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Contents

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FOCUS is a quarterly subscription journal devoted to the promotion of best practises in aviation safety. It includes articles, either original or reprinted from other sources, related to safety issues throughout all areas of air transport operations. Besides providing information on safety related matters, **FOCUS** aims to promote debate and improve networking within the industry. It must be emphasised that **FOCUS** is not intended as a substitute for regulatory information or company publications and procedures.

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Front Cover Picture: London's Air Ambulance at Tower Bridge

Safety, Security and Stability

by Dai Whittingham, Chief Executive UKFSC

As 2014 draws to a close it is worth noting that this year is likely to be remembered for all the wrong reasons. We have seen a wide-body aircraft vanish without trace and another unbelievably hacked out of the sky by a surface-to-air missile, both with significant loss of life, and we have seen operations into a developed nation temporarily suspended because of the threat from unguided rockets. And it is doubly unfortunate that both aircraft losses affected the same operator. Our friends at Malaysia Airlines of course have our sympathies for the loss of colleagues and friends but spare a thought also for those faced with the challenge of leading and managing in an attempt to get on with the job at hand, namely flying and maintaining a viable business.

The downing of MH17 will resonate through the industry for many years to come. While there may be persistent arguments about who fired what from where, and why, there seems to be little doubt that the aircraft was serviceable and being operated safely before it became a casualty of events in the Ukraine. There will certainly be continuing questions about the operator's decision to route through an area of known conflict, though few would have believed that a sophisticated military weapons system would be used to attack a third-party civilian platform. The problems of determining safe over-flight were discussed more fully in the last edition of FOCUS, but we can probably agree that the issue with MH17 was one of security rather than safety. Or was it? Are security and safety separable?

Turning to MH370, unless and until the aircraft is located we have no real prospect of determining whether its loss was due to one of the many postulated emergency scenarios, such as fire and fumes or depressurisation and hypoxia, or whether it was the result of a deliberate act by a crew member or someone else on board. Returning to our safety versus security question, an in-flight emergency is clearly a safety issue whereas deliberate intervention would, at first sight, be a security matter. Or is it really such a simple division? Consider for a moment a fire that is started deliberately. It is still a fire and must be dealt with like any other emergency situation but the cause arguably owes more to security than to safety, whatever the safety outcome. In February this year someone started 5 separate fires in passenger toilets on board an Etihad B777 routing from Australia to the UAE, resulting in the captain diverting to Jakarta. The flight continued after matches and lighters had been confiscated from all passengers and crew but the culprit has yet to be identified. Ironically, the early detection of the fires was a result of measures to prevent passengers from smoking in flight – without the prohibition on smoking there would perhaps have been no need to install smoke detectors in every toilet compartment - an unintended but happy consequence of an unrelated health measure.

However, in 2002 a passenger succeeded in bringing down a China Northern Airlines MD-82 by starting a fire at his seat with petrol he probably smuggled on board in water bottles. The passenger had taken out 7 life insurance policies shortly before travelling; his successful suicide also cost the lives of 111 innocent people who were unfortunate enough to have been on the same flight. So, security then, unless failure to manage security-related fire, smoke and fumes or damage can be attributed to poor training or weak design, in which case it becomes a safety issue again.

But the deliberate setting of fires in flight or suicidal actions on the part of flight crew or passengers are actually a manifestation of mental health problems. If, as some have already postulated, the loss of MH370 is eventually attributed to the mental health of one of the flight crew, the questions that arise are as significant for the industry as those resulting from our inability to track the aircraft in flight or locate the wreckage thereafter. On the latter point, ICAO is already taking action on improvements to crash position indicators and underwater locator beacons as a result of the AF447 experience, and EASA is accelerating work to enshrine the new standards in EU law. Mental health is, so far as our industry is concerned, a hidden problem. So is it a major problem?

The available statistics on mental health in the UK suggest 1 in 4 of the adult population will be affected by a mental disorder at some stage in any given year. At any one time, around 15% of the population is affected (because some disorders can be seasonal). And of course we need to remember that people entering aviation are a representative sample of the general population. Flight crew personalities tend to be stable, which may provide an element of protection, but it would be quite reasonable to assume that a proportion of the current crew population may be suffering, or have suffered, from a mental illness of some description.

Medical professionals – the only people qualified to properly diagnose mental illness - divide symptoms into 2 main groups: neurotic and psychotic. Neurotic symptoms can be considered as extreme forms of normal psychological responses such as depression, anxiety and panic, whereas psychotic symptoms are those that interfere with a person's perception of reality, such as delusions, paranoia and hallucinations. Psychotic symptoms are often associated with the more severe mental illnesses, but neurotic disorders can themselves be severe.

'Depression' is used to describe a range of moods, ranging from low spirits to more severe mood problems that interfere with everyday life. A depressive episode is diagnosed if at least two out of three core symptoms have been experienced for most of the day, nearly every day, for at least two weeks. These core symptoms are: low mood; fatigue or lack of energy; and lack of interest or enjoyment in life. A depressive episode may be classed as mild, moderate or severe, depending on the number and intensity of associated symptoms, such as sleep disturbance, anxiety, poor concentration, irritability and suicidal thoughts.

So is your irritable captain depressed? Almost certainly not, but it might be a warning flag if he or she is also having problems with sleep. Anxiety is perhaps more common than we may think, and it may be associated with a particular phase of flight or even a specific route. Most of you have come across passengers with an irrational fear of flying, some are terrified of take-off, others by landing, and some who find it hard to deal with the whole experience. And there are pilots who are uncomfortable in cloud or at high level, or who can't tolerate aerobatics; these are examples of mild disorders but for some it can presage full-blown panic attacks that may be incapacitating. And it can all be treated.

I had the privilege recently of listening to a lecture from Captain Richard de Crespigny, who was in command of QF32, the Qantas A-380 flight which suffered an un-contained engine failure resulting in multiple, compound failures that taxed its augmented crew to the limit; he described QF32 as having effectively been hit by a missile; indeed, his aircraft had over 500 separate punctures. Apart from a compelling account of the incident itself, he also took time to recount the fact that he subsequently suffered from post-traumatic stress disorder, no doubt generated by the extreme existential pressure at the time, a pressure exacerbated by the knowledge that 469 lives depended on his decisions and actions. Eight percent of all men will suffer from PTSD after a traumatic event; the figure is a little higher for women. With the aid of a psychiatrist Richard recovered to full health and returned to flying a few months later, but to his great and lasting credit he now talks openly and unashamedly about his PTSD experience. His message to the audience was simple: if your colleagues discuss mental health problems such as PTSD, anxiety or depression, or even admit to some of the symptoms, listen to them and believe them. Good advice.

So should we be screening people for mental health? Without evidence to support such a move, that would be a step too far and in any case some personality disorders would require the services of a forensic psychiatrist for proper diagnosis. However, the industry could well do with some understanding and enlightened management of those unfortunate enough to suffer from a mental health problem, which needs to be considered in the same light as any other ailment. With proper and early treatment to prevent descent into severe illness, the vast majority of people will return quickly to normal duties and many will be able to continue to operate in safety.

Where does this leave us with safety and security? One of the accepted models for successful statehood is 'Security, Stability, Prosperity'. Without physical security there will be no prosperity, and both will be undermined without the stability brought about by the rule of law and a political process that eschews extremes. They are interdependent factors; just so with safety and security. One cannot function without the other, but we do need to make sure that one does not compromise the other and that we are not so safe or secure we become unable to operate effectively. The locked flight deck door was an understandable response to 9/11 but there were unintended consequences: the imposition of a barrier to communication between flight and cabin crew; and an increasing number of young people who will never have the opportunity to see and be inspired by the modern flight deck and its occupants.

Aviation in all its forms will always carry an element of risk and we should not forget that. The move to performance-based regulation means that in future there will be a much greater requirement for operators to identify risk and treat it if possible, or tolerate it, or avoid it. Corporate risk appetite is a very subjective consideration and is thus quite hard to quantify or include as a policy within an SMS. There will be operations where increased risk is very evident – such as Virgin Galactic – but until such operations exceed the regulator's or operator's comfort boundaries this should be no bar to success provided there are customers willing to accept those risks. And let us not also lose sight of the fact that corporate risk is borne by the operator, while physical risk is borne by passengers and crew. The final call on whether security or safety risks are acceptable lies with the aircraft commander; it is the primary and most fundamental of command responsibilities.

Human Factors – and Flightdeck Design

by Chris Brady, Chairman UKFSC

Most aviation staff and safety professionals are now aware that human factors are present in almost every event to a greater or lesser degree. To combat this, commercial pilots have been trained and examined in CRM since the early 1990s and many organisations are starting to roll these training programs out to other operational departments such as engineering and ground ops.

There is perhaps another area of human factors which is less easily addressed by operators, that of design; in particular designs which unintentionally invite errors. Flightdeck ergonomics can set all sorts of traps which were not immediately apparent at the design stage. Whilst flightdeck design has undoubtedly come on a long way over the years there are still many traps out there. At one end of the scale, there are very few pilots who have not turned the wrong knob on an autopilot MCP or FCU and tried to enter a speed/heading/altitude in the wrong window. Many 737 pilots have almost (or actually!) switched off the B system hydraulic pumps when intending to put the engine anti-ice on because the pair of switches are identical and located above each other. Less frequently, but more significantly, there have been several reports of A320 crew operating the parking brake instead of the engine mode selector during engine start on pushback as both selectors are out of the immediate line of sight and require a right turn through 90 degrees. At the far end of the consequence scale was a 717 crew who accidentally trapped an iPad between the throttles and the engine master switches in the cruise knocking both switches off. Fortunately the engines were quickly relit and no harm was done. Most aircraft types have guards or gates on the engine master switches to prevent accidental movement; alas these appear to have been ineffective.

Boeing 717 Engine Master Switches

A recent high profile example of incorrect switch selection was a 737 over Japan in 2011 in which the First Officer accidentally moved the rudder trim knob instead of the flightdeck door admittance knob. This caused the autopilot to disengage and the aircraft rolled to a maximum 131.7 degrees and lost approximately 6,000ft of altitude. Both knobs are similar in size and location (aft of the pilot), are turned to operate and are spring-loaded back to neutral.

Boeing 737 Rudder Trim and Door Lock knobs. (JTSB)

The report (Ref AI2014-4) published by the JTSB in September 2014 and the subsequent FAA Special Airworthiness Information Bulletin, NM-15-03, published in November 2014 are both worthwhile reading for operators and manufacturers of any aircraft type as they give an insight into this sort of error and recommend some procedural and configuration changes which may help to prevent this type of event in the future.

Most mis-selection errors are minor or quickly corrected and hence go unreported and are therefore unknown by operators and manufacturers. The full extent of such slips and lapses can often only come to light from a LOSA study, which is one of the many reasons that I recommend every operator undertake a LOSA program. Once a trend is discovered it needs to be passed on to the regulators and manufacturers so that they can evaluate it with data from other operators and take any necessary mitigating action. Present reporting systems, such as the CAAs MOR scheme, tend to focus on the more severe events thereby filtering out the low level, precursor events which could lead to the type of consequences described above. The industry needs to engender a culture of proactive reporting of low level events and find a mechanism to escalate the trends upwards to those that are in a position to affect change.

Reducing Runway Landing Overruns

by Marisa Jenkins, Flight Deck Surface Operations Principal Investigator, and Captain Robert F. Aaron, Jr., Safety Pilot, Flight Technical and Safety

Working with industry, Boeing is implementing a combination of procedural improvements, flight crew knowledge, and flight deck enhancements to mitigate runway overrun excursions during landing.

Runway overruns during landing are a top safety focus for Boeing, regulatory agencies, and the entire commercial aviation industry. Boeing is working with the industry to develop a comprehensive runway safety strategy — called Situational Awareness and Alerting for Excursion Reduction (SAAFER) — that is based on a data-driven consensus of root causes, risk factors, and interventions.

This article explores the strategy in terms of near-and long-term recommendations to airlines and flight crews to address the causes of runway overruns as well as flight deck design solutions currently under development.

Causes of runway overrun excursions

Boeing event data shows that there are numerous contributors to runway overruns. Causes of landing overruns may begin as early as the approach briefing or occur once the airplane is on the ground and decelerating (see fig. 1). Understanding the root causes of runway excursions is fundamental to mitigating them.

Event data, analyzed collectively from 2003 to 2010, shows the factors contributing to landing overruns occur at these frequencies:

- 68 percent occurred after stable approaches.
- 55 percent touched down within the touchdown zone.
- 90 percent landed on an other-thandry runway.
- 42 percent landed with a tailwind of 5 knots or greater.

When flight crews are aware and in control of a situation, they are able to make effective and timely decisions to ensure a safe landing.

This event analysis was the key driver for developing Boeing's runway safety strategy. Solving the excursion problem also requires acknowledgment that:

- Excursions are caused by multiple factors.
- Mitigating any one factor will not fix the bigger runway overrun excursion problem.
- More than one type of solution is necessary.

The runway safety strategy

The Boeing SAAFER strategy implements a combination of procedural and flight deck enhancements along with additional crew education (i.e., training aids) to mitigate runway landing overruns. Components of this approach — procedural enhancements, training aids, and existing flight deck technology — are already available to operators. Boeing recommends implementing these excursion mitigations immediately.

Boeing's runway safety strategy provides flight crews with enhanced awareness, guidance, and alerting tools from the approach-planning phase through landing rollout and deceleration. The strategy's goal is to keep pilots aware and in control of this phase of flight and enable them to make correct and timely decisions that will ensure a safe landing.

This approach is considered a strategy because it encompasses more than just flight deck enhancements. It's designed to improve cognition and pilot decision-making during this high workload phase of flight without overloading the pilot.

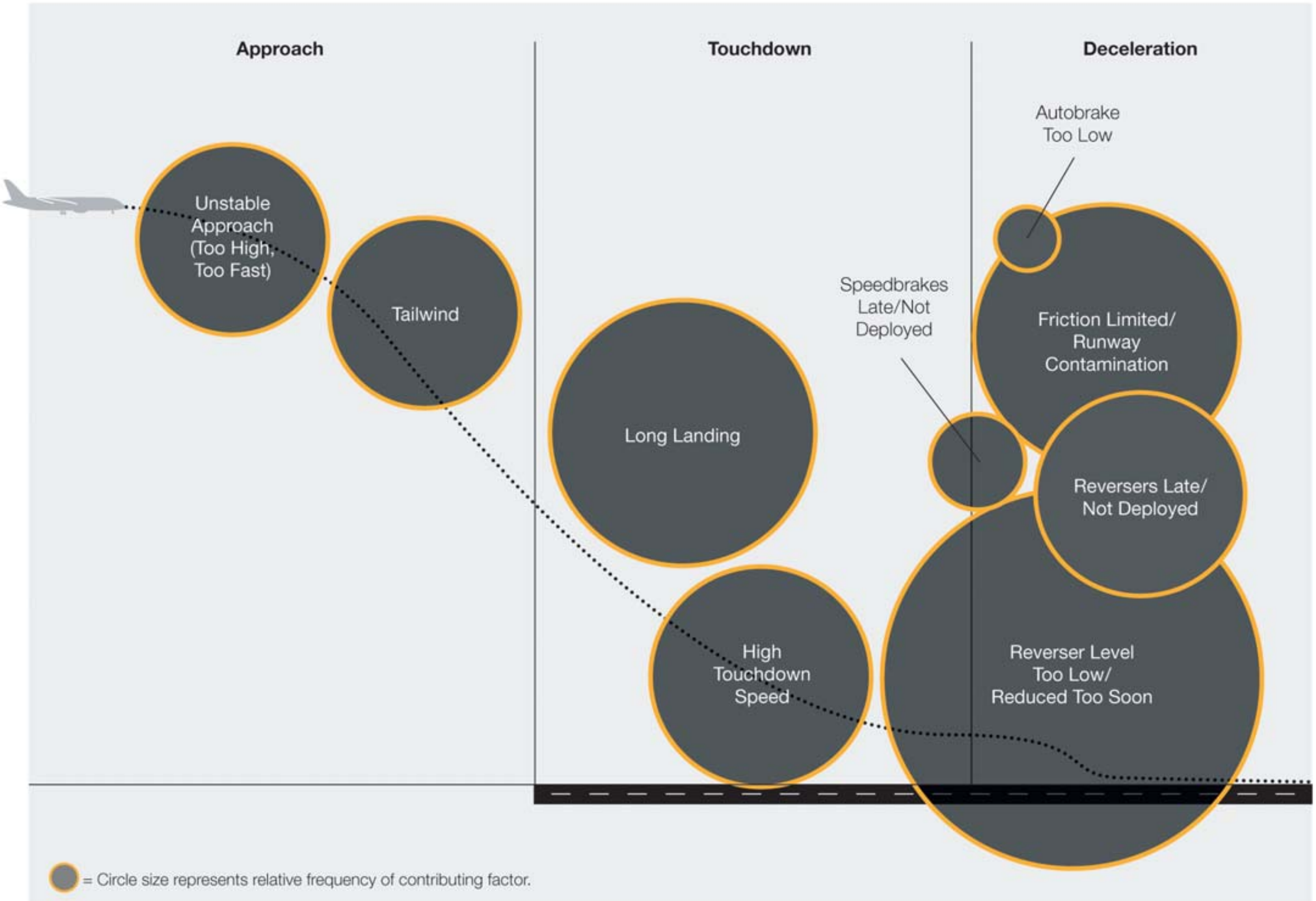
Recommended approach and landing procedures

Boeing recommends that airlines consider modifying their approach and landing procedures to incorporate runway safety recommendations. Augmenting existing landing procedures is a currently available solution that can mitigate runway overrun excursions in the near term without waiting for future technological flight deck enhancements.

- **Calculate required runway length**. As the flight crew prepares its approach briefing, it should use real-time information to analyze how much runway is required relative to runway available. Performing a landing distance calculation using the real-time airplane and actual runway data (e.g., contamination, wet, grooved, or ungrooved surface) can mitigate runway overrun excursions caused by inadequate runway length.

Figure 1: Causes of landing overrun excursions

The circle size represents the relative frequency that the item was a contributing factor to a runway overrun. Frequently, a runway overrun is the result of more than one contributing factor occurring simultaneously.



- **Determine go-around point**. Calculating and briefing a go-around point or the latest point on the runway by which the flight crew must touch down during the approach briefing also has potential to reduce overrun excursions. This go-around distance calculation can mitigate the approximately 44 percent of runway overrun excursions that are attributed to long landings.

- **Add thrust reverser callout**. Boeing has added a mandatory thrust reverser callout to the flight crew training manual and the flight crew operating manuals for all Boeing models. It is intended to increase the flight crew's situational awareness of thrust reverser deployment in conjunction with the speed brakes during the landing rollout. This callout, along with using the reversers until the stop is assured (no early stowage), provides a runway excursion mitigation for the approximately 80 percent of excursions where inadequate or late thrust reverser usage was a contributing factor.

Updating approach and landing procedures may not address all runway overrun excursion events that are caused by inadequate runway length when landing long or using inadequate or improper deceleration devices. These runway overrun excursions may require additional pilot situational awareness and involvement. However, these relatively simple, highly feasible, non-equipage enhancements can help reduce runway overrun excursions in the near term.

Runway safety training aids

Runway overrun event data suggests that a number of runway overruns can be avoided if the flight crew has a more thorough understanding of the interrelationship between the landing environment and the potential risks existing that day (e.g., weather, winds, runway conditions, minimum equipment list items, airplane weight).

Pilots need to better understand the relationships among these factors for each flight:

- Flying a stabilized approach.
- Runway contamination, known and accounted for.
- Runway length available versus required.
- Reported conditions compared to actual conditions.
- Approach speed for that flight's approach.
- Energy to be dissipated after landing.
- Speed additives and effect on landing distances.
- Reliability of runway braking action.
- Proper, timely use of all deceleration devices.

A failure or misunderstanding of each of these factors has contributed to runway overrun excursions. For example, many flight crews may not fully understand the importance of using thrust reversers on wet runways. As runway friction decreases due to deteriorating runway conditions, the role of the thrust reverser becomes more important. Additionally, there have been accidents in which the crew had difficulty deploying the thrust reversers and consequently neglected to ensure the spoilers were fully extended during the landing rollout.

Another concern centers on ensuring that the appropriate deceleration devices are used until the airplane is at a stop. This is especially important when there is a known risk of an overrun excursion. It is necessary to ensure all deceleration devices are utilized fully when facing a runway overrun excursion.

The aviation industry has produced a variety of useful tools to help pilots understand these relationships. The Flight Safety Foundation approach and landing accident reduction toolkit and the International Civil Aviation Organization/International Air Transport Association toolkits are available on the Internet. They provide valuable information flight crews can use to help avoid runway overrun excursions.

Boeing is developing an approach and landing training-aid video intended to be viewed by pilots in order to enhance their understanding of their dynamic landing environment, the day's risk factors, available tools, and desired actions and outcomes relating to runway excursions.

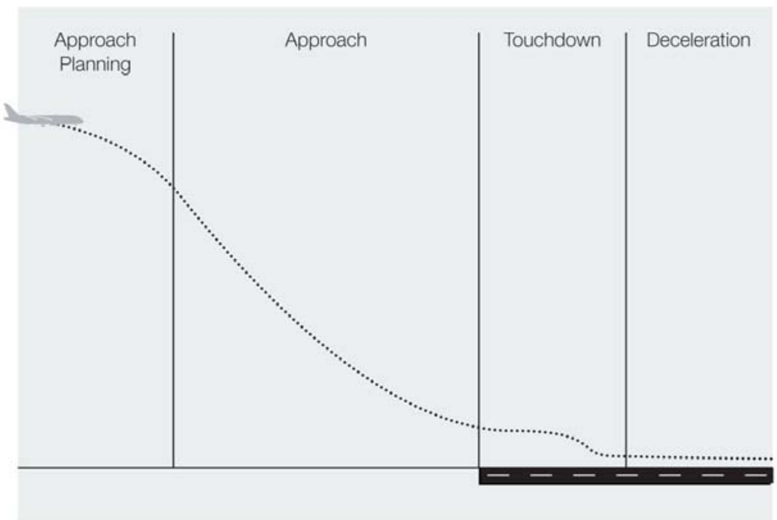
New safety technology

Boeing is focusing on human-factorsdriven flight deck design enhancements that are consistent with existing and planned airport, air traffic, and customer operating strategies. These enhancements are targeted at runway overrun prevention through all approach phases: approach planning, approach, touchdown, and deceleration.

During approach planning, flight deck tools and procedures assist the flight crew in determining the required runway length and where on the runway the airplane is expected to stop, given current conditions (see fig. 2). Boeing already offers a landing distance calculator on electronic flight bags. The new strategy augments this existing technology by adding a more effective way to display this information to the flight crew. By graphically depicting the dry and contaminated stopping location during approach planning, the crew can definitively assess its risk of runway overrun before touching down. The pilot also has the option of manually entering a reference line. This could be a land and hold short operation, a taxiway exit, or a desired touchdown or go-around point.

Figure 2: New approach planning technology

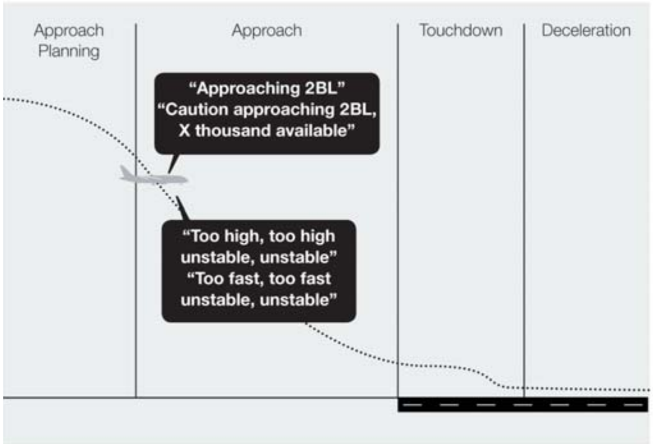
New technology is intended to enhance the existing flight deck during these approach, landing, and rollout phases.

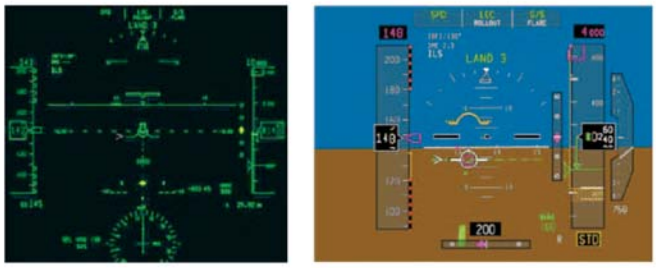


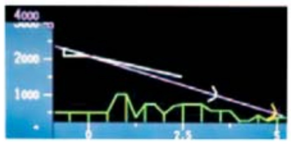
- Display of landing distance for dry/ contaminated runways
- Assessment of runway length vs. required

Figure 3: Approach technology

Flight deck enhancements provide aural and visual cues to assist the pilot in flying a stabilized approach.



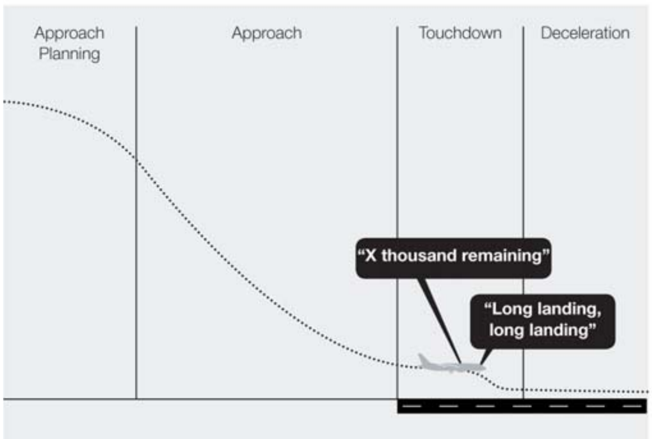


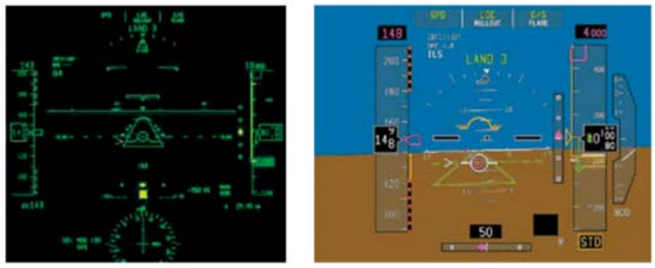


- Stability (speed, altitude, glideslope) guidance
- Simplified approach technique
- Runway situation awareness and alerting
- Instability alerting

Figure 4: Touchdown technology

Flight crews receive landing and flare guidance on the head-up display (HUD) and aural and visual runway positional situation awareness on the HUD and primary flight display.





- Landing and flare guidance
- Runway positional situation awareness
- Long landing alerting

During the approach, the airplane's stability and tailwinds are major contributing factors to runway overrun excursions. New flight deck enhancements provide aural and visual cues to assist the pilot in flying a stabilized approach (see fig. 3). Boeing's new runway safety strategy provides a simplified approach technique to reduce workload even in normal conditions. As a final safeguard, the system alerts the pilot to unstable conditions or to a runway that is too short for that landing.

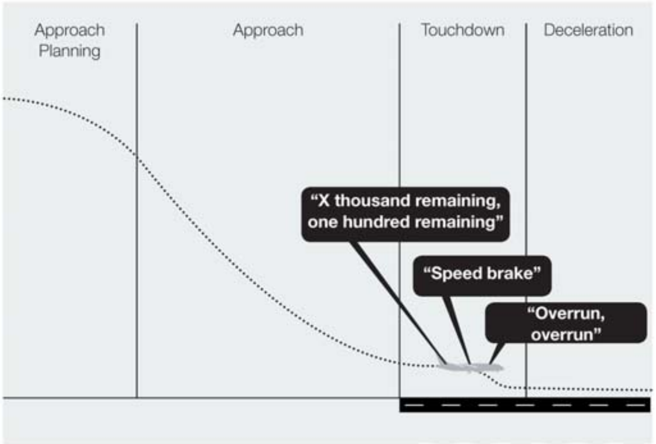
Communication and knowledge sharing in the flight deck are important. For airplanes that are equipped with head-up displays (HUD), the pilot and co-pilot can view the same information on the HUD and on the primary flight display. Even in a single-HUD airplane, both pilots will have the same display of information on which to base their piloting decisions.

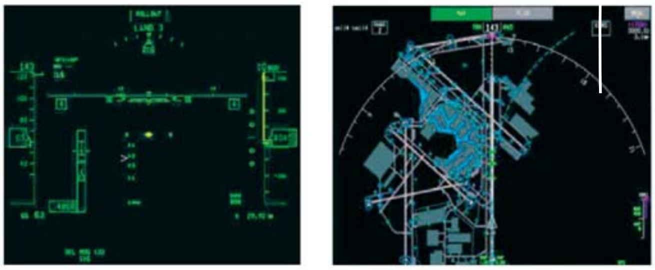
After reaching decision height but before touching down, the primary contributing factor to a runway overrun is a long landing (i.e., airplane that exceeds the touchdown zone). Boeing's new runway safety technology provides landing and flare guidance on the HUD and aural and visual runway positional situation awareness on the HUD and primary flight display (see fig. 4).

Conformal runway edge lines and runway remaining markers assist the crews' positional situational awareness on the runway even in low-visibility conditions. After touchdown, the primary contributing factors of runway excursions are the actual runway condition

Figure 5: Deceleration technology

The system provides a visual indication of the predicted stop point on the runway based on real-time deceleration, as well as a distance-remaining voice callout.





- Runway positional situational awareness
- Display of predicted stop location
- Overrun alerting

and inadequate or late use of deceleration devices. Boeing's SAAFER strategy provides a visual indication of the predicted stop point on the runway based on real-time deceleration. It also provides a distance-remaining voice callout and alerts the crew when its current deceleration is insufficient and may result in a runway overrun excursion (see fig. 5).

The purpose of all these flight deck enhancements is to increase the pilot's situational awareness by providing the guidance and alerting tools during all phases of the approach, landing, and rollout.

Availability of new flight deck technology

Advanced flight deck enhancements are in development. Boeing continues to focus on enhancements for in-production and future fleets. It is recognized, however, that the existing fleet can benefit from enhancements that can be feasibly developed and incorporated, and Boeing is also focused on developing cost-effective, model-specific solutions that build off of the model's existing features and architecture. For the in-production fleet, these enhancements are targeted to start in 2015. Out-of-production retrofit packages will occur afterward.

A number of technologies are already available. Boeing encourages fleet uptake of these equipage mitigations currently available:

- Head-up display.
- Vertical situation display.
- Onboard performance tool.
- Runway awareness and advisory system.

Summary

Boeing's SAAFER strategy combines procedural and flight deck enhancements with additional crew education to mitigate runway overrun excursions. When flight crews are aware and in control of the situation, they will make effective and timely decisions to ensure a safe landing.

For more information, please visit www.boeing.com/saafer.

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Third Country Operators – New rules enter into force for non-EU commercial air transport operators flying into the European Union

by Christopher Smith, Associate, Holman Fenwick Willan LLP

On 26 May 2014, European legislation (Regulation (EU) 452/2014) came into force, aimed at harmonising the process by which the safety of foreign (i.e. non-EU) carriers, known as Third Country Operators (TCO), undertaking commercial air transport to, from or within the EU, is assessed.

Historically, foreign airlines have had to satisfy individual Member States that they were operating to an acceptable safety standard, often involving different processes and applying different criteria. From 26 May 2014, however, TCO safety will be assessed by the European Aviation Safety Agency (EASA), on an EU wide basis, against a uniform framework set out in the new Regulation. This will require TCOs to obtain a safety authorisation from EASA.

A TCO authorisation is required by all operators performing commercial air transport to, from or within the EU under an air operators certificate or otherwise operating aircraft to transport passengers or cargo for remuneration or other valuable consideration. Accordingly, EASA, who will oversee the TCO authorisation process, has indicated that authorisation will not be required for private flights, flights operated by a US Part-91 operator or air operations properly classified as aerial work. For operations which do not fall within the new TCO scheme, operators will continue to apply to the Member State concerned for any applicable authorisation.

All TCOs currently operating to, from or within the EU have until 26 November 2014 to file their TCO application with EASA. Applications will then be dealt with, by EASA, over a 24 month transition period to ensure that air traffic is not disrupted. Existing operators who fail to file their TCO application before the deadline may face the risk of disruption to their operation.

Given the scale of change involved, EASA has published comprehensive guidance on the TCO application process.

Further information can be found on the EASA website www.easa.europa.eu

June Cox – "Silver Anniversary"

This edition of FOCUS coincides with a significant date for the UKFSC. On 4th December 2014, June Cox completes 25 years of unbroken service to the Committee as our Fairoaks Office Manager. Those of you who have attended UKFSC SIE meetings will have met her, as will anyone who has attended one of the Flight Safety Officer courses. Besides keeping the books straight, June also organises the SIE meetings and the courses, and she has become expert at keeping Chief Executives on track; I am the 4th to have benefited from her extensive corporate memory and wise counsel. There is however one element of her output that goes largely unrecognised in public - at least until now - which is her work on FOCUS. While it is my name that is recorded as being the editor, it is June who does the vast majority of the legwork in chasing articles, authors, photographs, deadlines and our publisher (thanks, Andrew), and who (with Lisa) has the delights of proof-reading the whole magazine.

Congratulations, June, on achieving this milestone in your working life and a huge thank you from all of us in the UKFSC for your commitment and for all you have contributed to the Committee, and to FOCUS, over the last 25 years.

Dai Whittingham
Chief Executive

Operations within a Joint Forward Air Control Training and Standardisation Unit (JFACTSU) Notice to Airmen (NOTAM)

"But it's only a warning!"

by Flight Lieutenant J Meadows, JFACTSU Deputy Flight Commander

Some of you reading this may have seen a JFACTSU NOTAM during sortie planning and experienced some frustration as a result. Whilst many operators will amend their sortie profiles to avoid the NOTAM, there may be occasions when this is not possible without impacting upon the aims of the sortie. Furthermore, the NOTAM is a warning rather than an avoid, allowing crews to operate within the airspace if they wish. This article will provide some insight into the nature of JFACTSU operations within the NOTAM, which will hopefully help crews operate safely whilst minimising disruption to their planned sortie profiles. The issued NOTAM should be viewed as an aid to safe planning, rather than a hindrance.

JFACTSU is the only UK unit conducting Forward Air Controller (FAC) training. The training consists of both simulated and live aircraft controls; the latter being conducted at a selection of Observation Posts (OPs). The student FACs and FAC-Is (instructors) will deploy to the OP, generally within 60 nautical miles (nm) of RAF Leeming, and they will usually operate from 0900 Local to 1700 Local (the hours of operation will be detailed in the NOTAM). Throughout the promulgated active hours there will be a variety of aircraft operating with the FACs, including the dedicated JFACTSU Hawks, based at RAF Leeming. JFACTSU exercises are additionally supported by the front-line squadrons and will, therefore, host a variety of platforms throughout the published hours of operation.
The airspace detailed in the NOTAM will often be 5nm in radius and will extend from the surface to a height usually between 5,000 feet and 14,000 feet. The NOTAM will include contact mobile phone numbers and radio frequencies. Aircraft operating with the FACs will be utilising a single UHF frequency for training whilst receiving an Air Traffic Control service on the **JFACTSU-owned VHF frequency 131.175.** JFACTSU Royal Signals personnel at the OP will monitor the published phone numbers and radio frequencies. The OP callsign, 'JACKPOT CONTROL', can be contacted either on the JFACTSU VHF or allocated UHF frequency.

Aircraft operating in support of the FAC training do not operate solely within the confines of the NOTAM. Participating aircraft will seek to minimise their time at low level and we may have aircraft holding outside the NOTAM awaiting clearance to join. The pilots' workload is extremely high as they are required to deliver simulated Close Air Support and act as airborne instructors to the student FACs, in consultation with the FAC-Is on the ground. The aircraft will conduct highly dynamic manoeuvres at low and medium altitude. Our primary concerns at JFACTSU are Controlled Flight into Terrain (CFIT) and Mid-air Collision (MAC), owing to the high workload and dynamic manoeuvres being flown.

The sorties are Radio Telephony (R/T) intensive for the participating crews, requiring them to receive briefs and rapid 'talk-ons' from the student FACs, whilst maintaining a listening watch with ATC and JACKPOT CONTROL. Where possible, we request that crews attempt deconfliction in the planning stage, prior to getting airborne. The easiest way to achieve this is to call the mobile phone number given in the NOTAM. Whilst JFACTSU exercises are planned to maximise the training for our student FACs, we will always try to minimise disruption to other aircraft operating in the surrounding area. Where possible, we will instruct participating aircraft to remain at medium-level such that other aircraft are able to transit the NOTAM safely. However, we are unable to achieve this if we do not know your intentions.

JFACTSU have elected to establish a NOTAM to provide some protection to aircraft operating in the area. The NOTAM is there to provide valuable situational awareness, and whilst it is a 'warning', as opposed to an 'avoid', I hope that this article illustrates how important it is to heed the NOTAM in order for all airspace users to operate safely. We will do all that we can to minimise disruption to your sortie, but we are unable to do this if we do not know that you are there.

Cognitive Decline

by Peter V. Agur, Jr.

When it comes to assuring safety in business aviation, operators can become more focused on the airworthiness of the aircraft than on the cognitive health of pilots, despite estimates that about 70 percent of accidents are the result of human factors.

"Cognitive decline, most prevalent among aging pilots, is a threat to safety that is similar to fatigue and substance abuse," says Dr. Quay Snyder, president and founder of Virtual Flight Surgeons. Like the effects of fatigue and substance abuse, cognitive deficiencies are insidious, have a substantial negative impact on performance and are hardest to identify when the crewmember is performing routine activities. One reason symptoms go unnoticed is that with practice and routine, the brain adjusts to mild to moderate cognitive impairment. In other words, normal activities can mask the severity of the deficiency.

However, if the flight crew's routine is interrupted by an urgent or stressful situation, like an in-flight emergency or an en route clearance change, then the extent of cognitive impairment may become more evident. Unfortunately, even those events are sometimes downplayed by both pilots as an inconsequential aberration.

Some aging pilots struggle to respond appropriately to this insidious threat.

Since 1956, over 6,000 adults ranging in age from 22 to more than 100 have participated in the Seattle Longitudinal Study conducted by K. Warner Schaie, Ph.D., a psychologist and gerontologist. The study has tracked the cognitive performance, relative to variance from the established norms, of the subjects as they aged. The study focused on six key factors in cognitive performance (the definitions shown are interpretations of clinical terms):

- Inductive reasoning — problem solving;
- Spatial orientation — comprehension of one's surroundings;
- Perceptual speed — pace of understanding;
- Numeric ability — pace and accuracy of mathematical problem solving;
- Verbal ability — conversational competence; and,
- Verbal memory — recollection of aural input.

Each of these factors also can be considered a critical cognitive element for the safe performance of flight deck duties. Figure 1 displays the average of the study group's performance. Individual rates of change varied, both positively and negatively.

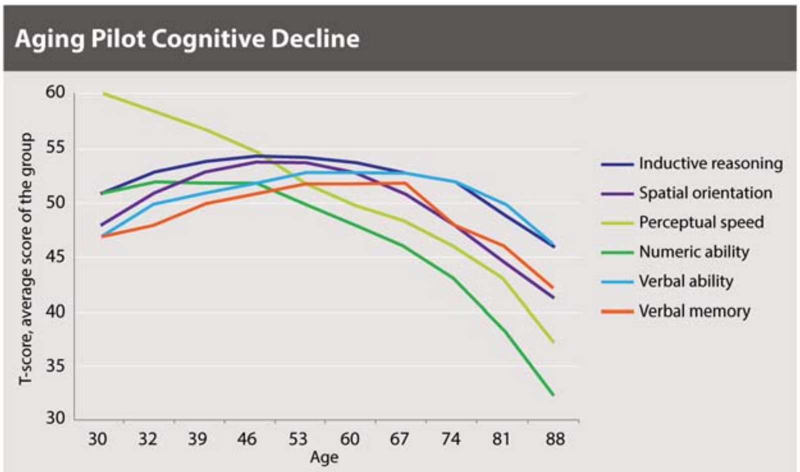
Schaie's findings show that, on average, cognitive skills remain good through age 60 or so. Verbal skills remain acute longer than spatial orientation and perceptual speed. In other words, as the error rate increases in other areas, the subject's ability to 'talk his way out of it' remains high.

Is cognitive decline a real threat, or is it purely an academic concern? While presenting this subject during Flight Safety Foundation's 2014 Business Aviation Safety Summit (BASS) in April in San Diego, I used electronic polling software to solicit answers to questions that would reflect opinions, attitudes and perspectives of the attendees. The number of respondents ranged from 72, as we were beginning the survey, to 115 for the last question.

As you look at the results, remember that these respondents were already safety-focused and representing organizations willing to make significant investments in furthering their safety efforts. Therefore, the data are not representative of the entire industry. Their responses are biased by an above-average level of concern for risk management. As a result, I believe you can assume a more representative group's responses would be more risk-tolerant.

The first question I asked was, "In your personal experience, how significant are the risks associated with cognitive decline in aging pilots?" In other words, I explained, who believed they had actually witnessed substandard performance that is characteristic of cognitive decline? Eighty-two percent of the respondents indicated the risks were moderate to high (Figure 2).

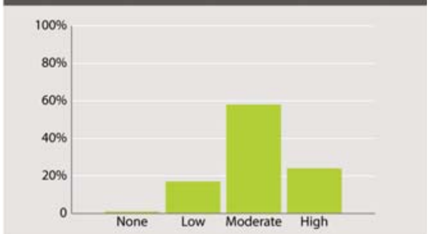
Figure 1



Note: Plotted lines show longitudinal estimates of within-participant age changes on the latent ability constructs (from 7-year longitudinal data).

Source: *The Seattle Longitudinal Study: Relationship Between Personality and Cognition* by K. Warner Schaie, Sherry L. Willis, and Grace I.L. Caskie <www.ncbi.nlm.nih.gov/pmc/articles/PMC1474018/>

Figure 2



Note: Results of audience poll during the Business AviationSafety Summit, April 2014

Source: Peter v. Agur, Jr.

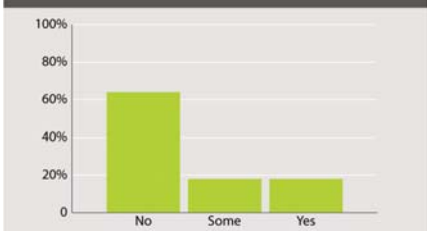
With that level of concern, I would assume the issue would have been previously addressed by aviation safety professionals. In fact, regulations do attempt to cover all the bases on this question. The U.S. Federal Aviation Administration (FAA) and the European Union, for example, both have set mandatory retirement ages for airline pilots. The use of regulations is an attempt to create a limit on the risks associated with aging crewmembers.

However, it is also a blanket approach to an issue that is unique to each individual. I have had dear pilot friends succumb to Alzheimer's disease before age 60. I also have observed my 85-year-old father, a retired military and airline pilot, climb into an unfamiliar airframe with a sidestick and glass cockpit displays (the first time he had encountered either). Within five minutes, he had the airplane 'wired.' He easily maintained the airplane's heading within two or three degrees and limited altitude deviations to less than 30 ft. An arbitrary, regulatory flight crewmember age limit may not catch the early onset of cognitive decline and does not allow older, but fully competent, crewmembers to continue their careers.

FAA partly relies on the provisions of Federal Aviation Regulations (FARs) Part 61.53, which says, in part that "no person who holds a medical certificate issued under Part 67… may act … as a crewmember, while that person: (1) Knows or has reason to know of any medical condition that would make the person unable to meet the requirements for the medical certificate."

Some business aviation operators have taken the added step of establishing policies and practices that further address aging pilot issues. This is an initiative often driven by senior executives' concerns. Other operators say they are concerned about the issue but are daunted by state and federal laws designed to prevent employment discrimination and breaches of healthcare privacy. The BASS audience was polled about the status of their companies' policies addressing aging pilots. Sixty-four percent indicated that no policies were in place, and only 18 percent indicated their policies appeared to adequately address the issue (Figure 3).

Figure 3



Note: Results of audience poll during the Business Aviation Safety Summit, April 2014

Source: Peter v. Agur, Jr.

Even with policies in place, operators are not protected against the risk of cognitive deficiencies without the organizational norms and behaviors needed to make the policies effective. That raises some challenging issues.

Self-reporting is not likely to be a reliable approach to policy implementation for several reasons:

- Cognitive impairment is like alcohol or drug impairment — the people affected are likely to be less aware of the condition than those around them. When a family member or friend is ready to urge a person to discontinue driving for this reason, it is usually well past the point of incapacitation.
- For many pilots, aviation is as much an avocation as it is a vocation. It is part of their sense of personal identity. The fear of losing that connection may be very strong — strong enough for people to be in denial that they may be putting themselves and others at risk.
- Many pilots are not prepared economically to either retire or change their careers. This puts strong financial pressure on them to continue to fly.

Operators cannot count on self-reporting as their primary method of identifying a crewmember who is symptomatic of significant cognitive decline.

If self-reporting is not the answer, should we look for a more intrusive regulatory solution? I asked the BASS audience if they thought current regulations effectively addressed the risks associated with cognitive decline. Ninety-four percent answered "no." The logical next step would be to call for a change in the regulations to more effectively address the issue. In the United States, those regulations would most likely be implemented through the FAA's aviation medical examiner (AME) network. However, the flaw there is, according to a number of different pilots with whom I have spoken, it is relatively easy to find AMEs in the network that are less than comprehensive in their examinations. Therefore, the pilot's work-around— selecting such an AME — would be too easy for this approach to be effective.

Without regulatory assurance of cognitive competence, the operators themselves are left with a blend of policies and performance assessments for dealing with the threat.

A possible policy would call for pilots to notify management when a fellow crewmember is suspected of being cognitively impaired. This sounds reasonable. After all, who is more likely to actually observe substandard performance than the person in the other seat?

However, there are challenges to using this approach alone for detecting the risks associated with cognitive decline.

By definition, the single-pilot operations in business aviation typically do not have another qualified flight crewmember to observe the pilot's performance. That leaves the passengers as the primary observers of the pilot's performance, but they are likely to be at risk long before a pilot's performance declines to a level that would cause most passengers to notice.

It is tempting to ignore single-pilot operations as an issue because they comprise a tiny fraction of all business aviation operations. However, the continued emergence of very light jets and high-performance, pressurized, single-engine turboprop aircraft will cause this segment to grow. The risks will grow with it.

In two-pilot operations, the operator's policy could make it mandatory for any observers to report their concerns to their manager. How effective would that policy be if the person who is demonstrating decline is the senior manager of the department? Or, what if the fading flyer is the mentor and "bestower of breaks" to the observer?

Other concerns about disclosure policies include fear of legal, financial and social exposure for the observer. On a higher level, disclosers indicated potential remorse at being part of a series of events that would lead to the unplanned end of a pilot's flying days as well as the sudden loss of his or her income. The structural and social barriers to a stand-alone policy's effectiveness therefore are substantial. That is why the full integration of a just culture forms the foundation for the effective mitigation of the risks associated with cognitive decline in aging flight crewmembers.

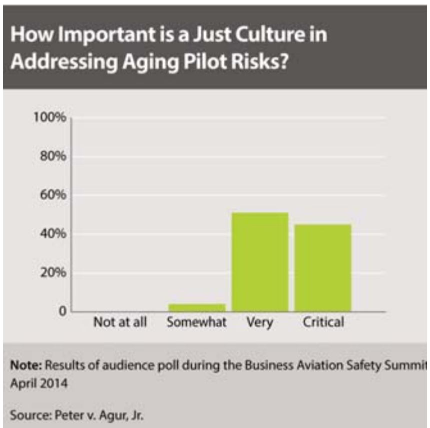
Safety theorist James Reason's extensive work in the arena of cultural impact on an organization's safety performance was ground breaking and continues to evolve. His founding definition is:

In a just culture, errors and unsafe acts will not be punished if the error was unintentional. However, those who act recklessly or take deliberate and unjustifiable risks will still be subject to disciplinary action.

During my BASS audience polling, I asked, "How important is a just culture in addressing aging pilot risks?"

The response was overwhelming: 96 percent of respondents said a just culture was important in addressing the issue (Figure 4).

Figure 4



I then probed the status and strength of just culture in the organizations represented by audience members.

These two responses reveal that, despite this audience's nearly universal understanding of the value and impact of a just culture on the quality of organizational performance, fewer than 10 percent of respondents whose organizations have implemented just culture precepts agreed that their organization actually ensures that they are effective. For a just culture to work, it must be applied comprehensively and consistently. Otherwise, by definition and in reality, it is neither just nor is it truly in effect.

For an excellent description of why and how to implement a just culture, refer to Flight Safety Foundation's legacy magazine, *Flight Safety Digest*, March 2005, for the article, "A Roadmap to a Just Culture: Enhancing the Safety Environment." This was compiled by the Global Aviation Information Network (GAIN) Working Group E. One of the points the paper makes is, "When hazards are reported, they are analyzed using a hazard based methodology, and *appropriate action is taken*." That phrase encompasses a performance assessment-based answer to effectively addressing the threat of crewmember cognitive decline.

Another logical approach to cognitive assessment of pilots would be to have training companies incorporate it into their recurrent training curriculum. In fact, the president of a major charter management company made that request over a decade ago. He asked the CEO of a major training company if his staff could design and conduct a cognitive competence diagnostic of the charter management company's flight crews. The response was, "Yes, but we won't do it." There were two reasons: marketing and legal concerns. The charter management company president then approached the CEO of another large training company and received the same answer.

Considering the lack of an established model, I offer the following as a recipe for addressing concerns about flight crew cognitive performance. Like all recipes, skipping steps and using inferior substitutes will cause the end product to vary, usually negatively. Flight departments will need to collaborate with human resources and legal departments to assure the policies and practices are equitable and defensible. If operators do not have the internal expertise to develop such policies and practices, they should use outside experts.

Here is a proposed outline of steps toward cognitive competence assurance, assuming the use of professional advice from AMEs and other health care specialists qualified in this field:

- Establish and maintain a comprehensive just culture. This lays the foundation for self-reporting, as well as observer reporting of significant and sustained variations from normally expected cognitive performance.

- Establish policies that apply to all flight crewmembers for:

  – Company approved AME selection and use; and,

  – Obtain loss of license and disability insurance coverage that is adequate to assure equitability in the case of identified deficiencies.

- Consistently use only valid cognitive assessment tools and tests:

  – Online, written and practical tests are widely available;

  – Conduct routine cognitive assessments to establish baselines and to identify variations;

  – Develop and consistently administer a periodic flight simulator session that incorporates proven elements of cognitive assessment that are easily observed and scored; and,

  – Use internal observers or consultants to conduct the flight simulator observations. The simulator training companies typically will not do this for the operator.

- When a significant variation is observed, conduct additional and more in-depth diagnostics to determine if the variation is:

  – Transient due to fatigue, a temporary or treatable medical condition, medications, etc. Address the source of the transient variation and have an AME reconfirm fitness for return to duty; or,

  – Permanent and progressive.

- When confirmed cognitive decline is severe enough to affect flight safety and is not correctible, deal with the results humanely and equitably:

  – Use the loss of license insurance benefits in place;

  – Use supplemental disability insurance benefits to compensate for gaps in income replacement;

  – Provide career-related and personal counseling; and,

  – Consider offering the person a nonflying position in the flight department.

- If separation is necessary, consider celebrating the person's legacy of contributions and accomplishments. It may help provide the most positive transition possible for the person and the department.

"The risks to flight operations from cognitive decline in aging flight crewmembers are significant," says Snyder. In the U.S., there are currently no adequate regulatory or industry safeguards that can assure business aviation operators that their pilots are cognitively competent. That puts the ball squarely in the operator's court.

Peter v. Agur Jr. is chairman and founder of The VanAllen Group, a business aviation consultancy team with expertise in safety, aircraft acquisitions, and leader selection and development. A member of the Flight Safety Foundation Business Advisory Committee and the National Business Aviation Association (NBAA) Corporate Aviation Managers Committee (emeritus), he has an MBA and an airline transport pilot certificate, and is an NBAA certified aviation manager.

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FEDEX MD-11 Landing Accident, Tokyo Narita, 23 March 2009

by Dai Whittingham

This article is based on the JTSB report AA2013-4 of 26 April 2013, into the accident involving MD-11 N526FE.

A FEDEX MD-11 was destroyed in a landing accident at Narita following a bounced touchdown and structural failure of the left wing; the aircraft rolled left and caught fire. Both crew members died.

The Accident

The aircraft took off from Guangzhou at 0315 local for the 3:26 hr scheduled cargo flight (FDX80) to Narita with the FO acting as PF and the Captain as PM. The flight was entirely normal until shortly before touchdown on RWY 34L. The crew checked in with Narita Tower at 13 nm finals and were advised that the surface wind was 320/28 but with speeds varying from 20-40 kt. At this stage the aircraft was flying with both autopilot and autothrottle engaged. Normal before-landing checks were carried out, including arming of the auto ground spoiler (AGS), and the crew discussed the wind, opting to add 10 kt to Vref to give a Vapp of 164 kt.

Two minutes after the initial contact, Narita Tower offered a PIREP from the preceding aircraft, which reported windshear of +/- 15 kt below 2000 ft. Surface wind was reported as 320/23 but gusting between 15-34 kt. The crew discussed the reports but were not unduly concerned as the wind was so close to the runway direction. However, the Captain advised the FO to remind himself of the windshear guidance. Further wind reports showed consistent gusting of of +/- 15 kt with a final wind of 320/29.

From 1000 ft radalt to 200 ft when the autopilot was disconnected, the gusting winds were evident in the fluctuations in control column position (+/- 2° from a datum of -2°) generating a pitch angle change of -2 to +4° with speeds ranging from 152-180 kt and roll angle also varying by +/- 5° .. At 500 ft the aircraft was at 179 kt but closely aligned with the ILS, at which stage the Captain called 'stablilized' and the approach was continued. No formal windshear warning was issued by ATC.

The speed at autopilot disconnection was 178 kt but this had reduced to 165 kt with 2-3 seconds dropping further to 157 kts (Vapp – 7) shortly afterwards. All three EPR were showing 1.0 (idle) until 130 ft radalt when they started to increase, reaching 1.3 as the aircraft passed through 50 ft with the airspeed starting to increase slightly. The EPR then reduced towards touchdown and were at 1.0 approaching 20 ft radalt.

20 feet

The flare was initiated slightly late at 20 ft and the pitch angle started to increase towards 3.5°. Just 2 seconds before the first touchdown there was a nose down pitch input of 5° although the body angle continued to increase to 4.6°. The aircraft touched down on the right MLG at a peak 1.63 g on the centreline, and at the aiming point, but bounced. The control column was pushed forward for a short period just before and just after the touchdown and the pitch angle reduced by around 6°. As the MLG left the ground the auto ground spoilers (AGS) started to deploy.

The first bounce

The second touchdown was in a nose-low attitude, still with idle power; the recorded vertical acceleration was 2.21 g and a loud bang could be heard on the CVR. The aircraft bounced for a second time, the DFDR recording a large 3Hz vibration which the manufacturer subsequently reported as being the first natural frequency of the fuselage structure. The AGS retracted the spoilers after this touchdown.[1] During the initial stages of the bounce the pitch angle changed from 2.5 to 6.7° in one second and the forward control column input increased to -7.5° and was held as the pitch angle started to reduce. The highest point of the second bounce was 16 ft radalt as the pitch angle reached +2.5° at which point the control input became nose-up, but the pitch angle continued to decrease towards -5.9°.

Second bounce apogee

The third touchdown was made on the NLG followed by the left MLG, centre MLG and finally the right MLG, with a highest recorded vertical acceleration of 3.06 g. The left wing was seen on a surveillance camera to bend downwards and the fuselage veered to the right as the right MLG touched. The left wing, with MLG and engine attached, was later found to have separated from the fuselage near its attachment point.

3rd touchdown on NLG

MLG touchdown, left wing already deflected down

The aircraft then began to roll left and a fire broke out near the rear of the left engine, rapidly engulfing the rest of the aircraft which rolled further left before inverting and coming to a halt to the left of the runway around 3500 ft from the first point of touchdown. The Narita fire and rescue team made heroic efforts to rescue the crew but were unable to enter the cockpit area for 40 minutes, at which stage the fire was still burning; it would not be under control for a further hour and was not fully extinguished until 5 hours after the accident.

The investigation

Having established from recordings that the wind had neither reached windshear warning thresholds nor exceeded the demonstrated performance of the aircraft, the investigation made a close examination of the handling aspects and, given the damage to the undercarriage and failure of the left wing, consideration of the load transfer mechanisms during the heavy landings. The type had suffered 7 hard landings leading to structural failure prior to the Narita accident, two of which involved wing spar breaks and subsequent rollover. There had also been 6 further incidents of hard landings with structural failure since Narita, which had prompted the NTSB to make 2 safety recommendations to Boeing.

A Longitudinal Stability Augmentation System (LSAS) had been developed for the MD-11. A software change to enhance low-altitude stability was available and had been recommended for fleet-wide installation after the Newark rollover accident in 1997. The upgrade included a Pitch Rate Damper function to mitigate rapid changes in pitch attitude, a Pitch Attitude Protection function which produced a nose-down command if attitude reached a 9.5° threshold on touchdown to protect against tailstrike, and a Positive Nose Lowering function after MLG touchdown and ground spoiler (AGS) deployment to counter the nose-up effect of spoiler deployment. The investigation examined the effects of LSAS before concluding via simulations that it had probably worked correctly to reduce the amplitude of the pitch excursions.

The aircraft weight and balance were in limits at the time of the accident at 405,000lbs and 31% mean aerodynamic chord (MAC), the allowable range for the weight being 12.6 - 34.0% MAC. The investigators noted that the MD-11 flight deck was around 100 ft forward of the CG position and that there would therefore be differences between the flight deck, CG and MLG heights and sink rates as the as the aircraft pitch angle changed in response to the PF elevator inputs. Aircraft response (pitch angle change) to elevator inputs is normally delayed by 0.5 – 1.0 seconds from the control deflection. Simulator tests showed that during the increasing pitch angle immediately prior to the first touchdown the result was a smaller flight deck sink rate compared with that of the CG. When the aircraft touched down, the flight deck sink rate was about 2 fps whilst the MLG tyres impacted at about 7 fps.

At the time of the first bounce, the CG and MLG tyres moved up about 4 ft but the flight deck height actually reduced by about 9 ft due to the pitch angle decrease. The investigation surmised that this change in pilot's eye height would probably have masked the fact that the aircraft had bounced. The nose down control input was reversed towards the top of bounce but the pitch angle continued to decrease. About 3 seconds after the second touchdown, the flight deck reached a highest point of 40 ft whereas the CG and MLG tyres reached high points of about 33 ft and 16 ft respectively. The final touchdown was initially on the NLG followed by the left MLG. The vertical kinetic energy was 6.8 times the ultimate load certification requirement for the structures.

The investigation found that the PF's large elevator inputs were a major contributing factor to the onset of the divergent porpoising motion that led to the accident. It also determined via simulator studies that a properly-flown bounce recovery - a go-around – would have been possible even during the second bounce. There was no DFDR or physical evidence to suggest that a go-around had been attempted or that the PM (the Captain) had intervened at any stage.

The investigation included detailed analysis of the failure mechanism for the left rear spar. The NLG had remained attached to the fuselage though the wheel rims were disrupted and detached (with the tyres) from the wheel structure; there was little damage to the NLG support structures in the fuselage. The left MLG was still attached to the wing and was largely intact. Two tyres had deflated but showed no sign of having burst. There was also little damage to the MLG support structure bar a dent near the attachment point. Crucially, the forward trunnion bolt, which was intended to act as a fuse pin, was intact though deformed by the impact.

The trunnion bolts (fuse pins) were designed to shear and hence separate the MLG in the event of an overload, thereby protecting the fuel in the wing. However, the MD-11 design assumed that such an overload would have an aft force as its primary component, in accordance with the interpretation of the certification requirements at the time of design. Because the MLG was not designed to fail for a purely vertical force component, the result was the transmission of the overload directly to the wing structure as the MLG bottomed out, causing the wing to fail and the rupture of a fuel tank.

This mechanism had been identified as the cause of a rear-spar failure and rollover in an MD-11 landing accident at Newark in July 1997; there had been a second spar-failure and rollover accident in Hong Kong only 2 years later. In total there have been 14 MD-11 hard-landing cases involving some sort of structural failure. The NTSB report into the Newark accident recommended that the FAA considered a change to the certification requirements; from 2004, the interpretation of the regulations includes vertical overload considerations but there was no action on applying this to previously certified designs.

The Aftermath

There were a number of medicines found in the Captain's personal effects after the accident and his urine, but not his blood, contained benzodiazepine (anti-anxiety), ibruprofen and Temazepam (a sleep-aid drug). These drugs were not believed to have had a bearing on the accident but were indicative of self-medication that may not have complied with FAA guidance.

There were extensive changes to training and education regimes instigated by the company ahead of the report being finalised and the company also installed HUDs to assist with accurate landings. Considerable emphasis was placed on the need to fly stable approaches and avoid high rates of descent close to the ground. Bounce-recovery training has been mandated, as has a policy that requires a go-around to be flown if a bounce is detected. Maximum g and pitch angle is auto-printed for use in each debrief. Manuals have been amended to require the landing flare to be initiated between 30-40 ft and hand-flying skills are checked at each line and licence proficiency check. In February 2011, Boeing revised its MD-11 FCOM which now cautions against high sink-rates on finals. The training and handling considerations discussed in the investigation are worth individual review; they can be found at paras 2.13 – 2.15 of the main report. http://www.mlit.go.jp/jtsb/engair_ report/N526FE.pdf

Comment

This accident shows clearly the linkages between design, certification, training and handling skills. The MD-11 is known to be challenging in some aspects of its handling, but such challenges can be managed with proper training. Certification activities add considerably to the time and cost of developing and fielding new platforms but they are crucial to safe operations. Similarly, crews need to understand their aircraft, its performance and handling. And if the task is particularly demanding, then the pilot with the greatest level of skill and experience should be the one carrying it out, whether that task be flight management or physical handling.

[1] *The AGS system was a factor in this accident but is not considered further in this article. See http://www.mlit.go.jp/jtsb/engair_report/N526FE.pdf para 2.14.7 for a full description.*

Understanding the New Widespread Fatigue Damage Rule

by Amos W. Hoggard, Technical Fellow (Retired)
Stephen R. Johnson, Aging Airplane Safety Rule/Widespread Fatigue Damage Program Manager, Chief Structures Engineer

Operators will need to comply with the limits of validity specified in the airworthiness limitations as early as July 2013.

The development of widespread fatigue damage (WFD) in airplane structure is a concern for older airplanes. The U.S. Federal Aviation Administration (FAA) has published a rule that will limit the commercial usage of older airplanes, requiring service actions to preclude the onset of WFD and retirement.

On Jan. 14, 2011, a new FAA rule (14 Code of Federal Regulations [CFR] 26 Subpart C) became effective requiring airplane manufacturers to make available service actions necessary to preclude the onset of WFD and to establish operational limits, known as limits of validity (LOV), of the maintenance program that effectively define an airplane's usable life. It is important that operators become familiar with the rule so they can prepare for changes to airworthiness limitations that will limit how long an airplane may be operated in terms of flight cycles or flight hours.

This article describes Boeing's approach to complying with the new rule and its impact on operators of Boeing airplanes throughout the world. It addresses the imminent future changes to airworthiness limitations, how those changes were developed, and how Boeing will assist operators with rule compliance.

About WFD

WFD in an airplane's structure is defined as the simultaneous presence of cracks at multiple locations that are of sufficient size and density that the structure will no longer meet required damage tolerance and will not maintain required residual strength after partial structural failure (see fig. 1). The risk of WFD onset increases as airplanes are operated well past their original design objectives in flight cycles or flight hours.

Because of the increased difficulty of identifying all of the necessary service actions and the inability of non-destructive inspections to reliably detect small cracks associated with the development of a WFD condition, airplane manufacturers, operators, and regulatory authorities have worked together to address WFD in aging airplanes.

Figure 1: Widespread fatigue damage (WFD)
The cracks on this lap splice are an example of WFD.

Fatigue cracks

The result was the creation of the LOV concept that effectively establishes the life limit on an airplane based on when the existing fatigue test evidence is no longer sufficient to reliably predict structural behavior (see "Sources of fatigue test evidence").

Sources of fatigue test evidence

The establishment of the LOV is based on the fatigue test evidence held by the manufacturer. Sources of this information include:

1. Full-scale fatigue test.
2. Full-scale component tests.
3. Teardown and refurbishment of a high-time airplane.
4. Less than full-scale component tests.
5. Statistical fleet-proven life techniques.
6. Evaluation of in-service problems/test data experienced by this model or other airplanes with similar design concepts.
7. Analysis methods that have been parametrically developed to reflect fatigue test and service experience.

Defining LOV

The LOV represents an operational limit based on fatigue test evidence that supports the maintenance program. The FAA defines the LOV as "the period of time (in flight cycles, flight hours, or both) up to which it has been demonstrated by test evidence, analysis and, if available, service experience and teardown inspections, that widespread fatigue damage will not occur in the airplane structure." It is further defined as the point in the structural life of an airplane at which there is significantly increased risk of uncertainties in structural performance and probable development of WFD.

Once the airworthiness limitations containing the LOV are approved by the FAA, an airplane may not operate beyond the LOV.

Actions required of airplane manufacturers and operators

The FAA's WFD rule specifies actions that are required of airplane manufacturers and operators.

Manufacturers must:

- Develop and make available an LOV as an airworthiness limitation according to a model-specific schedule contained in the rule.
- Provide any service bulletins required to preclude the development of WFD up to the LOV and publish those service bulletins in accordance with an FAA-approved binding schedule.

Operators must:

- Incorporate mandatory service actions into their maintenance programs.
- Adopt the LOV values provided by the manufacturer or, should the manufacturer not provide a LOV, adopt the FAA default LOV values by a date specified in the rule.
- Have a plan to stop operation of airplanes under Parts 121 and 129 when the airplanes reach the LOV.

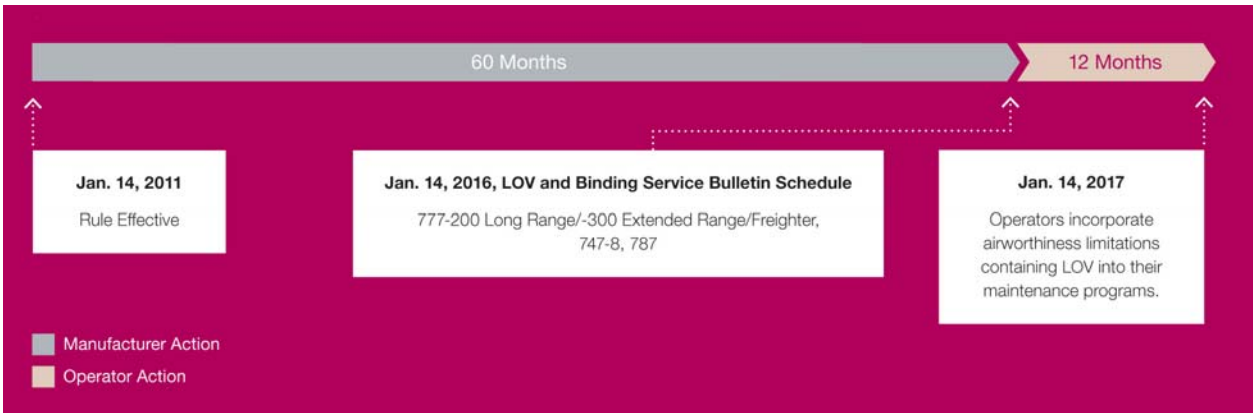
The FAA rule requires the manufacturer and the operator to comply by certain dates depending on the requirement in effect concerning damage tolerance (14 CFR 25.571) when the airplane was originally certified (see fig. 2).

Figure 2: Boeing compliance schedule
Boeing will provide amended airworthiness limitations containing limits of validity (LOV) to the FAA for each airplane model by the dates shown on this compliance schedule.

Group 1 Airplanes
The first group of airplanes affected are those certified prior to 14 CFR 25 Amendment 45.

Group 2 Airplanes
The second group of airplanes affected are those certified between 14 CFR 25 Amendment 45 and 95.

Group 3 Airplanes
The third group includes all airplanes certified to 14 CFR 25 Amendment 96 or greater.



Identifying WFD-susceptible structure

The FAA with operators and manufacturers documented 16 examples of airplane structure susceptible to multiple-site damage (MSD) and/or multiple-element damage (MED).

- Longitudinal Skin Joints, Frames, and Tear Straps (MSD/MED)
- Circumferential Joints and Stringers (MSD/MED)
- Lap Joints with Milled, Chem-milled, or Bonded Radius (MSD)
- Fuselage Frames (MED)
- Stringer to Frame Attachments (MED)
- Shear Clip End Fasteners on Shear Tied Fuselage Frames (MSD/MED)
- Aft Pressure Dome Outer Ring and Dome Web Splices (MSD/MED)
- Skin Splice at Aft Pressure Bulkhead (MSD) (see fig. 3)
- Abrupt Changes in Web or Skin Thickness — Pressurized or Unpressurized Structure (MSD/MED)
- Window Surround Structure (MSD/MED)
- Over-Wing Fuselage Attachments (MED)
- Latches and Hinges of Non-plug Doors (MSD/MED)
- Skin at Runout of Large Doubler (MSD) — Fuselage, Wing, or Empennage
- Wing or Empennage Chordwise Splices (MSD/MED)
- Rib-to-Skin Attachments (MSD/MED)
- Typical Wing and Empennage Construction (MSD/MED)

This list is not meant to be inclusive of all structure that might be susceptible on any given airplane model, and it should only be used for general guidance. It should not be used to exclude any particular structure.

Service bulletin actions to preclude the onset of WFD up to the LOV

As part of rule compliance, Boeing is required to identify WFD-susceptible areas for both the as-delivered structure and any structure that required modification by an airworthiness directive (AD). Boeing also must predict which of the identified WFD susceptible areas will develop WFD prior to when the LOV is reached and provide service bulletin actions to prevent that development (see fig. 3). These service actions would be in the form of service bulletins that would require inspection, modification, or both. The FAA will issue an AD to make these service bulletins mandatory.

To assist the industry in defining areas that might be susceptible to WFD, the FAA, with the assistance of operators and airplane manufacturers, identified 16 generic structural areas susceptible to developing WFD (see "Identifying WFD-susceptible structure" on this page). All of these areas are explained in the FAA Advisory Circular 120-104. This list is not meant to be inclusive of all structure that might be susceptible on any given airplane model, and it should only be used for general guidance.

Cost-benefit of specific service actions

While the establishment of the LOV will mandate the retirement of very old airplanes, the service bulletin actions to prevent WFD may present even more significant costs to the airline. Service bulletin actions include inspection, modification, or both and must be accomplished prior to utilization thresholds specified in the associated AD.

Similar to the requirements of LOV, operators may not operate airplanes that are past AD thresholds without complying with the AD-mandated inspection and modification requirements. The service bulletin actions for Boeing airplanes were developed with the assistance of the Structures Task Group (STG), which consists of Boeing, operators, and the FAA. The STG was asked to evaluate each proposed service bulletin action and ensure it was of value to the industry.

Using this information, Boeing has committed to make service bulletin actions available to the industry to enable operation up to the LOV (see fig. 4). Specific information about each of these bulletins may be found in the Aging Airplane Program Web site on the MyBoeingFleet.com products page under Structures Task Group.

A similar approach will be used to develop the compliance data for Group 2 and Group 3 airplanes.

Addressing WFD as an operator

Boeing will provide the FAA with updated airworthiness limitations containing the LOV for each airplane model in accordance with the compliance dates in figure 2. Following approval of the airworthiness limitations by the FAA, Boeing will make them available to operators on MyBoeingFleet.com. Operators will need to acquire the documents (per 14 CFR 91.403) and update their maintenance programs and have those programs approved by their FAA principal maintenance inspector by the dates specified in 14 CFR 121.1115 or 129.115 (see fig. 2).

Figure 3: Example of structure susceptible

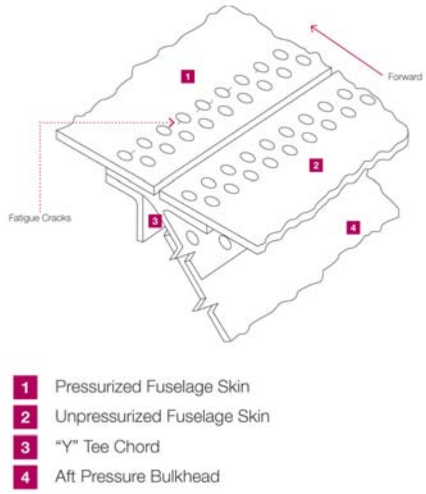


Figure 4: Group 1 service bulletins required to preclude WFD

This table details the number of service bulletin actions for Group 1 airplanes (certified prior to 14 CFR 25 Amendment 45) that operators will be required to adopt in order to achieve the LOV.

Model	Number of Inspection Bulletins	Number of Modification Bulletins	Number of Inspection and Modification Bulletins
727	2	0	0
737	5	3	2
747	5	3	7
DC-8	1	2	0
DC-9	2	1	0
DC-10	1	0	1
MD-80	1	0	0

Figure 5: LOV for Group 1 Boeing airplane models

Model	Minor Model	LOV		Airworthiness Limitation/ Certification Maintenance Requirement (AWL/CMR) Document
		Cycles	Flight Hours	
727	-100 Line No. 1–47	50,000	50,000	D6-8766-AWL
727	-100/-200 Line No. 48 +	85,000	95,000	D6-8766-AWL
737	-100/-200/-200 Cargo Line No. 1–291	34,000	34,000	D6-38278-CMR
737	-200/-200 Cargo/-300/-400/-500 Line No. 292–2565	75,000	100,000	D6-38278-CMR
737	-300/-400/-500 Line No. 2566–3132	85,000	100,000	D6-38278-CMR
747	-100, -200, -300, Special Performance	35,000	135,000	D6-13747-CMR
747	Short Range	35,000	135,000	D6-13747-CMR
747	-400 (Passenger and Freighter)	35,000	165,000	D621U400-9
747	-400 Domestic	35,000	165,000	D621U400-9
DC-8	All	56,000	125,000	MDC 12K9006
DC-9	All	110,000	110,000	MDC 12K9007
MD-80	All	110,000	150,000	MDC 12K9008
DC-10	All	60,000	160,000	MDC 12K1003

Figure 6: Anticipated LOV for Group 2 and Group 3 Boeing airplane models

These anticipated values are based on preliminary engineering calculations and are subject to final revision before final submission to the FAA. These LOV values are substantially beyond the original design service objectives embodied in the design of the airplanes. These are anticipated values only and are subject to revision. This information was part of Boeing multi-operator message 10-0783-01B, dated Dec. 19, 2010.

Model	Minor Model	Anticipated LOV	
		Cycles	Flight Hours
Next-Generation 737	-600/-700/-700 Cargo/-800/-900/ -900 Extended Range	100,000	125,000
757	All	75,000	150,000
767	-200/-300	75,000	150,000
767	-300 Freighter/-400 Extended Range	60,000	150,000
777	-200/-200 Long Range/-300/ -300 Extended Range	60,000	160,000
777	Freighter	37,500	160,000
747	747-8 Intercontinental/747-8 Freighter	35,000	165,000
787	All	66,000	200,000
MD-10	All	60,000	160,000
MD-11	All	40,000	150,000
MD-90	All	110,000	150,000
717	All	110,000	110,000

Boeing strongly recommends that airplanes above their LOV be immediately and permanently removed from service. However, Boeing will continue existing support policies for these airplanes up to the date when operators are required to comply with the operational rule.

For example, Boeing provided the compliance documents to the FAA on July 13, 2012, for the 727, 737-100/-200/-300/-400/-500, 747-100/-200/-300, DC-8, DC-9, DC-10, and MD-80. Subsequently, the FAA approved LOV values for Boeing's Group 1 airplanes (see fig. 5). Updates to the airworthiness limitations are now available on MyBoeingFleet.com. Operators of Group 1 airplane models already have to integrate the LOV into their maintenance programs and develop a plan to stop operation of these airplanes when they reach the LOV. Boeing has also developed anticipated LOVs for the Group 2 and Group 3 airplanes (see fig. 6).

Boeing will publish the service bulletin actions required to preclude WFD for Group 1 airplanes. These Boeing service bulletins will be identified by a statement in the background section of the bulletin. The FAA will mandate each of these bulletins in due course. If an airplane is above a specific threshold in the bulletin, Boeing recommends performing the service bulletin actions as instructed.

Boeing support of airplanes beyond LOV

Boeing estimated that approximately 25 Group 1 airplanes would exceed their FAA - approved LOV by the initial operational compliance date of July 14, 2013. Because the existence of WFD in the structure cannot be reliably detected by maintenance inspections beyond the LOV, Boeing strongly recommends that airplanes above their LOV be immediately and permanently removed from service. However, Boeing will continue existing support policies for these airplanes up to the date when operators are required to comply with the operational rule.

With the exception of certain military derivatives, including commercially certified airplanes in military service, Boeing will not provide support to airplanes beyond LOV after the date when operational compliance is required. This includes operations within the United States under any operational rules (not limited to Federal Aviation Regulations Parts 121 and 129), as well as airplanes operated outside of FAA jurisdiction. This also includes the 707/720 model, which has an FAA -defined LOV.

This policy will go into effect as of the respective operational rule compliance dates specified in 14 CFR 121.1115 or 129.115.

Resources for operators

Boeing has several means to keep operators informed of the latest information concerning WFD rule compliance. When significant information becomes available, Boeing will publish a multi-operator message or a service letter. Boeing also has recently introduced an Aging Airplane Program Web site on the MyBoeingFleet.com products page. This Web site is updated on a regular basis and contains links to the current versions of all service letters and multi-operator messages, as well as FAA rules and advisory circulars. It also provides directions for obtaining documents required for operator compliance.

Information concerning upcoming STG meetings and Boeing seminars on topics of general interest is also available on the Web site.

Summary

Concern about WFD increases as airplanes operate beyond their original design objectives. Manufacturers, operators, and the FAA have worked together to address WFD by defining service bulletin actions necessary to preclude the onset of WFD up to the LOV specified in the airworthiness limitations. Operators will need to comply with the LOV specified in the airworthiness limitations as early as July 2013 and to comply with future ADs.

For more information, please contact agingairplaneprograms@boeing.com.

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Editors Note

This article is slightly dated but has been included as an indication of the maintenance activities required to support older aircraft. It will be of relevance to anyone operating such aircraft or purchasing them from the US register.

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