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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.

Editorial Office:
Unit C2b, Fairoaks Airport, Chobham, Woking, Surrey, GU24 8HU
Tel: 01276 855193 Fax: 01276 855195
e-mail: admin@ukfsc.co.uk
Web Site: www.ukfsc.co.uk
Office Hours: 0900 - 1630 Monday - Friday

Advertisement Sales Office:
UKFSC
Unit C2b, Fairoaks Airport, Chobham, Woking, Surrey, GU24 8HU
Tel: 01276 855193 Fax: 01276 855195
email: admin@ukfsc.co.uk
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Front Cover Picture: A C130J Hercules aircraft from 47 Sqn, RAF Brize Norton, flying over the water during Exercise VALLEY COMMANDO at RAF St Athan, South Wales.

focus ON COMMERCIAL AVIATION SAFETY

The need for science

by Dai Whittingham, Chief Executive UKFSC

Science in its purest form has been at the heart of aviation since man first started experimenting with means of joining the birds in the sky. And some of our most intractable problems will require science to identify the root causes and perhaps point to the technology that can help us. I would suggest that science – particularly the lack of it - is also a link between the apparently disconnected topics of extreme weather events, cabin air quality and fatigue.

Let's start with extreme weather in all its various manifestations. Beyond the obvious hazards posed by strong winds, precipitation, poor visibility, thunderstorms and contaminated runways, serious turbulence events are being reported with increasing frequency and severity. Many of the turbulence encounters have led to injury to passengers and crew; whilst cabin crew members must inevitably move around the cabin as part of their normal duties during periods of turbulence, passengers continue to ignore advice to keep their seat belts fastened and get injured when CAT or wake vortices arrive unexpectedly. There is much work going on to develop turbulence detection systems, mostly using combined Lidar and radar equipment, and here the science is being exploited to good effect.

What is not clear from the incident statistics is whether the increase is due to increased traffic density (so a greater probability of encountering turbulence), the increased severity of the turbulence being encountered, or a combination of the two. Adverse weather events are occurring more frequently and with increasing severity, and there are many who will argue that this is a clear sign of climate change. There are plenty of others who do not share this view, though some go further and simply refute any scientific evidence as being flawed or incorrectly interpreted. President Trump famously tweeted that: "The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive". Whatever one might think of this US-centric view of our environment, the scientific community seems well-aligned in its conclusions about climate change and the reasons for it. Ignoring the science may be politically convenient but the data can't be dismissed as 'alternative facts'. We need the science to determine what is actually happening in the environment in which we operate, coupled with the technology that will help keep us safe in the air.

Cabin Air Quality

A casual glance at any of the incident listings will show that smoke and fume events are featuring more prominently than ever before. It seems that hardly a day goes by without a diversion and members of the crew being taken to hospital after an emergency landing. As with the adverse weather case, are we seeing more reports because there is more activity, because there are more failures or because people are more aware of the issue than previously? Smoke and fume events should always be taken seriously, as it is better to be safe than sorry, but there is also a place for some common sense to be applied by those determining crew response to unexpected odours. Good advice can be found in the Royal Aeronautical Society reference document "Smoke, Fire and Fumes in Transport Aircraft" (SAFITA), available at: http://www.aerosociety.com/flightoperations For fumes in particular, there is considerable debate about the existence or otherwise of toxicity in cabin air, and there are deeply entrenched views on both sides. Rumours abound of insidious poisonings from pyrolised engine oil by-products (organo-phosphates) leaking through the bleed air systems, or from other neuro-toxins present in cabin furnishings. The trouble is that whilst there is evidence some crew members have suffered from illnesses that have all the hallmarks of poisoning with a neuro-toxin, there is no direct evidence of the source so far. The limited air-sampling studies undertaken to date have shown no abnormal levels of compounds in aircraft cabins that would be of concern, but critics argue that the studies have been too limited in their scope. Many people have commented on the fact that a surprising proportion of incidents only affect members of the cabin crew, whereas it would be reasonable to expect that a fumes incident rendering crew unfit to continue with their duties would also affect passengers. Some argue that this shows crews are over-reacting, others would argue that there is an element of crews becoming sensitised to small doses of a toxin because of repeated exposure, which is why it only affects crew.

The cabin air quality debate needs some serious science to answer the questions. If manufacturers and operators are presented with incontrovertible evidence that 'aerotoxic syndrome' is bona fide then we can rightly expect action to deal with the problem. If, on the other hand, science can find no evidence of a link, then we will need to start looking elsewhere for the source of the illnesses that people are describing. There will always be people who will be unwilling to accept that science does not support their position – and if I was suffering with a neuro-toxin based illness, I might be one of them – but the result will be continued pressure to ensure that absence of evidence is not evidence of absence. In the longer term, continued sampling and measurement of cabin air would seem to be a sensible preventive measure to take. We need to keep looking for evidence and we should try to keep an open mind until the debate is settled one way or another.

Fatigue

Why should science have anything to do with fatigue? The straight fact is that there is plenty of science on the subject, and there are people making good livings out of helping others to sleep (it is one of the reasons I write long editorials...). Fatigue is also an issue that neatly straddles the boundary between commercial pressures and safety imperatives. Unfettered commerce would have pilots flying 16 hours every day; the safety approach would have 16 pilots flying for 1 hour per day. As ever, the answer lies in a compromise between the 2 extremes, and science should help us arrive at the correct balance point. The difficulty comes when the science is ignored, as is widely held to have been the case when the initial EASA FTL scheme was being developed. The FTL scheme, which has been in force since February 2016, is now being reviewed and, hopefully, the fatigue/sleep scientists will be fully engaged in the work.

An initial survey was conducted on EASA's behalf earlier this year to scope a data-gathering campaign intended to gather evidence on fatigue and alertness; there is further work to come. All science relies on the use of evidence to discover or prove, and it is here that we have a duty to help. As aviation professionals, whether you work in the air or on the ground, you are a source of information and knowledge. Your opinion carries weight, especially if it is shared with others. If 1000 pilots are asked the question: "Is X dangerous?" and 999 of them agree that X is indeed dangerous, a decision to take a contrary view would seem unreasonable even to a casual observer. Surveys are frequent and response levels are usually less than 50%, perhaps because people believe their opinion will make no difference or because they can't be bothered to spend a few minutes on the task.

The FTL survey is crucial as it will underwrite the FTL scheme on which you will operate for years to come. You need to get involved with it because its outcome will affect you personally, as well as those who follow in your path later. The same can be said for many other surveys – if you do not offer your view, important and valid evidence is missed. It is also true for consultations on airspace changes etc.; there is no point in not contributing and then complaining about the result.

Science, Technology, Engineering and Mathematics (STEM)

To continue the theme of contributing to debates, aviation arguably has its foundation in STEM. As aviators, we need to understand our environment and the aircraft we operate, and STEM is a sine qua non when it comes to manufacture. Beyond the looming pilot shortage the competition for engineers is fierce, especially for those who understand information technology and can write software. The young need encouragement to study STEM subjects, as it seems not enough of them are choosing careers in aviation and/or engineering. If you are asked to get involved with talking to young people about STEM, please take the time to do so. You might be the one person to inspire a young man or woman who, 5 years down the track, fixes your aircraft so that you can depart in time to stay within your FTL scheme!

Human Factors: The 'Soft Skills' and the Flight

by Jacky Mills, Chairman UKFSC

Human Factors were rightly identified many years ago as having a significant part to play in the safe execution of a flight. Crew Resource Management (CRM) training was introduced in the UK in the 1990's and is now widely recognised as an important part of the training syllabus for Flight and Cabin Crew. Some Operators have wisely extended this training to other areas of the business with Ground, Engineering, Operations and other colleagues participating in Team Resource Management training, and thereby gaining valuable knowledge of what have become known as the 'softer' skills.

Without an understanding of what affects each and every human in the execution of their daily lives it is impossible to know how to gain the optimum result from every task. Significant progress has been made in recent years with the introduction of EASA Flight Time Limitations (FTL) and the inclusion of Fatigue reporting and monitoring as an integral part of this. Research has shown how skill levels are degraded in many areas when the human being is not appropriately rested for the day or night's duties ahead. Crew members now receive training in fatigue awareness and how to manage their rest periods to take best advantage of the rest time available. Fatigue reporting is now widely used by Flight and Cabin crew in UK airlines, reporting both roster and non-roster related concerns and describing the reasons for a fatigue induced absence, if necessary.

This area is now mature enough to play a useful part in the Airlines' safety culture, with trends being identified of potentially fatiguing schedules or work patterns, as well as being the means to report those unforeseen events, which unfortunately can happen, and prevent crew members achieving adequate rest prior to their duty. So a great step forward towards crew members arriving for a flight feeling well rested and ready for the duty ahead.

However great this progress is, there are still many other facets of simply being a human ready to spoil the day... Human error will happen despite all endeavours to prevent it – that is quite simply a fact – so whilst there are humans involved we need to put as many barriers in place as possible, to reduce the impact of the error. Looking at how many barriers remained in place following the event which is being investigated has been proved to be a very valuable part of the safety investigation.

Our Safety Management Systems are nowadays looking at the 'near miss' events and 'precursors' that have been trapped and systems also have the benefit of comprehensive data mining in a bid to develop a robust and rounded safety system. With enlightened safety cultures now being prevalent in industry, reports are more and more often submitted describing the 'nearly happened' which enables additional barriers to be developed to prevent the serious incident. Developing a safety culture which results in increased reporting is very much the starting point...

Safety professionals have a huge responsibility to ensure that the valuable time taken by colleagues to describe their safety concern is used in the optimum manner. Damage is expensive there is no doubt, so putting barriers is place to prevent damage will be cost effective and is definitely a winner, but when justifying expenditure on those 'precursors' it is harder to show the financial benefit. Reducing trends look good but how do we prove that the measures implemented are the reason for the improvement? Metrics which measure success are as important in their own right, to ensure that valuable resource is being directed in an appropriate direction.

Ideally the Safety Management System Review will reveal what are the most beneficial areas to concentrate resources on. But how about using some resource to look **not** at the failures - as has traditionally been done to 'learn from our mistakes' - but to look at the positives – the things that have been done well – the successes – those things which have worked well – and learn from those - what positives can be taken over into other parts of the operation. It is always going to be a work in progress – there will always be more to understand. Lessons are learnt every single day and that learning is constantly poured into the safety systems to make them more robust, to tweak, to refine, to improve. Focus on success instead of failure.

We are now regulated using a Risk Based approach – audits are conducted on our Risk Based Performance – many airlines have introduced Advanced Training Qualification Programme (ATQP) for their training so flight crew Simulator sessions are now concentrating on those areas which could be made more robust – rather than practising the well-honed techniques which have always been practiced - this all makes sense. All Operators are different – there will be some common areas of risk – but there will also be many issues individual to their particular operations which could benefit from concentrated effort for optimum performance.

One facet of human behaviour which has become more talked about in recent years is what is known as **Startle Effect**. The startle response is the physical and mental response to a sudden and unexpected stimulus and in aviation startle effect can be defined as uncontrollable, automatic reflex elicited by exposure to a sudden, intense event that violates a pilot's expectations.

Startle effect includes both physical and mental responses – while the physical responses are automatic and almost instantaneous, the mental responses – the conscious processing and evaluation of sensory information – can be much slower. The ability to process the sensory information – to evaluate the situation and take appropriate action – can be seriously impaired or even overwhelmed by the intense physiological responses. Studies have found that following a startling stimulus – a loud noise for instance – basic motor response performance can be disrupted for as much as 3 seconds with performance of more complex motor tasks impacted for up to 10 seconds.

It is well to also be aware of the time it takes to recover in a cognitive sense after a startle event. Startle has been found to impair information processing performance on mundane tasks, such as the continuous solving of basic arithmetic problems, for 30 – 60 seconds after the event. The duration of the performance degradation increases as the task becomes more complex. Therefore, the startle effect disrupts cognitive processing and can negatively influence decision making and problem solving abilities.

As aircraft become more reliable pilots can be surprised or startled by events and as a result have taken either no action or the wrong action. This surprise or startle is largely due to the enduring reliability of the aircraft and has unwittingly created a conditioned expectation of normalcy among today's pilot. This results in an expectation of critical events occurring being so low that the startle effect which is encountered during such events is higher than would have been some decades ago when things often went wrong.

Flight crew can be exposed to a variety of stimuli which have the potential to elicit the startle reflex and response. Bird strike events or sudden illumination by lasers have resulted in incidents where pilots have been startled or disoriented. The immediate impact of the startle reflex may induce a brief period of disorientation as well as short term psychomotor impairment which may well lead to task interruptions or a brief period of confusion. In this case a period of time will be required for reorientation and task resumption. Performance after a startle event can be affected to the detriment of the safety of the flight, but a greater concern stems from what the crew do during the conditioned startle response itself. Here decision making can be significantly impaired, especially higher order functions necessary for making judgments about complex flight tasks.

Startle effect was considered a factor in two well publicised aviation accidents in the past decade. There was the Airbus A330-200 operated by Air France on a scheduled passenger flight from Rio de Janeiro to Paris CDG – it exited controlled flight and crashed into the sea with the loss of the aircraft and all occupants. It was found that the loss of control followed an inappropriate response by the flight crew to a transient loss of airspeed indications in the cruise resulting from the vulnerability of the pitot heads to ice crystal icing.

A second accident in which startle effect was considered a factor, amongst other factors including fatigue, was a DHC-8-400 operated by Colgan Air on a scheduled public transport flight from Newark to Buffalo-Niagara. On an ILS approach to the destination runway in night VMC control was lost and the aircraft crashed in a residential area approximately 5 nm from the runway.

The Airbus accident investigation found that all activations of the stall warning system had occurred in accordance with their design, and that the stalled condition had been characterised by the onset of the buffet. It also noted that at no time had there been any reference to the stall warning or any formal identification of the stalled condition by any of the pilots.

In considering the failure of the co-pilots to respond rationally to the onset of unreliable airspeed and subsequently to perform an appropriate and timely recovery from the self-generated and subsequently active stalled condition, the investigation noted that the only opportunities available to the two relatively low experience co-pilots to learn about stall were during their basic training, and then as part of one or two simulator sessions during their initial training for A320 type rating. These exercises were conducted at low altitude – FL100 – with the focus on demonstrating and analysing the phenomenon, and with particular attention on the operation of the aircraft's protections in normal law.

At high altitude the margin between the normal angle of attack in cruise and the angle of attack that activates the stall warning is very small. Trainees who perform the exercise at low altitude note a reduction in speed compared with the reference values but are not sensitised to the proximity of the angle of attack threshold at which the warning is triggered.

The demonstrative nature of the exercises undertaken does not indeed, enable the crew to appreciate the startle effect generated by the stall warning, nor the reflex actions on the controls that may be induced. The investigation also concluded that current training practices do not fill the gap left by the non-existence of manual flying at high altitude, or the lack of experience on conventional aeroplanes. Furthermore, they limit the pilots' abilities to acquire or maintain basic airmanship skills.

A number of strategies have been identified which can reduce the negative effects of startle and improve pilot performance during and immediately after a startle event. These include familiarity with the technical aspects of the aircraft, maintaining manual handling skills, maintaining effective situational awareness, avoiding complacency and the anticipation of threats using effective threat and error management strategies. Simulator exercises conducted on evidence based events as discussed earlier as being included in ATQP programmes, as well as unexpected critical events can also support crew members when facing startle effect.

A plan of action is always going to be another barrier which can be in place, for common non-normal events as well as rarer out of the ordinary events. A plan can always be adapted to new circumstances but expecting the unexpected is probably one of the best strategies and most valuable item in the toolkit.

And whilst the human being is involved in operating the aircraft there is undoubtedly the likelihood of the unexpected occurring.

Doc's Corner: Pilot Incapacitation

By Dr David Stevenson, RAF Centre of Aviation Medicine

In-flight pilot incapacitation is, fortunately, uncommon, especially given the massive amount of flying which takes place these days, as evidenced by the 37.6 million passenger flights which took place in 2015.

This is mainly because rigorous selection and medical certification criteria for pilots are being strictly enforced.

It is rarely a problem in two-pilot aircraft, but obviously can have serious consequences even in the two-pilot situation. The nature and severity of incapacitation can vary in degree from mild (coming down with the flu) to death (e.g. from a heart attack).

A few significant examples of pilot incapacitation:

- On 25 October 1999, a Learjet 35 crashed in South Dakota following loss of control attributed to crew incapacitation due to hypoxia.
- On 14 August 2005, a B737-300 aircraft belonging to Helios Airways, crashed near Grammatiko, Greece. The pilots became incapacitated due to hypoxia caused by lack of cabin pressurisation.
- On 10 January 2007, a First Officer became suddenly incapacitated by seizure during a flight from Anchorage to Hong Kong. A diversion was made and the affected pilot hospitalised where the cause was identified as a previously non-symptomatic brain tumour.
- On 20 August 2011, an RAF Hawk impacted the ground due to G-induced incapacitation.
- On 28 March 2012, a passenger aircraft pilot suffered an apparent psychotic episode, and "... yelled jumbled comments about Jesus, September 11, Iraq, Iran, and terrorists." He was subdued by passengers and an emergency diversion ensued.
- On 24 March 2015, Germanwings Airbus A320 crashed near Prads- Haute-Bléone, France. It was determined that this was a pilot suicide.

Definition

Any reduction in fitness, or any physiological or psychological state of a nature that is likely to jeopardize performance of one's duties and/or flight safety. In this regard, the Germanwings incident is a form of incapacitation: a mental health problem prevented the pilot from performing his duty - flying his passengers safely. Incapacitation may occur suddenly, or gradually.

"From the operational standpoint, it is irrelevant whether degraded performance is caused by a seizure, preoccupation with a serious personal problem, fatigue, problematic use of recreational drugs or abnormal heart conditions. The effects may be similar, and often other crew members will not know the difference." (ICAO Manual of Civil Aviation Medicine Doc 8984 AN/895 2012 p 1-3-1). The performance degradation needs to be dealt with no matter what the cause.

Subtle Incapacitation

Skills or judgement may be lost with little or no outward sign. The victim may not respond to stimulus, may make illogical decisions, or may appear to be manipulating controls in an ineffective or hazardous manner. Failure to respond normally to two consecutive challenges or one significant warning. ***('You're 100 feet below decision height')*** should trigger action. Symptoms may be evident only in moments of high stress or workload. The victim's condition may lead to more dramatic or complete incapacitation.

Causes

- **Subtle incapacitation** is most commonly caused by hypoxia, hypoglycaemia (low blood sugar), extreme fatigue, alcohol, drugs or other toxic substances. Neurological problems, such as stroke or brain tumour, may also be a cause.
- **Cardiovascular conditions.** Heart problems and fainting are the main causes of serious incapacitation. Complaints of chest pain (often confused with indigestion), weakness, palpitation or nausea should be taken seriously. Pallor, unusual sweating, repeated yawning or shortness of breath should all trigger suspicion. Strokes also fit into this category.
- **Mental health.** In one study, half of all in flight incapacitations were as a result of mental health causes, predominantly panic attacks and acute anxiety. And then, of course, there is the terrible example of the Germanwings incident.
- **Gastro-intestinal.** A frequent cause of pilot incapacitation commonly caused by spoiled food. Vomiting, diarrhoea, stomach cramps, alone or in combination, may be incapacitating.

- **Physiological effects** such as G-induced loss of consciousness, hypoxia, toxic fumes, hypoglycaemia (low blood sugar), and barotrauma in the form of ear or sinus blocks or intestinal cramping.

- **Self-medication**, recreational drug use, including alcohol.

- **Fatigue** which may cause a multitude of cognitive and behavioural problems.

- **Laser strikes** causing eye damage.

There are countless other causes of incapacitation in flight, from coming down with the flu to kidney stones. It is neither useful nor practical to list them all.

Countermeasures

- Robust aircrew selection practices and periodic medical monitoring of aircrew – number one defensive measure: keeping peoples' medicals up to date and honestly declaring medical conditions.

- Crew should eat different meals at different times.

- Don't self-medicate except for very minor conditions as specified in RA 2135(8) para 50, which states that aircrew should not take any prescription medicine, drugs, tablets or remedies (i.e. non over-the-counter) before flying unless prescribed or approved by a MAME, nor should they use any over-the-counter medicines, drugs, tablets or remedies within 24 hours of reporting for flying duties unless approved by a MAME, as the effect on an individual's fitness to fly may not be immediately apparent.

- Maintain currency in hypoxia and G-LOC training.

- Follow unit and aircraft specific SOPs for incapacitation. CAP 789 Requirements and Guidance Material for Operators states that airlines must provide for incapacitation training for aircrew and cabin staff. In addition, this document provides some very sound advice that ***"If during line flying it appears that both pilots are suffering from some form of incapacitation or that one pilot appears to be in any way incapacitated for no obvious reason, then the flight crew should don oxygen masks without delay."***

- If you suspect pilot incapacitation, state your concern. When in doubt, ask. People, especially pilots, will often ignore or deny that there is anything wrong with them. ***'You do not seem to be yourself.' 'I do not understand what is happening', or, "You are deviating from established procedures.' 'Are you all right? Are you ill?"***

If incapacitation is established, here is some good advice from the Canadians with their CHASE mnemonic:

- **C**ontrol the aircraft.
- **H**elp. Declare an emergency and alert other crew. Contact ATC and ask for SME medical advice. Ask for assistance from other crew members, both to assess what is happening, and decide on a course of action.
- **A**ssess the situation.
- **S**ecure the victim and cockpit. Restrain the victim if necessary
- **E**xplain your plan to ATC and other crew members.

To read the complete Canadian article, search the internet for 'Transport Canada TP 11629'.

You

Are you an incapacitation risk?
Keep your medical up to date. If you are feeling unwell or are otherwise uncertain of your medical status (including fatigue) prior to a flight, check with an aviation medicine trained doctor prior to flying. If you become unwell in flight, declare it to your crewmates prior to it becoming a problem. It is your responsibility to inform them if you might be an incapacitation risk.

Reprinted with kind permission of Air Clues, Issue 23.

Pilot Monitoring Article for GCAA 'Investigator'

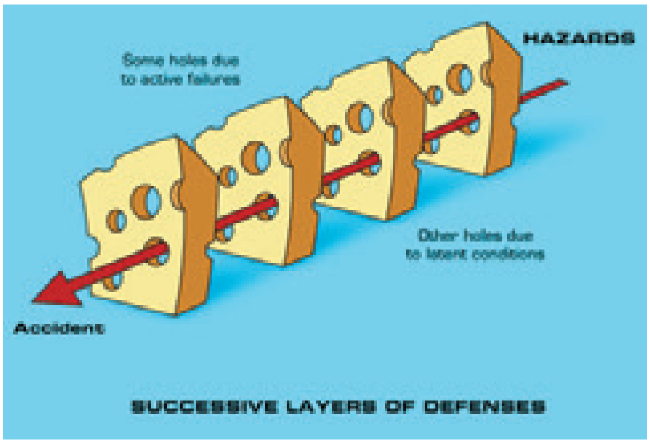
Captain Anthony Wride – Former Chairman UKFSC

Introduction

The flight deck team normally consists of two pilots who both have an important role in ensuring the aircraft remains safe. On some flights, for example Augmented or ULR flights, there can be additional pilots who are not just there as passengers but should also be involved in a monitoring capacity at the critical phases of the flight. While the Pilot Flying (PF) may be considered by some as being the important role, in fact it could be argued that it is the Pilot Monitoring that actually has the key role. In so many accidents within the Commercial Aviation industry, the accident could have been prevented if effective monitoring had occurred, and also in some cases if the Pilot Monitoring had challenged the actions of the Pilot Flying.

One way of looking at the role of the Pilot Monitoring is to consider him/her as the last, and therefore most critical, safety barrier to prevent an Undesirable Aircraft State (UAS), incident or accident.

The James Reason model likens the defences (barriers) that prevent a hazard being released and progressing to an accident to Swiss cheese with holes. The defences can be things like operating procedures, aircraft equipment (for example EGPWS), and training. If all of those earlier barriers have been breached then it is left to the final barrier to prevent the accident and hence the importance of the Pilot Monitoring.

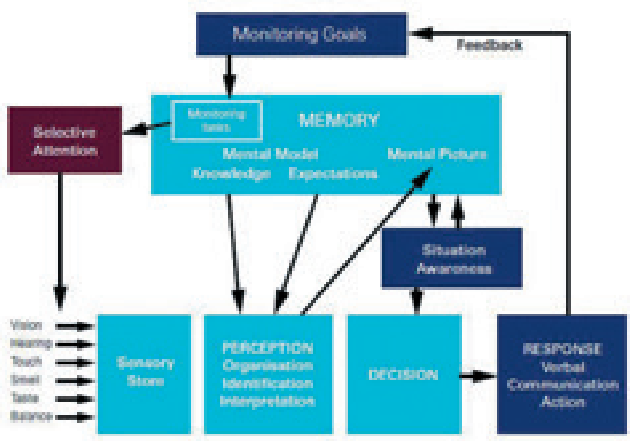


In this article we will show some examples of where ineffective monitoring ultimately led to an accident and also how accidents and incidents can be prevented if the Pilot Monitoring focuses on actively monitoring key areas.

To begin, we will start by giving some background information on monitoring.

How Do We Monitor

The trigger for monitoring will always be purpose-driven by the need to satisfy an information/decision requirement (e.g. height requirement on Non Precision Approach). **Monitoring Goals**, as shown in the figure, relate to the execution of monitoring tasks contained in SOPs (e.g. Non Precision Approaches), monitoring checks against plans/basic flight operation (e.g. monitor height and speed on approach) across the phases of flight, cross monitoring other pilots' actions and monitoring communication channels.



Thus, in pursuit of the goal, the pilot will activate the relevant monitoring tasks that reside within the long-term memory. **Monitoring tasks** are similar to encoded computer subroutines determining when and where to look, listen etc. When these tasks are well rehearsed and very familiar, the response will be carried out subconsciously and monitoring tasks, like instrument scanning, should become habitual. Conscious control is more likely to occur when the monitoring task relates to a predictive activity e.g. in the NPA example 'is the vertical speed too excessive to achieve the height capture'.

The monitoring task will focus **selective attention** on the specific information source (e.g. the PFD for height readout and VOR/DME panel for distance in the NPA example) which will stimulate the respective senses to transmit the responses via the **sensory stores** (e.g. in this case a visual task). The brain **perceives** the sensory responses within the short term memory and interprets the context of the input via **knowledge** stored in the **long-term memory** (e.g. NPA requirements). Within the working memory the processed input is compared against the **expected** value/mode contained within the **mental model** associated with the **knowledge** of the systems, flight plan and expected actions in the case of the other crew member. A comparison of the mental model and mental picture updates the **situation awareness** state and allows **decisions** to be made. In the NPA example this would result in advice on height deviations from required flight path. The PF will monitor the outcome of any flight path corrective action and the PM will continue to monitor PF actions and repeat the NPA monitoring task in accordance with the NPA goals as specified on the approach charts.

Invariably the decision process is not dependent on a single source of information and rapid selective attention switching (visual and/ or auditory modes) can occur (e.g. on take-off engine state and speed sampling is carried out whilst monitoring communications channels). This is frequently referred to as 'multi-tasking' and can be effective over a short period of time but over a longer period the continual brain re-focus will become error prone.

When the visual and auditory channels are stimulated at the same time depending upon the type of auditory input (a system warning, intercom, or verbal communication from co-pilot/ATC) the pilot will either transfer attention to deal with the warning or divide attention between listening to the input and keeping an eye on the readout on the display or instrument.

When attentional resource capacity becomes limited, **prioritisation** of the monitoring task is essential which will be enabled through training and experience.

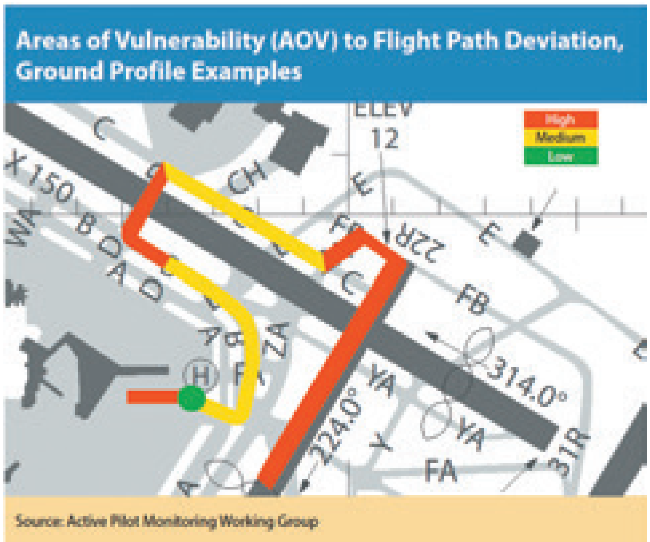
The PMs **primary** responsibility is to monitor the aircraft's flight path (including autoflight systems, if engaged) and to immediately bring any concern to the PF's attention.

The PM is secondarily responsible for accomplishing non–flight path actions (radio communications, aircraft systems, other operational activities, etc.) but he/she must never allow this to interfere with his/her primary responsibility, monitoring the flight path.

The Flight Safety Foundation Approach-and-Landing Accident Reduction (ALAR) Task Force found that "inadequate monitoring and cross-checking" were present in 63 per cent of approach-and-landing accidents. Three-quarters of the monitoring errors failed to catch problems that the NTSB has identified as causal.

LOSA collaborative, 21 worldwide airlines observed more than 2,000 airline flights and noted that roughly 62 per cent of unintentional errors went undetected by flight crews. In other words, sometimes we aren't very good at catching our own errors. Researchers examining these data noted that more effective crew monitoring could have averted nearly one-fifth of errors and 69 per cent of undesired aircraft states.

Areas of Vulnerability



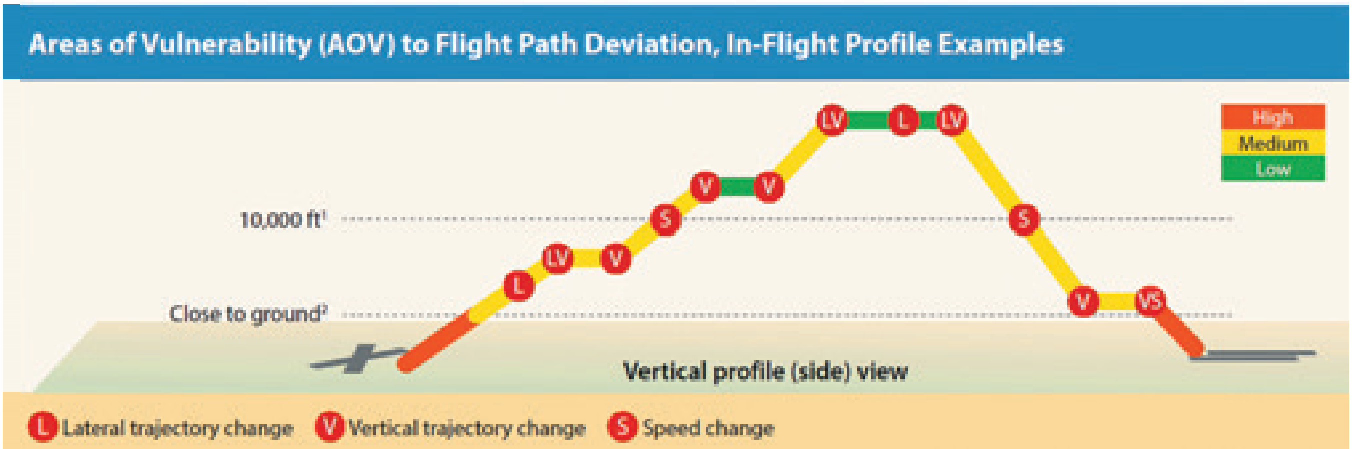
During any flight there are areas of vulnerability that have been identified. During the departure from the ramp area to the take-off, the diagram shows areas where the risk is increased and therefore the monitoring has to be at a high level.

The initial pushback, start up, and obtaining the taxy clearance are high risk areas. The initial taxy may be thought of as slightly less risky until the point where a runway crossing is required. The other high risk area is the final line-up and the take-off itself.

In the majority of taxiway incursion events the route causes were invariably poor crew co-ordination (working as a team) and lack of effective monitoring (following the route and pre-empting turns).

Once airborne again, there are areas of increased risk and also areas of low risk once in level flight.

However, whilst it might be tempting to relax when in the cruise, it must be remembered that monitoring never ceases. There may be a requirement to suddenly switch to a more active monitoring stance when given an ATC clearance to, for example, climb to a higher level or commence a decent.



In the final stages of the flight the risk level increases as the aircraft makes its approach.

Types of Monitoring

Passive Monitoring (keep an eye on, maintain regular surveillance, listen to)
Maintaining a scan of the instruments/displays related to the aircraft attitude, power, performance and position, and vary according to the phase of flight. Routine check of autopilot modes and auto throttle modes, engine display, flight progress, attending to communication requirements.

Example of Passive Monitoring	Attendance to communication requirements	Monitoring Activity: Monitor proper radio setup and checks

Active Monitoring (cross check, oversee, report on)
Relates to all monitoring tasks where a call out is required and also includes *cross checks* of for example:

- engine instruments;
- flight parameters;
- A/C configurations (operation and confirmation of indications);
- FMA modes;
- Cross check other crew members' actions (particularly related to guarded switches).

Example of Active Monitoring	Call for FLAP on speed schedule	Monitoring Activity: Monitor speed/ flap retraction schedule

Periodic Monitoring (check over a period of time)
Relates to carrying out a check every pre-determined time interval, such as the aircraft state for example:

- pressurisation; ■ anti-icing;
- engine instruments, oil temperature etc.;
- hydraulic pressure/contents; ■ cabin temperature;
- fuel; and ■ radio/ATC checks.

Example of Periodic Monitoring	Fuel Check	Monitoring Activity: Monitor fuel usage and balance at regular intervals.

Mutual Monitoring (cross check, watch over, oversee, report on)
Where an action is carried out by one crew member and cross-checked by the other for example:

- altimeter changes; ■ use of charts;
- AP Flight modes; and ■ FMS changes.

Example of Mutual Monitoring	PF announces GO-AROUND FLAP and sets go-around thrust	Monitoring Activity: Verify that engines are spooled up and Go-Around thrust is set. Check speed and altitude and select Go-Around Flap. Monitor correct flap setting achieved.

Predictive Monitoring (advise, urge):
Is comparing flight path parameters against known tolerances – equivalent to mentally flying the aircraft and advising on deviations. Advising on confirmation of acceptable criteria (speed, bank, vertical speed, and configuration).

Example of Predictive Monitoring	Achieve stabilized approach at 1000ft or 500ft	Monitoring Activity: Monitor all stabilization criteria and call out any deviations

Inadequate or Ineffective Pilot Monitoring Examples

Air France 447 – A330 South Atlantic.

Nobody flying the aircraft - Crew focused on the ECAM and PM not monitoring the flight path. There is a good TV documentary "Fatal Flight 447 – Chaos in the Cockpit" about this accident on YouTube that highlights the lack of cockpit discipline; https://www.youtube.com/watch?v=YJzg6W2f7Ng

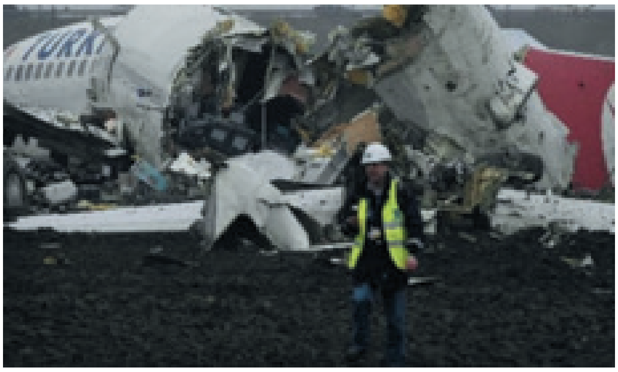
Air Blue 202 – A321 Pakistan

The report issued by Pakistan's Civil Aviation Authority in November 2011 cited a lack of professionalism in the cockpit crew along with poor weather as primary factors in the crash. In particular, the report noted that the captain ignored or did not properly respond to a multitude of Air Traffic Control directives and automated terrain warning systems. The report also claimed that the first officer passively accepted the captain's actions, after the captain on multiple occasions took a "harsh, snobbish and contrary" tone with the first officer and "berated" him.

Korean 801 – B747 Guam

The National Transportation Safety Board determined that the probable cause of this accident was the captain's failure to adequately brief and execute the non-precision approach and the first officer's and flight engineer's failure to effectively monitor and cross-check the captain's execution of the approach.

Recent Accidents in which Inadequate Monitoring was Cited as a Factor



Turkish Air 1951 – 2009 – B737 – Amsterdam

The crash was caused primarily by the aircraft's automated reaction which was triggered by a faulty radio altimeter. This caused the autothrottle to decrease the engine power to idle during approach. The crew noticed this too late to take appropriate action to increase the thrust and recover the aircraft before it stalled and crashed.

Colgan 3407 – 2009 – Dash 8 Q400 – Buffalo

Aircraft stalled due to low speed and then incorrect actions by both the Captain, pulled back on the control column, and First Officer who retracted the flaps.

Ethiopian Airlines 409 – 2010 – B737 – Beirut

Crew mismanaged the aircraft's speed, altitude, heading and attitude. The crew's flight control inputs were inconsistent and these resulted in the loss of control of the aircraft. The crew failed to abide by Crew Resource Management principles of mutual support and verbalising deviations and this prevented any timely intervention and correction of the aircraft's flight path and manoeuvers.

Asiana 214 – 2013 – B777 – San Francisco

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's mismanagement of the airplane's descent during the visual approach, the pilot flying's unintended deactivation of automatic airspeed control, the flight crew's inadequate monitoring of airspeed, and the flight crew's delayed execution of a go-around.

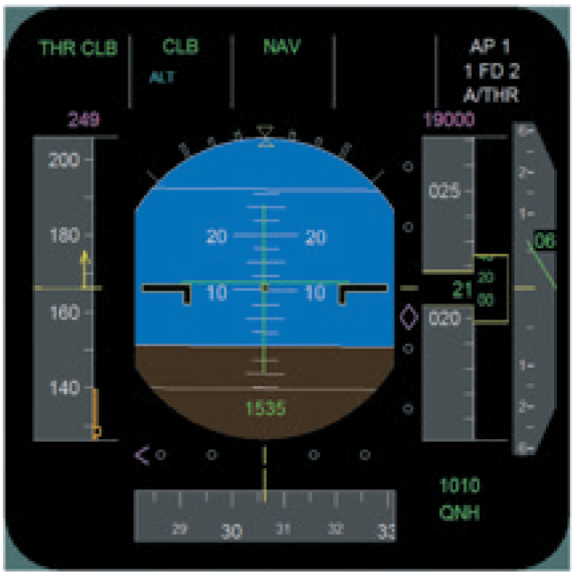
It is worth noting that a key factor in these accidents was speed and as we all know a lack of speed in an airliner is not conducive to staying airborne!

An Example of Lack of Correct Pilot Monitoring;

In the commercial aviation environment ineffective Pilot Monitoring can result in such things as flap overspeeds, gear overspeeds, altitude busts, taxiway incursions, unstable approaches, no reverse selection on landing or other undesired aircraft states (UAS). Below is an example to highlight a lack of pilot monitoring which led to an undesired aircraft state.

British Registered Airbus Flight – Early Flap Retraction and near Alpha Floor activation. In this example an initial error by the Captain (PF) is not 'trapped' by the First Officer (PM) resulting in the aircraft getting close to Alpha Floor as the Flaps and Slats retracted.

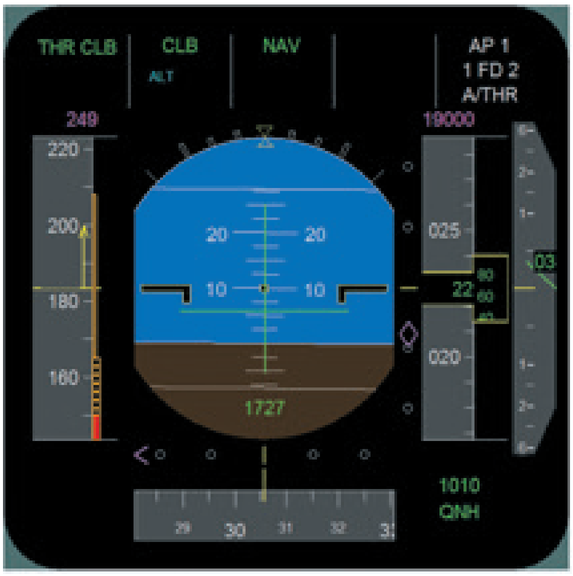
"Flap Zero" S Speed (Slat retraction speed) = 205kts – Initial error by Captain (PF)

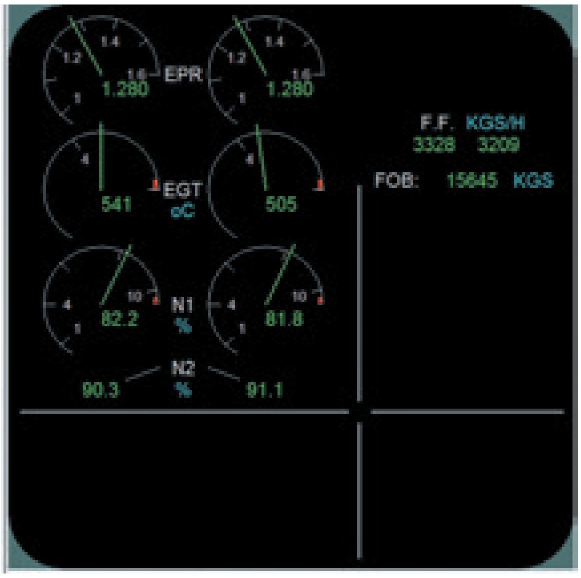


"Speed Checked, Flap- Zero" – The opportunity for First Officer (PM) to trap the error and prevent the undesirable aircraft state.

Flap almost retracted, speed well below V_{LS} (lowest selectable speed, indicated by top of amber line)

Speed well below V_{LS} ; V prot and Alpha Floor increasing as slats fully retract (indicated by top of black/amber and red lines)





It would be fair to say that the First Officer was not checking the speed, or if he even looked that he did not understand the importance of ensuring that it was high enough to allow flap and slat retraction.

What can we learn from this example?

1. *Never assume that the Captain is always right!*
2. *As Pilot Monitoring, know the importance of what critical factor you are monitoring, in this example having enough speed to retract the flaps/slats.*
3. *If you are an additional crew then also monitor what is happening, don't assume the operating crew will always get it right!*

Pilot Monitoring Focus

Throughout the flight the focus of the Pilot Monitoring will shift depending on the stage of flight. Below is a table that gives some, **but not all**, of the 'Focus' areas associated with various parts of the flight.

Phase of Flight	***Event***	***PM Monitoring Focus***
Ground	Taxying to runway	Route and groundspeed
Ground	Crossing a runway	Positive clearance from ATC, runway clear, and route
Take off	Entering runway	Clearance confirmed, stop bars off, approach clear
Take off	Take off roll	Engine parameters, speed and directional control
Initial climb	Climb to acceleration	Speed and height towards level off
Initial climb	Flap retraction	Speed increasing above appropriate retraction speed
Climb	Climb to altitude	Correct altitude selected and ROC
Climb	Climb to Flight Level	Correct Flight Level selected, ROC, and speed
Climb	Lateral Nav change	Correct route or heading selected
Climb	Level off	Rate of climb approaching level off
Cruise	Lateral Nav change	Correct route or heading selected
Cruise	Cruise climb	Correct Flight Level selected, rate of climb, and speed
Descent	Descent to Flight Level	Correct Flight Level selected, ROD, and speed
Descent	Descent to altitude	Correct altitude selected and ROD
Descent	Level off	Rate of descent approaching level off
Approach	Flap extension	Speed decreasing below limit speed for next flap setting
Approach	Gear extension	Speed decreasing below limit speed for gear extension
Approach	Approach descent	Crosscheck of height and distance, stability criteria, missed approach altitude set
Approach	Short finals	Lateral position, glidepath and speed
Approach	Flare	Lateral position, pitch angle and speed
Landing	Landing roll	Lateral position, spoilers, reversers, deceleration
Go around	Initial climb	Thrust applied, flap changed, climb confirmed, gear up, missed approach altitude correct, lateral navigation correct, autopilot usage, level off
Ground	Taxying to stand	Route and groundspeed

Conclusion

It cannot be overstressed how important the role of the Pilot Monitoring is. If we are to maintain a high level of safety within the commercial aviation world, then we need our pilots to continue to perform the Pilot Monitoring duties diligently and professionally. Remember that if you are the Pilot Monitoring you might be the person, that final barrier, which prevents a major incident or accident. Similarly if you are the Pilot Flying then remember that Pilot Monitoring is there keeping an eye on critical aspects of the flight. If the Pilot Monitoring highlights something then take it as help not as a criticism. None of us are perfect and despite a wealth of experience we can all make mistakes.

Fly as a team working together to get safely to your destination.

Further Reading:

UKCAA Paper 2013/02 -Monitoring Matters - Guidance on the Development of Pilot Monitoring Skills

Flight Safety Foundation - A Practical Guide for Improving Flight Path Monitoring

Unusual Flight Plans: Case Study

By Tom Herbert, NATS

Timeline

The Flight Plan (FPL) for ABC123, with a Requested Flight Level (RFL) of FL330 was accepted by NATS Flight Data Processing System at 09:02:28.

At 11:29:14 the FPL for ABC123 was amended with a RFL of FL130.

The flight got airborne at 13:15. Flight strips were produced in Terminal Control (TC) and data was sent to the Swanwick Flight Server (SFS) with the RFL of 130.

The pilot of ABC123 was subsequently issued with multiple climb instructions above their flight planned level by the TC controller (who was climbing the aircraft in accordance with the normal profile for an aircraft of that type on a similar route which have an RFL195+).

The controller then transferred the aircraft to an Area Control (AC) controller in accordance with the Standing Agreement.

ABC123 then reported on to the AC frequency. The radar display at this time is shown in Figure 1.

Figure 1

As ABC123 had filed a RFL level below AC airspace, the controller had no details of the flight and consequently it was displayed as a 'Background Track'.

Note: *A Background Track has the following limitations with the iFACTS tools: Trajectories are only produced for paired Background tracks when individual flights are Manually Recognised (when they become part of the Recognised Flight set) or when they become Rogue Sector Entry.*

Reports

The TC controller reported that:

"[AC] soon telephoned to remark that they were not expecting the aircraft and were (quite rightly) perturbed that this aircraft had just entered their airspace without coordination and was totally unexpected, raising serious safety concerns.

It was only afterwards that I noticed that the RFL for this flight was FL130. I can only assume this was to evade flow restrictions. Had I noticed the RFL (which is easily missed) I would have made sure that the aircraft was appropriately coordinated"

The AC controller reported that:

"The pilot of ABC123 called onto the frequency at 13:27 […] at FL200. The track was initially background on the radar before becoming Rogue Sector Entry (RSE). The planner 'force offered' the aircraft and coordinated with Brussels. The sector was very busy at the time and there were no details on the aircraft.

On further analysis, the filed FL was FL130, assuming to avoid DVR regulations. The aircraft should not have been climbed above this level before checking. The aircraft should have been manually coordinated by TC."

Implications

Flights that enter sectors they have not flight planned to enter can cause significant disruption to the controllers and the ATM system. The potential safety outcomes and their impact are detailed below:

- ATC Overload – ATC sectors capacity are carefully monitored to ensure that controllers can safely handle the amount of traffic planned to enter them. Extra flights that enter a regulated sector can easily add additional workload which may cause the controller to become overloaded.

- Loss of Separation – Conflict detection is based upon having advanced knowledge of the flights in & about to enter a sector. Flights that enter sectors they have not planned to, make conflict detection more difficult.

- Lack of Pilot Situational Awareness – If the controller begins to instruct the pilot to do things they have not planned to this may reduce situational awareness within the cockpit environment.

Actions

NATS has taken the following actions from this incident:

- A Safety Information notice was published to all controllers and assistants immediately after the incident highlighting the issue and asking for more reporting of the same issue so that hotspots can be identified.

- A new procedure has been introduced for evaluation within the TC Ops room which instructs the Assistants to highlight unusual RFL's and bring these to the attention of the controller. Controllers were further reminded of their requirement to check the RFL before climbing aircraft to Standing Agreements.

- Future Systems will be developed to include automatic detection of RFL's below standing agreements and bring this to the attention of the controller.

- RAD (Route Availability Document) restrictions on ABTUM below FL135 are under consideration to ensure that aircraft filing below AC airspace are re-routed to make detection of these flights easier.

- Work with European Partners and internal departments to identify large differences between Flight as Filed and Flight as Flown and refer those for impact assessment and follow up.

For Our Customers

It is acknowledged that there is the ability to re-file flight plans below regulated airspace to permit a departure earlier than would have been possible with an optimum RFL. However, this can lead to safety incidents such as overload or loss of separation.

As such we would request that where a plan is re-filed below a regulation that crews are informed of the reason behind the re-file and either should not accept a higher level earlier than they had planned to or should flag up to the controller that they are level-capped.

In future crews should be advised that in this situation, they should not expect to be tactically climbed or sent direct.

“Standing in the Way of Control”
Pre-Flight Control Check Analysis

Capt. H. Feller, Flight Data Services Ltd

Introduction

In 2014, an accident to a Gulfstream IV aircraft highlighted the risks involved in failing to perform a flight control pre-flight check. The Executive Summary of the NTSB report, recommendation reference A-15-34 Annex A, directed the National Business Aviation Association to:

Work with existing business aviation flight operational quality assurance groups, such as the Corporate Flight Operational Quality Assurance Centreline Steering Committee, to analyse existing data for non-compliance with manufacturer-required routine flight control checks before take-off and provide the results of this analysis to the members as part of a data-driven safety agenda for business aviation. (NTSB Report A-15-34)

NBAA Action:

The NBAA asked Flight Data Services, as a Corporate Aviation FOQA service provider, to assist this committee and report on the subject.

Research Focus

The purpose of the research was to analyse corporate aircraft flight control pre-flight check data to determine the level of procedural noncompliance in business aviation. The initial requirement was to only look at operations in the United States but FDS decided it was prudent to include all of the FDS corporate jet customers and use the data to do a comparative analysis. The terms N-reg refers to aircraft registered in the United States and the term ROW refers to “Rest of World”.

Methodology

The analysis is based on “business jet” aircraft and only those involved in corporate flying including company owned or corporate charters. No scheduled operations are included. Table 1 is a summary of operators aircraft, flight count and event rates. Figure 1 indicates the month over month trend since Jan. 2013 to June 2016. Table 2 gives a breakdown of pre- and post-accident and pre- and post-NTSB report publication event rates. It highlights whether pilot awareness of the requirement to do the flight control check has increased.

The terms caution and warning refer to relative range of travel by combining Rudder, Aileron and Elevator, in other words if all the flight controls are moved to their full travel range, this would = 300%.

Caution = 160%<240%

Warning = < 160%

Cautions and warnings therefore indicate that pre-flight control checks were not completed in accordance with manufacturers’ SOPs.

Data Summary

Table 1 - Corporate Operator Summary

	No. of operators	No. of aircraft	Total flights 2013-2015	Average event rate (Caution and warning) 2013-2015	Total no. of flight 2013-2016	Average event rate (caution and warning) 2013-2016
N-reg(US) operators	11	23	5153	14.0%	6311	13.6%
ROW operators	11	82	4834	21.0%	6427	18.9%
Totals	22	105	9987		12738	

Comparison US and ROW Jan 2013-Jun 2016 Figure 1

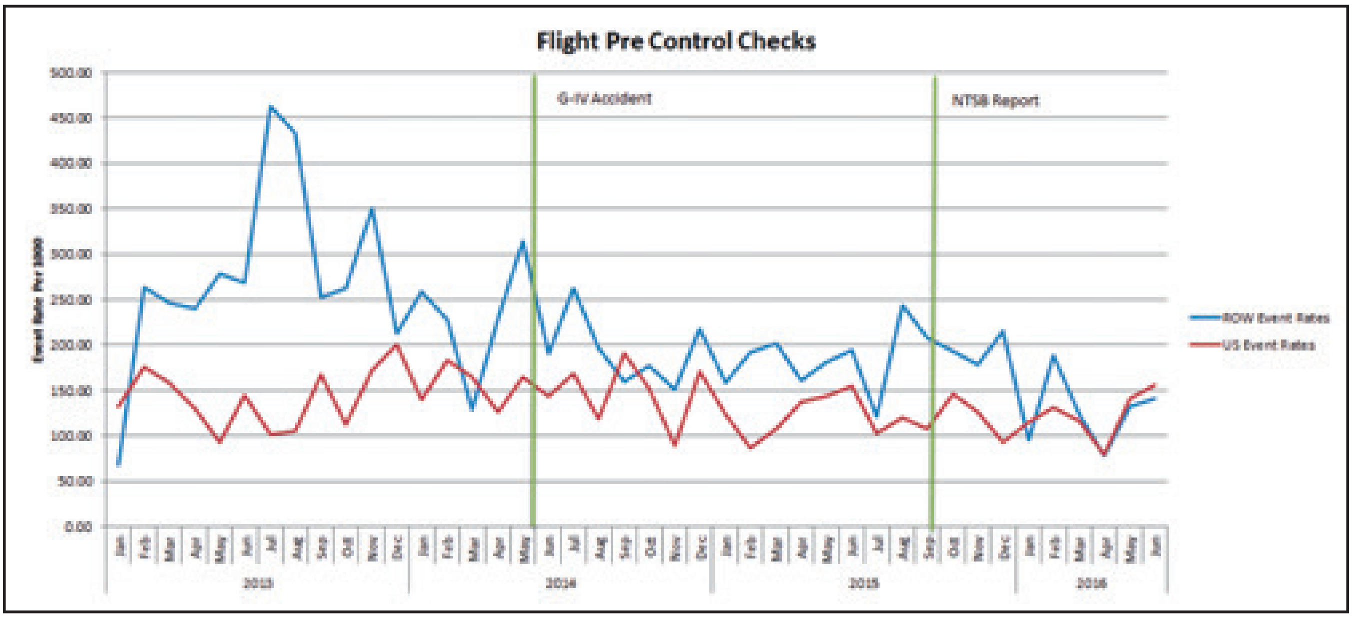


Figure 1

N-reg (US) yearly event rate for caution and warning:

- 2013 = 14.6%
- 2014 = 16.5%
- 2015 = 12.2%
- Jan-June 2016 = 12.1%

ROW yearly event rate for caution and warning:

- 2013 = 26.9%
- 2014 = 20.6%
- 2015 = 18.8%
- Jan-June 2016 = 12.6%
- **For N-reg (US) aircraft 2014 was the worst year with an event rate =16.5%**
- **For ROW aircraft 2013 was the worst year with an event rate = 26.9%**
- For N-reg there has been a decrease of about 4.4% in 2016 from the 2014
- For ROW there has been a decrease of about 14.3% from 2013
- ROW has a higher event rate in 2013 but the difference is negligible from US data toward June of 2016. We investigated the spikes in the ROW data which is most pronounced in the June and July data of 2013. We found that it is due to the operation of one operator only. When we remove this operator, spikes disappear and the ROW and N-reg are fluctuating around the rate of 150 events per 1000 flights, which is about 15%. This particular ROW operator, in 2013 had a 42% event rate. They experienced a steady decrease in 2016 to 3.5%. This case highlights that one or a few operators can cause data spikes because the sample size is not large enough. This can make it difficult to compare between operators as well as compare between US and ROW.
- The vertical lines indicate the month when the accident occurred and the month when the NTSB report was published.
- As noted above, the data spiking due to individual operators and a relatively small data set, makes it difficult to see discernible trends. The yearly trend is perhaps the best indication. "Caution and Warning (Total) Event Rates" have been decreasing since 2014. Comparing data for N-reg (US) operators, prior to the accident (Jan 2013-May 2014) the average event rate was 14.5%. The event rate after the accident (Jun 2014-Jun 2016) was 12.9% a decrease of 1.6%.

Table 2 - Comparison of Event Rates Pre and Post Accident/ NTSB Report

Rates include warning and caution levels

Date Ranges	N-reg US	ROW
Jan. 2013-May 2014 (prior to accident)	14.1%	25.3%
June 2014-Jun 2016 (after accident)	12.8%	16.9%
Jun 2014-Aug 2015 (after accident & prior to NTSB report	13.3 %	18.7%
Jan 2013- Aug 2015 (prior to the NTSB report)	13.9%	21.3%
Sep 2015-Jun 2016 (after NTSB report)	12.0%	15.0%
Jan 2013-Jun 2016 (entire period)	13.3%	19.0%

Table 2 gives a breakdown of pre-and post-accident and pre- and post-NTSB report publication event rates. It highlights whether pilot awareness of the requirement to do the flight control check has increased.

Summary N-reg (US)

- The event rate after the accident decreased by an overall rate of 1.3%.
- The event rate after accident and prior to the NTSB report decreased by 0.5%
- The event rate after the NTSB report decreased by 1.9%.
- The event rate prior to the accident and after the NTSB report decreased by 2.1%.

Post-accident awareness advisories and the NTSB report itself *may* have had an impact on decreasing event rates. However, the numbers may not be statistically significant because the data set is relatively small.

Summary ROW

- The event rate after the accident decreased by an overall rate of 8.4%.
- The event rate after accident and prior to the NTSB report increased by 1.6%
- The event rate after the NTSB report decreased by 10.3%.
- The event rate prior to the accident and after the NTSB report decreased by 4.0%.

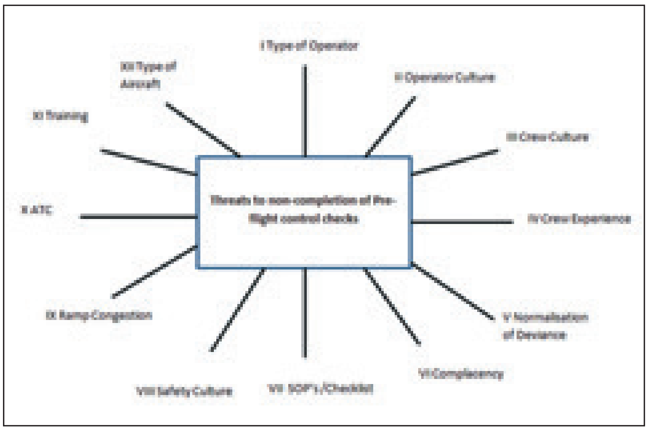
The event rates for ROW have decreased significantly since the NTSB report but it is unclear whether this report had any influence. The numbers can be misleading if previous comments regarding a single operator can skew the results. See Figure 1.

Discussion

As stated in the NTSB report, procedural compliance is the cornerstone of safety in aviation. Understanding the reasons that non-compliance occurs is an important component to helping resolve this critical issue. During a 10-year study in the late 1990s, Boeing found that in more than 138 accidents totalling over 5,600 fatalities, failures of the pilot flying and pilot monitoring to adhere to standard operating procedure were the primary cause of 80 percent of those accidents.

The following diagram (Figure 2) could be applicable to almost any aspect of aviation but the focus of this report is the "Flight Control Check." The diagram will help review additional threats and factors related to intentional or unintentional non-compliance of SOPs, in particular the flight control pre-flight check.

Figure 2 – Threats to Non-Completion of Pre-flight Control Checks



I. **Type of Operator** The different types of business jet operators include: private contractors, fractional ownerships, charter, private company jets, etc. Each company decides their level of commitment to a Flight Safety Program. They will inevitably have a different approach to Safety or they may defer the responsibility to the pilots. As the data suggests it is important to assess each operator on a case by case basis and evaluate their approach to Safety.

II. **Operator Culture** Is there a Safety Culture? Are they NBAA members? Are there pressures on crew to push limits, extend duty days, meet strict schedules, and push weather limits? Does the operator require pilots to also support administration? In the G-IV Bedford accident the co-pilot had other administrative duties; flight safety was not mentioned. These are all additional distractions.

III. **Crew Culture** Determined by aviation background and safety training. Crews of mixed nationalities/race are not applicable in this case but it could be an issue for other operators. CRM training?

IV. **Crew Experience** Age and hours between crew members. Two Captains together or Capt. / FO. In this case both pilots were very experienced. This is not always a good formula for safety. The Asiana B777 SFO (July, 2013) accident is a case in point.

V. **Normalization of Deviance** It was an accepted practice to not complete the pre-flight control check. Nothing had ever happened before. Perhaps it took too much time and they were in a hurry or their passengers were in a hurry. **This crew was non- compliant 98% of the previous 175 flights.**

VI. **Complacency** A stated and known issue in aviation. Familiarity with crew members breeds complacency. Small operators should be aware of this.

VII. **SOP's Checklist** Is the Checklist a challenge and response one? Or, is the controls check a memory item? Is the checklist completed after engine start, prior to taxi, or completed during taxi or completed just prior to take off? Checks which are required to be completed on taxi out may be omitted because it's not convenient to do while taxiing. Checks which are required before take-off may be incomplete if crews are rushed by ATC. In the Bedford case the crew should have completed the check prior to taxi as per their SOPs. What were the distractions?

VIII. **Safety Culture** should embrace operator and crews as well as the *corporations* and *customers* they serve.

IX. **Ramp Congestion** Small airports usually have small ramp areas. These can be congested and require hurried movement of aircraft resulting in a missed check.

X. **ATC** requests to expedite missed slot times could result in long delays putting pressure on crews to cut corners.

XI. **Training** Understanding the reason for doing any check is motivation to complete the check. Appreciating that the flight control check not only validates gust lock disengagement but also confirms that there is no FOD, weather or any other damage resulting from ground handling equipment.

XII. **Type of Aircraft** Do the pilots fly the same aircraft all the time? Are newer versions remarkably different resulting in different checklists and procedures?

Conclusions

The Pre-flight Control Check Analysis concludes that the current event rates have not decreased significantly since the Bedford accident. The event rate for both US and ROW has hovered around 15% since 2013. The slight decreases in event rates since the accident are mathematically not significant. There is not enough evidence to indicate whether any awareness advisories, reports, or other notifications have had any impact on reducing this event rate. Figure 2 and the 12-point summary illustrate the many factors influencing issues related to intentional or unintentional SOP compliance. It discusses some considerations which, if implemented, will help mitigate non-compliance problems. It is presented to encourage industry conversation. Reviewing operators (auditing) on an individual basis with a critical eye on Flight Safety should be a priority. The same kind of review could also be completed on all aircraft types to understand the differences in procedures and the differences between checklists to determine areas where there could be greater compatibility.

Operators require an independent flight data monitoring program.

Safety campaigns highlighting SOP compliance should be more robust.

Essential questions to ask are: What is an acceptable level of compliance? What is a tolerable event rate?

Aviation continually strives to improve safety standards. Procedural compliance is a foundation for that improvement and reducing FDM event rates is a key element. The ultimate goal is zero events leading to zero accidents.