are discussed below.

AOA backup indication following pitot or static system failures. The AOA instrument described in this article is useful as a backup for unreliable airspeed indication caused by pitot or static source blockage because the calculation of indicated AOA is not greatly affected by pitot or static pressure inputs for its calibration, and the displayed value has not been normalized.
Pitot or static system failure requires the flight crew to take several fundamental steps to resolve the problem (see “Erroneous Flight Instrument Information,” Aero no. 8, Oct. 1999):

- Recognize an unusual or suspect indication.
- Keep control of the airplane with basic pitch and power skills.
- Take inventory of reliable information.
- Find or maintain favorable flying conditions.
- Get assistance from others.
- Use checklists.

Recognition of a problem will be accomplished by instrument scanning and cross-check practices or crew alerts, depending on the design of the system in the airplane. In this respect, AOA instruments can be useful as an additional cross-check.

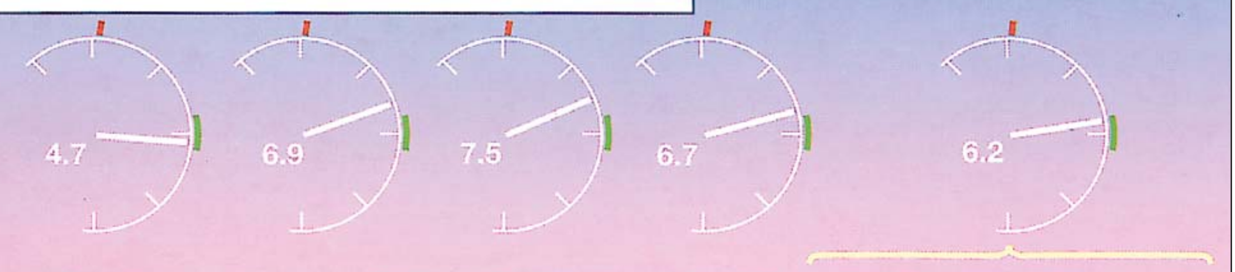
Present procedures for unreliable airspeed call for flying the airplane by reference to pitch attitudes, and refer the pilots to reference tables showing pitch attitudes for various configurations, weights, and altitudes that will result in safe angles of attack and speeds. AOA could be useful if the relevant data is included in the pitch and power tables that already exist in the non-normal checklist procedures. AOA would be most useful in flying the airplane in multiple failure conditions where all pitot or static sources are affected, making all airspeed indicators unreliable.

Care should be taken when flying the airplane by reference to AOA in lieu of airspeed. Control should be made by reference to pitch attitude, using AOA as a cross-check to ensure that the pitch attitude results in the desired speed or AOA. Attempting to follow AOA or speed indications too closely without stabilizing the airplane in pitch can lead to an oscillatory flight path.

Reference during upset recovery, windshear escape, and terrain avoidance maneuvers. Windshear escape and terrain avoidance maneuvers require immediate change in pitch attitude and thrust, followed by monitoring of the situation and further increases in pitch attitude if needed, while avoiding stick shaker activation. The PLI was developed primarily with these purposes in mind and works well. On all current production models, PLI is shown when flaps are down. At this time, PLI is available with flaps retracted on the 717, 767-400, 777, and MD-11. Work is under way to make this capability available on other Boeing-designed models currently in production.

The first steps in windshear escape and terrain avoidance procedures involve

13 FIGURE AOA GAUGE UNDER VARIOUS CONDITIONS ON APPROACH TO LANDING



Weight error	0	23,000 (14%)	0	0	16,000 (9%)	23,000 (14%)	0
CG	mid	mid	mid	fwd	mid	mid	aft
Speed	$V_{ref} + 5$	$V_{ref} + 5$	$V_{ref} + 5$	V_{ref}	$V_{ref} + 5$	$V_{ref} + 5$	$V_{ref} + 8$
Speed brake	down	down	40%	down	down	down	40%

Key points to emphasise in training

- **AOA is most useful in high-AOA, low-speed parts of the envelope; it is less useful at most normal speeds.**
- **Airspeed and Mach are still the primary sources for performance data for reasons of precision, regulatory basis, system redundancy, and integrity. Therefore, if the AOA is indicator is used, flight crews should cross-check with other instruments, just as they would with airspeed.**
- **The AOA approach reference green band may be used as a cross-check for configuration errors, reference speed calculation errors, or very large errors in gross weight. Normal variations in AOA measurement dictate the width of the green band. Also, because approach speed in some cases can be determined by issues not related to or sensed by AOA, increasing or decreasing approach speed by targeting the centre of the green band can result in appropriate approach speeds.**
- **Pulling to stick shaker AOA from a high-speed condition without reference to pitch attitude can lead to excessive pitch attitudes and a higher probability of stall as a result of high deceleration rate.**

applying maximum certified thrust and control of airplane pitch attitude to an initial target, while honoring stall warning. AOA margin to stick shaker, whether shown with the PLI or the AOA display, is a secondary reference during this part of the maneuver, not the primary target. As mentioned in the section on PLI, pitching up by sole reference to AOA-based indications can result in excessively high pitch attitudes if the maneuver is entered at sufficiently high speeds. Because the AOA display is separate from the pitch attitude display, it does not provide protection against high pitch attitudes if the indicator is used as the flight crew's primary focus or target during such maneuvers.

For upset recovery, either the PLI or the red stall warning mark on the AOA indicator may be used to assess the margin to stall warning.

Indication of maximum L/D or range, detection of weight errors, and a check of fuel consumption during cruise. As shown in the section on airplane performance, AOA is not the appropriate parameter for optimizing cruise flight, because of the strong influence of Mach number on airplane performance. Because AOA is not very sensitive to speed or weight changes at cruise speeds, even large gross weight errors may not be detectable. A 0.5-deg error in AOA is equivalent to 30,000 lb on a 757-200, or approximately 14 percent of the maximum takeoff weight.

Cross-check to detect weight or configuration errors on approach to reduce the probability of tail strikes on landing. AOA can be used during approach as an extra cross-check for errors in configuration, weight, or reference speed calculation. Proximity of the barber pole to the reference speed on the airspeed tape can be used in a similar manner because it is based on AOA margin to stick shaker.

However, for either method, the errors must be large enough that they are not masked by other factors. Normal variations in AOA as a result of the regulatory requirements on approach speed, as well as those caused by differences in thrust, CG, sideslip, and the installed accuracy of the AOA measurement system, may act together to mask all but large errors in weight or configuration. These factors are taken into account in determining the size of the green approach reference band. To keep the size of the green band from becoming too large, these variations were root-sum-squared because of the low probability that they would all add in the same direction at any one time. The resulting green band is about 2 deg wide for the 777 and 3 deg for the 737. The band is centered at an AOA equivalent to Vref +5 kt, assuming a nominal gross weight, mid-CG, no sideslip, a stabilized 3-deg glideslope thrust level, and no system error.

A 20,000-lb weight error on a 757, corresponding to approximately 10 percent of maximum landing gross weight or about a 40 percent error in payload, yields a change in AOA of 1.7 deg. So, it can be seen that even relatively large weight errors may not be enough to move the needle out of the green band. Conversely, it is also possible that flying at the proper speed and configuration may yield an AOA that is outside the reference band. Figure 13 illustrates how errors can be masked or cancelled out by variation in the other parameters.

For these and other reasons, the AOA indicator can be used as an additional means to check for large errors in weight or configuration, but it should not be used as a substitute for current procedures to establish approach speeds and verify configurations. To determine the approach speed based solely on placing AOA in the green band can cause situations of excessively high or low approach speeds, depending on a variety of circumstances.

Summary

AOA is a long-standing subject that is broadly known but one for which the details are not broadly understood. While AOA is a very useful and important parameter in some instances, it is not useful and is potentially misleading in others.

- The relationship between AOA and airplane lift and performance is complex, depending on many factors, such as airplane configuration, Mach number, thrust, and CG.
- AOA information is most important when approaching stall.
- AOA is not accurate enough to be used to optimize cruise performance. Mach number is the critical parameter.
- AOA information currently is displayed on Boeing flight decks. The information is used to drive the PLI and speed tape displays.
- An independent AOA indicator is being offered as an option for the 737, 767-400, and 777 airplanes. The AOA indicator can be used to assist with unreliable airspeed indications as a result of blocked pitot or static ports and may provide additional situation and configuration awareness to the flight crew.

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Federation of Aerospace Support Services

The Federation of Aerospace Support Services (FASS) is the trade association of UK companies specialising in supplying skilled temporary workers – "contractors" - to the aerospace industry. FASS was created by its 13 founder members in 2001 to set a high minimum benchmark standard for contractor supply businesses, to gain thereby the confidence of its clients and the CAA/JAA, to provide an industry voice in Government and regulatory fora, and to act effectively and in unison in matters such as training, the future supply of skilled engineering labour, and response to regulatory proposals.

The part-time Executive Director is Jon Cousens, based in Exeter. He comes from an airline and airport management and consultancy background. The Federation is a Company limited by Guarantee.

The CAA's support for FASS is pro-active. One of the outcomes of this is close co-operation between FASS and the CAA on the production of a document entitled "Managing Contractors Safely", providing guidance on "Best Practice" for the engagement, induction and management of contractors.

"Managing Contractors Safely" addresses safety issues raised in the "Review of Temporary Staff in Aircraft Maintenance in the United Kingdom", published in February 2001 by UK Flight Safety Committee.

The Federation has agreed its Code of Quality Conduct, governing its procedures for recruitment of staff and verification of their technical qualifications, experience and training. These issues were raised in the UKFSC Review.

A Code of Member Conduct has been agreed, governing ethical matters of members' relationships among each other and the Federation. A full Members' meeting is held routinely every 3 months.

All FASS members must hold ISO 9001:2000 accreditation, with operating manuals and procedures that incorporate the FASS Codes of Quality and Member Conduct. FASS assists new members to obtain accreditation quickly, at relatively little expense, by offering a FASS "template" for a Member's Policy & Procedures Manual. This template is now available.

Continuation and development training for existing temporary aerospace workers is high on FASS' agenda, as is recruitment of future engineers for an industry already suffering from a manpower shortage.

As its chosen way to take an effective part in the development of the UK Aerospace Engineering workforce in the medium and long term, FASS is a member of the Aero Skills Alliance, which brings together all the principal branches of the aerospace industry to ensure jointly that training and career development of engineers receives its due priority.
Any company in the business of recruiting and supplying temporary aerospace workers, which commits itself unequivocally to FASS Codes of Conduct, will be welcomed to FASS.

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How safe is your destination airport?

by Mike Seller

How safe is your destination airport? Last summer, one UK-based charter airline contracted an independent company to undertake safety audits at its overseas destinations.

Why?

JAR-OPS 1, describing Quality Assurance Programmes, states (at Subpart B, Section 2, at AMC OPS 1.035, sub-

paragraph 5.1.2) "The ultimate responsibility for the product or service provided by the sub-contractor always remains with the operator. A written agreement should exist between the operator and the sub-contractor clearly defining the safety-related services and the quality to be provided. The sub-contractor's safety related activities relevant to the agreement should be included in the operator's Quality Assurance Programme."

Starting Point

Focusing on services provided by others, the Airline agreed the auditor's inspection plan; that plan contained questions for the Handler, the Fuelling Company, ATC, Aerodrome Ops, Maintenance, and the Airport Fire Service. These five areas played the most active role in the safety of aircraft, their passengers and crews.

Was the Auditor Welcomed?

With advanced warning, through the Airline's Agent to Airport Management, the auditor was received, without exception, with the utmost courtesy. It is worth noting that the auditors, all pilots, had been senior Ops Managers at the UK's largest airports, and they enjoy their work!

Reports and Airline Actions

Typically, an audit report to the Airline contained 30 observations on both good and bad points, and 6 or 7 items where the airport did not conform to ICAO rules or guidance, or where the Airline's safety expectations were not met. Non-conformity items included a risk assessment. The Airline then wrote to the Airport requesting that problems should be rectified. Some "fixes" will take longer than others but help from the CAA could be requested, if necessary.

Findings

On the outbound flight the auditor would quiz the flight-deck crew about the destination and hear about any regular problems. The auditors developed the habit of "following leads" and would significantly exceed the 321 questions and actions in their manual. They discovered much about the airport's overall safety awareness.

It was disappointing to find a Handling Manager who declared that her staff had no responsibility for picking up apron FOD.

One Airport Director claimed that national funding left him short-staffed and short on funds, but he had a new, "state of the art" radar, two very costly new fire vehicles, and the most modern, new, runway-friction-measuring device!

Some airports needed to improve their bird control measures (particularly one averaging 20 bird-strikes a year), but one airport had not had a bird-strike in the last ten years!

It was common to find ATC towers that had no fire drills and no evacuation plan.

Few airports had a disabled aircraft recovery plan, and none of them engaged in any recovery exercises.

It was unusual to find an airport that had a regime for regularly checking standby electrical generators (for essential services) or where test runs for diesel generators exceeded a few minutes a week.

A monthly safety meeting, involving all parties, was a rarity, some airports managed two such meetings a year, and one had none at all!

Where Management had "forgotten" their ICAO Aerodrome Reference Code, it was perhaps not surprising that a taxiway was too narrow and wing tip clearances below standard, with no published warnings.

It is pleasing to report that fuel companies demonstrated consistently high standards.

One busy airport, which lacked computer assisted check-in, had adopted practices which failed to comply with routine security requirements.

When a major incident occurs, reputations are saved, or lost, by the manner in which survivors and the media are handled. Descriptions of airport exercises suggest that these aspects were not practised realistically.

Very few of the airports visited had modern manoeuvring area signs, but one country had filed a "difference" with ICAO, such that the new requirements would not be adopted.

All airports conducted incident investigation, but safety cooperation was lacking, since the lessons learnt were not shared with others.

The overseas airfields generally paid little heed to ICAO requirements for runway and taxiway surrounds to be levelled, free from excessive weed growth, and cleared of loose material which might be ingested into engines.

Coastal airports generally failed to provide any realistic sea-rescue capability.

These "findings" are mainly negative, but the auditors also found positive points. Airport cleanliness was generally good. The airports were blessed with some very professional and very enthusiastic staff, and each airport had at least one "benchmark" procedure which could be adopted elsewhere. These included:

- Firefighters allotted 3 weeks refresher training each year at their national/ military fire-fighting school.
- Each working shift inspecting their whole area of responsibility for faults – looking for trouble!
- An individual's understanding of new procedures and new rules acknowledged with a signature.
- Handling staff who produce computer- generated trim-sheets, now practise the manual method every Tuesday, to retain their skills.
- Fuel bowsers limited to a 20kph speed limit, on the ramp.
- An Airport Authority's monthly safety and performance statistics distributed, internally, to illustrate achievement against annual targets – an airport "howgozit" report!
- Poor airside driving discouraged by the introduction of a penalty points system which might ultimately cost a driver his job.

Considerations

A bit like wallpaper in a home, a worker's environment can become too familiar and largely unnoticed. An observant and knowledgeable auditor can provide the much needed "immigrant's eye"; he can also demonstrate a sceptical lack of confidence in inspections that are not recorded, procedures that are not documented, and equipment that is not serviced, and not regularly tested. The auditor has the advantage of being able to compare airport with airport. He can seek out recurring weaknesses, and follow an "audit trail" from management policy, through the documentation of procedures, to a worker's training and observed competence on the ramp.

Were the Audits of Value?

The Airline expected to gain an assessment of how well their Handling Agents were performing and an opportunity to quiz Airport Authorities about their facilities, or lack of facilities! However, this Airline got much more than that, as the example "findings", above, might indicate. As a direct result of one audit, the apron stands available to this operator's largest aircraft have been limited, because wingtip clearances were found to be inadequate. We shall continue with these audits and continue to pursue the "areas of risk" already identified. We hope that this audit technique will be adopted by other airlines, and thereby bring more pressure to bear in improving safety at overseas airports.

About the Author

Mike was an RAF transport pilot. He joined BAA where he was the Operations Manager at Gatwick and then Heathrow. In retirement he has undertaken consultancy work for Wake Ltd.

Questions

If you would like to know more about independent safety auditing, then please contact the author, Mike Seller, on 01273 494332.

Rain Repellents, are there any benefits?

by Richard J Flute, Managing Director, OL.G International Ltd

Introduction

Are there any benefits? For most people involved in commercial aviation, at the heavy end of the industry at least, the answer to my opening question will be a fairly definite No! This is almost certainly because their involvement, if any, will be with a rain repellent which has recently been withdrawn for both environmental and operational reasons. It was carried on board aircraft in liquid form and sprayed onto windscreens and was only effective across the area swept by the wipers. It was also highly toxic and any leak posed severe problems, not least to the health of air and ground crews. However, although this particular rain repellent system was the most widely used, it was also the least effective.

The CAA have recently agreed with at least one major UK airline that a rain repellent is no longer required and it would seem this opinion is widely held throughout the UK airline industry. There can be little doubt this attitude is shared by most aviation authorities throughout the world. For the purposes of this article I will limit my comments to UK only registered aircraft and AAIB reports.

In recent years there have been a small number of heavy landings involving UK registered airliners landing in rain causing severe damage. The circumstances all seem remarkably similar to those which led the United States Air Force to issue a requirement for an effective rain repellent some thirty or more years ago. Circumstances which, these days, are not often known about. Over several years I have sent letters to the AAIB questioning if these accidents could have been avoided if the subject of refraction distortion was well understood and received a pretty negative response.

Suddenly, recently an experienced investigator took the time and trouble to look again at the issue and assess the implications. The main result to date is this article.

Because of huge advances in aircraft and airport instrumentation, equipment, procedures and crew training methods the business of landing and taking-off has become very safe indeed in all but the very worst conditions. The presence of rain at an airport is barely thought about unless it's very heavy. It would seem that for most airline staff and pilots a rain repellent is generally viewed as some sort of not very effective alternative to wipers. The problem is probably in the name….rain repellent. It is not a good description and that is probably why the danger still lurks…..unseen and ready to strike.

Flying with water

Water is of course essential to life and for many years, as a private pilot, I have been fascinated by all the multitude of ways in which water in all its forms significantly endangers life, especially for aviation. For this article I will focus simply on the visual effects of rain. For a pilot light to moderate rain presents three main visual problems; Reflection, Diffraction and Refraction. Very heavy rain poses several other problems of course.
To better illustrate the point consider moderate rain first. Without wipers moderate rain can virtually eliminate all forward vision, the degree of lost forward vision varies according to many factors but with wipers the problems seem to disappear. In fact only two properties are largely eliminated….reflection and diffraction. These can both been seen so the problem appears solved. The remaining problem is of course refraction and refraction distortion cannot be seen. Hence the danger.

Refraction distortion ...what is it?

The problems facing pilots regarding refraction distortion seems to have gone the same way as air pockets in airline folklore. Who today refers to air pockets? To introduce, (reintroduce?), the problem I'll make reference to two items. The first comes from the U.S. Army Aviation Digest dated February 1975. To quote, "Water also causes a refraction error making the horizon appear to be 10 degrees lower than it actually is. In addition, the ripples, especially on canopies like those found on the AH-1 HueyCobra, cause objects to appear lower. The effect can be as much as 5 degrees or a 100-foot error each 1,200 feet lateral distance". In other words a potential 15 degree visual error reading.

The second item comes from our own CAA. I refer to AIC (Pink) 80/1978. The CAA had "measured refraction distortion on a wet windscreen at 200ft at 1 nautical mile from the threshold" and stated, "this can significantly endanger landings". The handling pilot will perceive himself as being two hundred feet higher than he actually is. In most circumstances pilots can usually easily reconcile the disparity between what the instruments say and what the Mark One eyeball is reading.

The hidden danger

Time and time again I have been told by airline operations staff that pilots these days no longer look outside the flight deck even when landing and taking off. It's all done either automatically or purely on instruments. I have friends who are highly experienced commercial pilots and they get very upset when hearing these opinions. It seems to indicate a very serious breakdown in understanding and communication in many airlines between the people who 'run' the airline and those that 'fly' it. I don't wish to dwell on this but it is an important area to be examined.

Many commercial flights are conducted IFR right down to decision height which can of course be very low at CAT 3 airports. But how does the handling pilot adjust when popping out beneath the clag, into rain, at night, onto a dark runway, with often severe winds and turbulence, taking a quick peek through the windscreen to doubly make sure they're on the runway centreline and perceiving the runway lower than it actually is? Normally very well indeed. The non handling pilot will be reading out the numbers etc and nothing untoward usually happens. Touchdown might well be on the heavy side but well within limits. Both pilots will of course have the same perceptual picture.

Operations staff will say that's why we pay these pilots so much and spend thousands training and examining them. They should do a good job. The principal point I made to the AAIB is….is this reasonable? Putting it bluntly there has been the odd occasion when the crew have been dealing with a flight from hell sometimes lasting for an hour or two before landing with consequent fatigue. At a CAT 1 airport perhaps, even sometimes at an airport without an ILS, or PRA facility etc. Sometimes airports have these facilities but they are not functioning. The list of potential problems confronting crews is nigh on endless but the core question remains.

Nearly all commercial pilots will admit that there are a few seconds on every flight when the Mark One eyeball is the primary flight instrument. For judging the exact moment to flare the aeroplane to soften the landing is the best example. If the pilot has no way of adjusting vision due to refraction distortion is it reasonable to attribute all heavy landings solely to pilot error? Some aircraft have very limited pitch angles for landing and taking off so the effects of refraction distortion can easily prove critical.

ATPL Flight Training

It would appear that the subject of refraction distortion affecting pilots visual perception has never been included in the ATPL flight training syllabus, at least in the UK. It certainly doesn't exist at primary flight training level. At face value this does seem rather extraordinary. Has

all the research, time, money and effort spent investigating this serious problem really been dumped, ignored and generally discarded by the airline industry? If this is indeed the case…why? The problem hasn't gone away and to the best of my knowledge no other effective means, apart from an effective rain repellent, has been employed to counter it.

Cost effectiveness

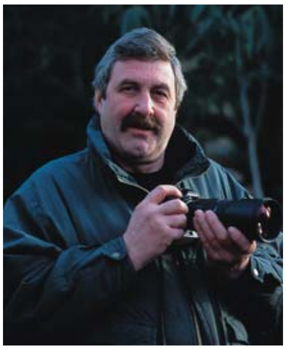
What are the costs of a very heavy landing? They are not of course purely financial. Loss of an aircraft for days, weeks and perhaps months can cause severe operational problems disrupting schedules and involving locating another suitable aircraft and perhaps crew(s)? Closure of an airport for several hours? Very bad press and possible drop in passenger revenue? Increased insurance premiums? Perhaps some passengers never wishing to fly again and only too eager to spread their message? Drop in air-crew and staff morale? The list goes on.

There is one rain repellent available which has material costs of about £1 a week per aircraft and at least one other better but more expensive option. It does seem astonishing that effective 'rain repellents' are now deemed as no longer required. Simply viewed as added insurance to assist pilots the cost seems minimal set against the potential losses.

Lesser but still significant savings accrue by using an effective rain repellent. In flight a good rain repellent virtually eliminates use of wipers. Many operators have shown savings in replacement wipers, arms, motors and converters resulting in savings worth thousands of pounds in parts alone. With the Royal Air Force and other Air Forces potential loss of an aircraft forms part of the cost equation especially during low flying exercises. Helicopter operators serving the world wide oil industry have found using a rain repellent very cost effective. British Aerospace recommend a rain repellent for most of their military and civil aircraft. In fact some of their aircraft are not certified for flight without one being applied.

Conclusion

This article is not intended to be an advertisement for commercially available rain repellents. That is why no details or contact numbers have been provided. My sole purpose in raising the issue of the dangers involved with refraction distortion to both the AAIB and UKFSC was purely to raise awareness of a significant element regarding flight safety which has been generally ignored in recent times.



Technology in the pending tray

Your editorial in the winter edition of FOCUS referred to control difficulties due to incorrect loading, and to the training that should be provided for pilots.

Several types of weight and balance system have been available for thirty years and more. They may not have proved all that accurate or reliable in practice. Operators generally seem to have taken the view that unnecessary delays from false indications and the extra cost of maintaining such systems were too high a price to pay.

Why have such systems not evolved to the point where no operator or certification authority could fail to consider them as a vital safety monitor? Even if the accuracy achieved were modest, a reliable system would provide the essential check – for a gross blunder in loading.

The more general issue is that of "loss of control in flight".

In the World Airline Accident Summary that heading and the one of "mechanical failure" include accidents arising both from penetration beyond the flight envelope and from failure in aircraft structure or system.

From the safety point of view they must be considered separately. The two different safety questions are: "why did the pilot let this happen?" or "why couldn't the pilot recover from this failure?" Pilot training apart, the second question returns the discussion to the history of technology.

The design of hydraulic systems has been called into question more than once, in relation to loss of control. Two well-remembered examples are those of the 1985 B747 accident, where the rear pressure bulkhead ruptured, and the 1989 DC-10 crash-landing at Sioux City, after it suffered major damage from a disintegrated engine fan. In both cases the aircraft completely lost hydraulic power, due to local disruption of all systems.

At the time of the first accident, the problem of closely positioned hydraulic lines were re-assessed. There was much discussion of "hydraulic fuses" – which shut off a line when a major one-way flow of hydraulic fluid is detected, thus at least preserving fluid and pressure in one or two systems and so retaining minimal control in some utilities.

After the second accident, trials were run on an MD-11. The autopilot/throttle function was modified so that automatic adjustment of thrust could aid or substitute for normal lateral and longitudinal control. Indeed a landing was made in this mode.

Of course no solution will be the perfect answer to all possible events. But, after the recent A300-600 accident, arising from the physical loss of the fin and rudder structure, isn't it time to re-visit all the causes and possible remedies to "loss to control"?

Captain Harry Hopkins

Duplicate/Secondary Inspections Working Group Draft Report

This report on the Duplicate Inspection process, (currently mandated within the United Kingdom and an integrated part of our aircraft maintenance systems), is intended to evaluate the integrity and value of the practises applied within the aviation industry today. The working group's investigation has been wide spread covering all disciplines from manufacture to line maintenance and best practices within other regulatory systems have been reviewed.

It is not our aim to eliminate a valid safety net but to provide information that can be effectively used to enhance the value of a process and its contribution to flight safety. Should you have any comments on the report we would be delighted to hear from you.

Comments can be e-mailed to chris.clark@british-european.com or posted c/o UKFSC at Fairoaks.

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Introduction

In the light of recorded events where duplicate inspection practices have failed to provide the requisite protection against flight safety incidents, the UKFSC Maintenance Sub-Committee elected a team of members to evaluate the validity of duplicate inspection. Terms of reference for the work package were developed, the defined objective being: "To identify opportunities for improvements in duplicate/secondary inspection processes to ensure their positive contribution to flight safety".

The attendant programme of work comprised the following tasks:

1. Determine and review the regulatory requirements for duplicate/secondary inspection in maintenance, and understand their relevance to current technology.
2. Quantify the application of duplicate inspection/secondary inspection practices, both to meet regulatory needs and to address negative experience.
3. Consider the effect of duplicate/secondary inspection on maintainability processes in both manufacturing and operational environments.
4. Develop a definition of "duplicate/secondary inspection", and provide initial guidelines for effective and efficient application.

As the project has progressed and its variable facets exposed it became necessary to use these topics for guidance only.

This report is the first deliverable of the workpackage with final recommendations to the UKFSC to follow.

Discussion

The origins of duplicate/secondary inspections appear to stem from the need to ensure primary areas of aircraft integrity, e.g. structural wires, mechanical links etc. and was developed as a post-war requirement to re-establish strict controls in the aircraft industry.

Duplicate inspection as a practice is defined in BCAR A6-2/B6-2 but is not referenced in JAR 145 as the JAA principles see duplicate inspections as a dilution of the maintenance engineer's responsibility. However, JAA Technical Guidance Leaflet 2 does provide for duplicate inspection processes when required by the aircraft maintenance programme but does not extend to direction on what circumstances prevail to warrant such additional inspections. These clearly fall under the aircraft operator's responsibility. The FAA, through FAR 21, chooses to mandate the listing of Required Inspection Items (RII) in the maintenance schedule.

The UK is almost unique in its definition of duplicate inspection arrangements and its application varies between manufacturing and maintenance activities. Whilst other countries may not specifically require or apply duplicate inspection, it is recognised that other assurance processes may be used to compensate for its absence. But what is clear is that current duplicate inspection activity does not fulfil the originally intended purpose. Indeed, there is evidence of a level of indifference being attached to duplicate/secondary inspections both in terms of its optional selection and the rigour with which it is undertaken and some examples are:-

- required inspections not being carried out

- crossed connections on equipment
- verification of improper maintenance
- workscopes ill-defined or too generic
- comfort factor for maintenance personnel

In other cases it can be argued that the duplicate inspection process did not fail but was not supported by robust processes earlier in the operational cycle. This argument would be sustainable if there was available evidence, but it has been shown that typically duplicate inspection results are not recorded. Hence, the actual success or failure of duplicate inspection systems cannot be quantified.

Whatever the failure or success rate is, the team are minded to consider there are enough anecdotal accounts to question the integrity and value of duplicate inspection processes as applied today.

The history of duplicate inspection is orientated around independent verification and can be considered as an early and easy option for error management. Although in the current climate of industrial change and preventative techniques this philosophy can be viewed as flawed, there are areas where duplicate inspection remains valid and important. However, this importance can be easily taken out of context and can be readily demonstrated by asking maintenance engineers the question; 'Why are you doing duplicate inspections?' The variety of answers will perhaps help to explain why the practice is seldom proposed as a remedial action from investigations into serious equipment related flight safety events.

Aerospace organisations have developed significantly in recent years with lean enterprise initiatives, business improvement programmes, personal accountability, technological advances, and management systems. Against this background, many of the regulatory conditions have not developed coextensively with technology and industry practice and continue to address the effect of traditional practices rather than the root cause of failures. The UK CAA have been leading or promoting a number of initiatives.

Safety Management Systems (SMS)

Maintenance Error Management Systems (MEMS)

Human Factors

Maintenance Error Decision Aid (MEDA)

CHIRP

These can provide a sound opportunity for potentially reducing or alleviating the need for 'company orientated' additional duplicate inspections.

It follows that any additional inspection should be applied in a way that reflects the importance of the task and must add to the maintenance process rather than compensate for any inherent inadequacies in it. It should be applied to those features or attributes that are specifically safety related and proportional to, and consistent with, service performance and experience. Typically, such importance would be assigned to:

ETOPs maintenance philosophy

Helicopters

Vital and Critical Parts

Vital Points (pre JAR-25 Type Certification)

Control Systems (BCAR A6-2)

This approach would ensure that duplicate inspection is only used in those exceptional circumstances that relate to true flight safety conditions. To this end, a maintenance organisation should determine the circumstances, method and frequency of duplicate inspection practices and demonstrate these to the satisfaction of the National Aviation Authority in parallel with other control systems to provide for assurance of product safety.

Conclusions

In the current climate there is a clear need and a role for duplicate/secondary inspection processes. To protect the integrity of this need, further consideration needs to be given to what constitutes best practice to provide a process that is both effective and efficient.

The exercise to consider opportunities for improvements in the duplicate/secondary inspection area has concluded, thus far, that the process has lost some of its importance and relevance in the safety orientated culture of today's aerospace industry. However, it is recognised that notwithstanding advances in technology and operating practices, the ETOPs maintenance philosophy by implementation of robust procedures

evidently does work and prevails in its assurance of flight safety. The benefits of this disciplined approach must be recognised and re-applied to the duplicate inspection process.

It has been determined that an over-emphasis on duplicate/secondary inspection processes can create complacency, as it becomes a routine rather than an exceptional requirement demanding rigorous attention. To enhance the role of such additional inspections there needs to be clear and unambiguous criteria for differentiation between duplicate, secondary and independent inspection requirements. Such enhancement, though, is constrained by the absence of a clarified JAA position on additional inspections, which is a prerequisite to a definitive standard, which reflects an agreed European approach.
It is recognised that variations to the application of duplicate/secondary inspections do exist at different maintenance stages, and the rationale for these variations does require to be addressed to ensure any industry wide approach is credible.

Route for Change

The project team propose the following as a way forward that develops the role of duplicate inspection rather than a radical change that could unknowingly jeopardise airworthiness.

1. Duplicate inspection, as a defined process, should be relaunched to establish it as safety orientated and value added.

2. Results of all duplicate inspections should be recorded and analysed such that the continued efficacy of the process can be determined.

3. Approved organisations develop the necessary clear, unambiguous, robust procedures for duplicate inspections which will satisfy the current regulatory requirements.

4. Maintenance personnel should be trained and developed to understand the implications and accountabilities of their activities such that the need for routine duplicate inspection can be minimised.

5. Manufacturers' maintenance documentation needs to reflect a process control approach to verification.

6. All aerospace industry sectors with an interest in flight safety should work together to minimise the need for additional inspections including design, manufacture, maintenance, operations and regulation.

7. The application of best practice processes should be sought and developed as a guide to the industry.

8. The CAA be encouraged to review their requirements for duplicate inspection and issue guidelines for a revised approach in line with this paper through an Airworthiness Notice.

The following documents were referenced during the compilation of this report:

British Civil Airworthiness Requirements, Chapters A5-3 and A6-2/B6-2

CAA Airworthiness Notices No.3 and No. 72

CAA Civil Aircraft Airworthiness Information and Procedures, Leaflet 2-13

US Federal Aviation Regulations, Parts 121.37, 121.365 and 127.132

US Federal Aviation Regulation, Part 43

UK Royal Air Force AP100B-01, Orders 4924 and 3975

Joint Aviation Requirements JAR 145

JAR 145 Administrative and Guidance Material, Leaflet No.2

Various UK Airline Company Procedures and Technical Instructions

Various UK Helicopter Operators' Procedures and Technical Instructions

Various UK Aircraft Maintenance Organisations' Procedures and Technical Instructions

Lock and Load? Safety and security in the air

by Dr Simon Bennett FICDDS - Scarman Centre, University of Leicester

The fallout from September 11th has been significant. The American aerospace and air transport industry has shed 100,000 jobs. Midway has gone under. In Europe Sabena has gone bankrupt while Swissair has been saved only by a thinly disguised state intervention facilitated by industry and the banks. BA's predicted loss for 2001 is £775 million.

Airlines that are exposed on the volatile North Atlantic market, have had to take action to restore public confidence. Companies are retrofitting more secure cockpit doors. In the US the FAA instigated a Special Federal Aviation Regulation (SFAR) under which the airlines could modify cockpit doors to make them more secure. An SFAR accelerates the approvals process. According to Mecham the temporary devices 'range[d] from deadbolts to bars that resemble[d] the crossbeams prairie settlers lowered to keep the bad guys out'. One airlines' solution was typical:

'After experimenting on [two aircraft types] it received FAA approval to install a metal brace that the pilots swing across the door from jam-to-jam on their side of the cockpit. The brace slides into U-shaped latches attached to the door frame.'

While airlines are to be commended for their speedy response, a number of points need to be made. First, none of these temporary measures provide a watertight defence against cockpit incursion. As the Vice President Engineering of one manufacturing company explained; '... no cockpit door modification currently being developed can absolutely assure denied access to the flight deck'. An engineering manager at Boeing admitted that even their Kevlar-reinforced door and bulkhead ensemble could not guarantee the security of the flight deck. As he explained to a US government panel: '[T]his [installation] does not prevent access by a determined intruder'.

Secondly, locking and barring cockpit doors inhibits quick and easy access between the flight deck and cabin. Given that free access is a prerequisite of crew resource management (CRM) the locking and barring of cockpit doors compromises CRM. Krause, citing research conducted by Chute and Wiener, suggests that even closing the cockpit door impacts CRM:

' A closed cockpit door can serve as a point of division in the same manner as when flight attendants are huddled in the aft galley. A territorial attitude of 'You take care of your part of the airplane, I'll take care of mine', is another problem indicative to the physical separation in an airplane.'

Clearly the greater the number and complexity of barriers to physical contact between flight and cabin crew (locks and door bars that can only be released if the PNF gets out of her/his seat; new interphone protocols; the use of spy-holes, etc) the greater the impact on CRM. Of course, some would argue that CRM is overrated. Those who hold this view should consider how much CRM contributed to the survival of passengers on board Al Haynes's DC-10 at Sioux City and how much CRM could have contributed at Kegworth. The AAIB's 1990 report into the crash asserted that; '... present patterns of airline training do not provide specifically for the exercise of co-ordination between cabin and flight crew in such circumstances'. The report concluded that; '... a different pattern of training could have favourably influenced the outcome'. Forty-seven passengers died at Kegworth, and sixty-seven were seriously injured. The airline went on trading, but only because of the Chairman's skilled and thoughtful media management.

What has been most interesting about the commercial aviation industry post-September 11th has been a) the huge emphasis placed on security measures and b) the de-facto de-emphasis of safety protocols like CRM. While this is perhaps understandable it should be remembered that overall safety levels are a function of both on-board security and CRM (and other inputs like intelligent design, high quality training and maintenance, etc.). In the US ALPA has embraced the new on-board security measures. In the UK there has been greater circumspection. (This may be a function of the 'risk attenuation' effect of physical distance). Speaking just after Virgin and BA announced their

retrofit programmes BALPA's General Secretary stated that locks that could only be operated if pilots left their stations were '... ill-considered, ill-conceived and potentially dangerous .... Deadlocks will put passengers in more, not less danger'. BALPA stated that locked doors would prevent cabin crew from carrying out periodic checks on the Captain and First Officer and alleged that pilots had not been consulted about the changes. The Chair of BALPA's Security Committee commented:
' The locking of cockpit doors can in fact reduce the safety both of the crews and of the aircraft by denying access in the case of an accident or incident .... [D]eadlocked cockpit doors ... won't stop the terrorist and they do hinder the crew.'

While there was no overt reference by BALPA officers to CRM, the General Secretary did state: 'You cannot turn the cockpit, which is the nerve centre of a complex environment, into a fortress. The success of a flight relies on a close working relationship between pilots and cabin crew (my emphasis).'

Locking and barring cockpit doors raises a third issue — crime displacement. The crime displacement theory states that if a would-be terrorist is denied access to their preferred weak point — the flight deck, for example — the terrorist will look for another 'chink in the armour'. The December 22nd attempt by British Muslim Richard Reid is a case in point. It might be theorised that the only effect the locking of the cockpit door had on Reid was to persuade him to bring the airplane down from his seat. (Had Reid used a lighter instead of matches he might have succeeded in igniting the explosives secreted in his shoes). That is, the locked door had no effect other than to persuade Reid to change his strategy, an example of tactical crime displacement. Crime displacement could take other forms, too. If thwarted by tighter check-in security, terrorists might resort to bringing aircraft down over London with shoulder-launched SAMs. SAMs are readily available in Eastern Europe. A terrorist could simply drive into Richmond Park, unbag the SAM, wait, aim and fire. In all probability s/he would not be traced from the crime scene.

A fourth point concerns what might happen if the airlines invest more resources in security. A correlate of this investment may be dis-investment by other parties. A theory called 'risk compensation' explains how this might come about. Within any socio-technical system (like commercial aviation) if one component part is made safer, other parts may become less safe, the premise being that the overall level of safety in any system tends to remain the same (through a process known as risk homeostasis first identified by Professor John Adams). Regarding commercial aviation, risk compensation suggests that if aircraft are secured there is less incentive for the government to invest in intelligence and policing and for airports to invest in adequate equipment, screener training and remuneration (woefully inadequate in the US pre-September 11th). That is, risk management is transferred wholesale to the airlines (physically, to the aircraft themselves). Dis-investment in ground-based security (or a failure to increase investment to adequate levels) is made possible because the locking and barring of cockpit doors means that the airborne component of the system is less vulnerable to attack (at least in theory). Why invest in costly law enforcement and airport security if — through on-board security — the airlines are bearing the risk?

It would seem self-evident that the safest location for an interdiction is on the ground, preferably well away from the airport terminal, either at the terrorist's home or place of work or somewhere in between. The worst location is on board a kerosene-laden aircraft flying close to the speed of sound at 35,000 feet half-way across the Atlantic. Could there possibly be a less satisfactory place to fight the War on Terrorism? The consequences of a successful attack in this situation are enormous: loss of life; loss of capital; loss of reputation (let us not forget that Lockerbie spelled the beginning of the end for Pan Am); acute economic disruption; psychological trauma; chronic impacts on tourism, the insurance industry and political stability. All these

impacts have been seen post-September 11th. In contrast, an interdiction away from the airport, even if it goes wrong, will have very limited consequences. Intelligence and law enforcement officers and informants may be killed — but no aircraft will plunge into the sea. There will be no watershed images of prestige locations aflame or destroyed. Innocent lives will not be lost. There will be no stock market panic. In all probability there will be no media coverage whatsoever. BALPA identified this issue in their October 31 press release:

' It's on the ground that terrorists need to be stopped, and new systems have been developed that are about to be trialled [like QinetiQ's Matchmaker]. Once a terrorist gets on an airliner .... [t]he damage is done.'

Bennett, too has highlighted the primacy of ground-based security:

' You [safeguard aircraft through] effective intelligence and law enforcement, relevant laws, training security personnel and paying them well, motivating them and giving them the equipment.'

Pre-emption is the ideal. But pre-emption requires a number of difficult preconditions to be met. First a willingness on the part of all governments to deal with the problem head-on. Secondly a willingness to share intelligence. Thirdly a willingness to invest the necessary financial resources in law enforcement, and intellectual resources in a workable and relevant system of national and international laws to counter the hijacking threat. If necessary, rich countries should subsidise poor countries. In security as in other fields 'the chain is only as strong as its weakest link'. There is a precedent for 'cross subsidy' in commercial aviation: For many years African aviation has been plagued by inconsistent levels of investment in air traffic management (ATM). But through the cross-subsidisation activities of the Common Market for Eastern and Southern Africa (COMESA) and Southern African Development Community (SADC) the standard of Africa's ATM is improving.

Globalism has delivered many economic benefits. Global thinking on law enforcement could deliver commensurate benefits for security and safety. Surely a worthwhile objective for the second century of flight? And a worthy epitaph for the thousands of people murdered on September 11th, 2001.

Sources

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Dr Bennett's latest book *Human Error — by Design?* is available from Perpetuity Press price £14.95. Email orders@perpetuitypress.co.uk or http://www.perpetuitypress.com

8.33 kHz Exemption

Since the issuing of AIC 102/1999 (Yellow 344), 22 additional States, including the UK, have agreed to take part in the horizontal expansion of the implementation 8.33 kHz channel spacing. Implementation within these States will have an effective date of 31 October 2002. Hence the current 8.33 kHz exemptions within the UK will be extended until 2359 UTC 30 October 2002.

Should you require any further information with respect to the horizontal expansion of 8.33 kHz operations within the UK then please contact Mr A P Knill, Mgr S&SM, telephone 020 7453 6530.

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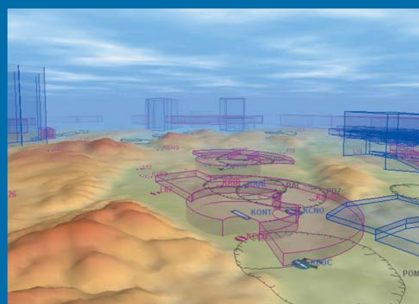

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