THE INVESTIGATOR

Air Accident Investigation Sector
UAE General Civil Aviation Authority

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INCLUDED IN THIS ISSUE:

- GCAA REGULATORY FRAMEWORK FOR HELIDECKS
- PILOT FATIGUE
- STARTLE EFFECT
- PILOT MONITORING

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REPORT SAFETY HAZARDS

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Foreword by H.E. Saif Mohammed Al Suwaidi

Director General - UAE General Civil Aviation Authority

The GCAA holds the organizations that it regulates to high standards. We ensure that standards are maintained through audits and inspections and GCAA personnel have established good contacts with each organization to ensure that any changes in management, operations or maintenance do not have an adverse effect on safety.

Nevertheless, each organization must understand that mere adherence to regulations will not meet the required safety objective. It is necessary for all parts of the aviation system to exceed compliance. A good example of an enlightened approach to achieving an acceptable level of safety is an organization that maintains a safety management system that is supported by a safety culture that involves everyone in the organization from the Board of Directors, through all members of senior management, to each individual staff member.

Safety must receive the constant active support of the highest levels of management. This support must be visible to everyone in the organization so that it is understood that the safety of the operation is a key objective of the organization.

For the benefit and promotion of safety investigation, and the promotion of safety as one of the pillars of SMS, I have asked the Air Accident Investigation Sector to increase the number of issues of The Investigator to three per year. The response from the industry and the recipients of this publication has been positive and we should build on things that work to further safety. To the many people who have contributed the interesting articles published in The Investigator I offer our appreciation and our thanks for donating your knowledge, experience and time to an important endeavor.

Civil aviation is the safest form of transport. Through the oversight and support of the GCAA, in cooperation with industry stakeholders, the most important goal of the GCAA is to maintain and improve the safety of the civil aviation system.

Foreword by Eng. Ismaeil Al Hosani

Assistant Director General - AAIS

The role of the Air Accident Investigation Sector of the GCAA is to investigate accidents and incidents occurring in the United Arab Emirates, and to assist investigations by foreign investigation authorities into safety occurrences involving UAE registered aircraft that happen overseas. The very first investigation of an aircraft accident took place in 1908 in the United States. Since then occurrence investigations by authorities around the world have resulted in many safety improvements in all aspects of aviation.

As AAIS experience and capabilities have grown, we have been able to contribute significantly to improving safety. The investigation of safety events is a reactive activity. The harm from the safety failure has already occurred, sometimes with great human cost. Nevertheless, it is very important to identify the causes of the safety failures to remedy identified problem areas. In the case of fatal accidents the investigation activity is vital not only in preventing a repeat of a similar accident in the future, but also in providing answers to grieving relatives so that the reason for their loss can be put into some perspective.

In addition to carrying out investigations, AAIS also produces safety cases covering areas of interest where it may be possible to take preventive action to eliminate potential causes of safety occurrences.

The 2017 MENASASI Seminar and Tutorial will be held in Jeddah from 7th to 9th November. All ISASI/MENASASI members and intending members are warmly invited to attend.

Khalid Al Raisi

Director GCAA-AAI

Composite Materials

The initial development of composite materials started during the 1960s. Composites are now used for primary structure in commercial, industrial, aerospace, marine and recreational vehicles. The nature of composite materials consists of fibrous reinforcements bonded together with a matrix material. Composites allow the stiffness and strength of the material to change with the direction of loading.

Today, major aircraft manufactures are moving toward composite materials because they provide strength, corrosion resistance and reduction in weight compared to classic materials such as aluminum. The use of composites leads to a lighter weight aircraft, and improved fuel efficiency. However, two basic facts make the application of carbon fiber to primary structure difficult. Firstly, carbon fiber materials are expensive at about eight to ten times the cost of E-glass. Secondly, composites are much more sensitive to misalignment during the manufacturing process.

Advanced composites do not corrode like metals. The combination of corrosion and fatigue cracking is a significant problem for traditional aluminum fuselage structure. An example is the Aloha Airlines B737-200 accident when the aircraft suffered extensive damage after an explosive decompression. Although the aircraft had a relatively low time airframe it had flown 89,090 cycles resulting from a route structure of frequent short flights. An additional factor that contributed to the fuselage failure were chemical processes related to operating in a moist and warm environment.

Boeing 787

Advantages and Disadvantages of Composite Materials

Advantages	Disadvantages
• Lower assembly costs (fewer fasteners, etc.) • Tailorable mechanical properties • Weight reduction (approximately 20-50%) • Corrosion resistance • Fatigue resistance	• Nonvisible impact damage • Some higher recurring costs • Higher nonrecurring costs • Higher material costs • Repairs are different than those to metal structure • Isolation needed to prevent adjacent aluminum part galvanic corrosion

Airbus A380

How use of composites has increased on commercial aircraft

Year	Airplane	Percentage composite by weight
1950s	B707	2
1990s	A310/300	5
1980s	A340/330	10
	B777	12
2000 +	B787	50
	A380	25
	A350	53

The Airbus A380 and Boeing 787 structure contain large areas made from carbon fiber reinforced polymeric composites. In terms of percentage by weight, the B787 composite content is 50%, whilst the A380 consists of 25% by weight composites. In these and other modern aircraft, traditional metal construction has been substantially replaced by the use of composite material with higher strength to weight ratios and many other advantages.

Composite structure poses some challenges in accomplishing quick repairs should it sustain damage. Aluminum aircraft structure lends itself to quick application of temporary patch repairs. Whilst damage to composite structures may involve disruption of the composite fibers or sandwich honeycomb panels, and hence the repair can take a longer time and be more expensive. Manufacturers provide handheld ultrasound tools that check for problems and assist engineers in deciding whether an aircraft is safe to dispatch.

The quick-cure patch process for composite materials involves epoxy bonding a pre-cured composite patch over the damaged area. The process, which involves the use of a chemical heat pack to cure adhesive at a relatively low temperature, provides a temporary method of restoring sufficient residual strength to allow the aircraft to continue in service. Depending on circumstances, some airlines prefer to make a bolted repair, which involves a repair similar to the traditional process used on aluminum aircraft. The choice as whether to use a bolted or bonded repair frequently depends on how much time the airline has available. Although it is claimed that repairs can be done relatively quickly, one operator reported that a skin puncture repair (which on a conventional aluminum aircraft would be done in a few hours), required a complex repair process carried out by a team from the aircraft manufacturer. The complete repair took around four weeks at very significant cost.

The structure of future aircraft will include larger proportions of composite materials in their construction due to their weight saving advantage over aluminum and to their significant increased strength over traditional materials.

Airbus A350

Hans Meyer

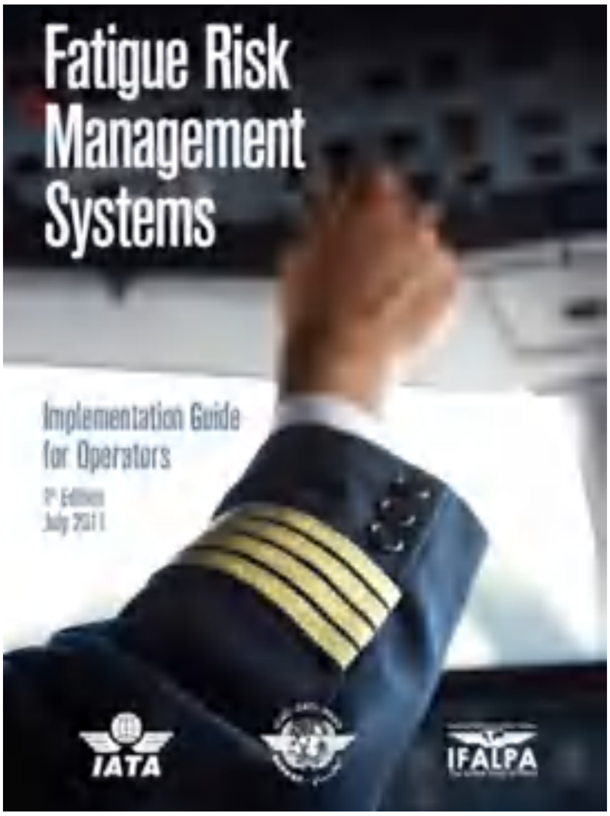
Air Accident Investigator
GCAA - AAIS

Pilot Fatigue and the Usual Suspects

In July 2011, IATA, ICAO and IFALPA, published the Fatigue Risk Management Systems Implementation Guide for Operators. In its foreword the guide states:

"Traditionally, crewmember fatigue has been managed through prescribed limits on maximum flight and duty hours, based on a historical understanding of fatigue through simple work and rest period relationships. New knowledge related to the effects of sleep and circadian rhythms provides an additional dimension to the management of fatigue risks. An FRMS provides a means of adding this safety dimension, allowing operators to work both safer and more efficiently."

Now, six years later, has the industry learned from the many fatigue studies, and do we have more alert pilots flying us on holidays or business trips around the globe?



The consequences of not getting enough sleep are well known. Yet, we still learn of pilots who do not respond to ATC radio calls because they are both asleep, of rare occasions when a "Pan, Pan" call has been made en-route because both pilots are fatigued enough to declare an urgent situation, of accident investigators finding that fatigue contributed to missed checklist items or delayed decisions, and of a senior airline manager's response to pilot fatigue complaints being to "toughen up, princesses".

The NTSB identified that the crew involved in the Colgan Air flight 3407 accident in 2009 were likely to have been fatigued after the Captain spent the night before the flight sleeping in the crew lounge, and the First Officer had commuted for 15 hours overnight from Seattle on cargo flights.

It is widely accepted that sleep deprivation night after night results in the accumulation of sleep debt, which occurs when minimum rest periods are scheduled for several days in a row, and the person is not able to "catch up" on sleep. Alertness and mental performance decline when sufficient sleep is not achieved over a long period of time. Studies suggest that 7 hours of sleep over 7 consecutive nights is not sufficient to prevent a progressive reduction in reaction time. Restriction of sleep to five hours or less induce these "dose-dependent" effects even faster. The pressure to sleep increases over days of sleep restriction until it finally results in uncontrollable micro-sleeps.

Full recovery of mental functions and regaining full alertness after sleep restrictions can take between two nights and two weeks, if sleep restrictions are chronic. Studies have shown that after several days of severe sleep restriction, people become more and more unreliable at assessing their own fatigue level and actions.

Laboratory tests have also shown that some people are more resilient to the effects of sleep restrictions than others, and that more complex mental tasks such as decision making or communication seem to be more affected. A simulation study has shown that sleep loss increased the number of errors made by flight crews and decreased the ability to resolve detected errors.

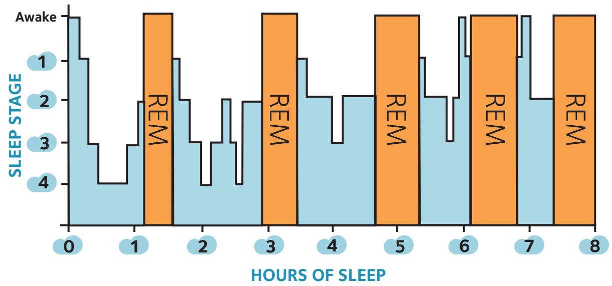
Non-Rapid Eye Movement and Rapid Eye Movement Sleep

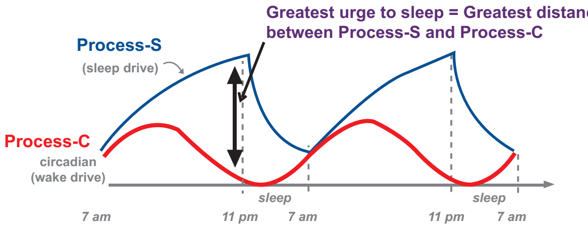
Scientific tests have shown that Non-REM and REM sleep alternate in a 90-minute cycle for a normal night's sleep. Sleep always starts with a slow-wave sleep regardless of when the sleep occurs, or the point in the individual's circadian body clock cycle. This ensures that the homeostatic sleep pressure is slowly released first. The homeostatic sleep pressure is the body's urge for sleep which naturally builds up over the awake period. While studies suggest that the later stages of Non-REM sleep are important for the consolidation of some types of memory, the regeneration of brain functions occurs during the REM sleep cycle. This explains the importance of providing not just enough time to include both cycles in your next sleep, but also the environment for quality sleep in which both types of sleep can be completed without interruptions.

Studies have shown that crewmember's sleep in onboard crew rest facilities, or during flight deck naps, are lighter and more interrupted. There seems to be sufficient evidence to suggest that in-flight sleep improves alertness and reaction speed and is a valuable tool to reduce flight crew fatigue. The studies identified that random noise, thoughts, not being tired, turbulence, aircraft noise, uncomfortable beds as well as the low humidity and the need to visit the bathroom causes most disturbance to in-flight sleep.

"The Icelandic investigation board investigated a runway excursion in Keflavik, Iceland, in 2007 and identified

Stages of Healthy Sleep





fatigue as contributing factor. In its report, it stated that: "Rest alone does not reduce fatigue. Rest implies that although the crew person may be inactive, they may remain awake. If the crew person is awake, their brain physiology will not enter a restorative sleep state and therefore, fatigue will not be reduced. For normal healthy adults without sleep disorders, restorative sleep is usually only obtainable in dark, quiet environments where the skeletal muscles can fully relax. This level of muscular relaxation is usually only obtainable in a horizontal position. A reclined position does not normally permit adequate skeletal muscle relaxation. Any diversion from the optimal configuration (dark, quiet and horizontal) will decrease the probability that the crew will be able to experience adequate restorative sleep and benefit from the rest period. The risk of fatigue and fatigue related errors would therefore remain present."

Studies have also shown that with age, the proportion of time spent in slow-wave sleep declines and sleep generally becomes more fragmented and that this consistently affects the duration and quality of sleep. However it is also identified that older pilots are more experienced in terms of flying skills and managing their fatigue, which can reduce the likelihood of fatigue related errors.

SLEEP CYCLES CHANGE WITH AGE

	Age 20	Age 40	Age 60	Age 70	Age 80
Time to fall asleep	16 minutes	17 minutes	18 minutes	18.5 minutes	19 minutes
Total sleep time	7.5 hours	7 hours	6.2 hours	6 hours	5.8 hours
Time in regular sleep	47%	51%	53%	55%	57%
Time in slow wave sleep	20%	15%	10%	9%	7.5%
Time in REM sleep	22%	21%	20%	19%	17%
Time asleep while in bed	95%	88%	84%	82%	79%

JamesClear.com

Source: Sleep, Nov. 1, 2004, pp. 1255-73

Effects of fatigue

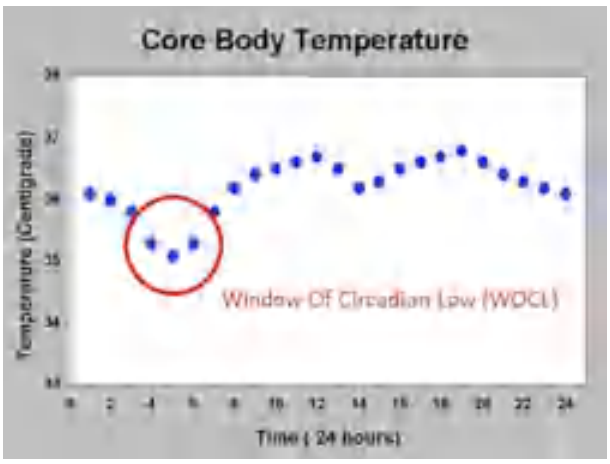
There has been a lot of research into the effects of fatigue on the body and mind. It has been found that during sleep, the body is nurturing one's physical and mental health. Studies have shown that sleep deprivation reduces the immune system's ability to do its job in fending off bacteria and viruses. This is the reason why recovering from illnesses when fatigued takes much longer. Additionally, long-term fatigue raises the risk of developing type 2 diabetes and cardiovascular diseases. According to Harvard Medical School studies, a link was established between the lack of sleep and weight gain, and is one of the risk factors for obesity.

For professions which require a high level of mental abilities, lack of sleep have demonstrated that:

- Alertness is reduced
- Vigilance is degraded
- Responses are slow and inaccurate
- Decision–making ability is reduced
- Risk assessment ability is reduced
- Motivation is lowered
- Task prioritization and management is affected
- Leadership behavior is negatively affected

Circadian Rhythm Core Body Temperature and the Window of Circadian Low in relation to the Asiana B777 accident

The circadian body clock generates an innate body rhythm, which is sensitive to light and regulates the human day/night cycle. Almost every human body function is influenced by the circadian body clock, including changes to core body temperature. The daily minimum core body temperature, which usually occurs around five am for a night sleeper, is the time when a person will feel most tired and when mental and physical tasks are most difficult to perform. This time in the circadian rhythm is called the window of circadian low (WOCL) and is a high risk period for the occurrence of fatigue related errors. While it is difficult for some professions to avoid mental tasks at this time of day, it helps to be aware that this is the time when fatigue related errors are more likely to occur.

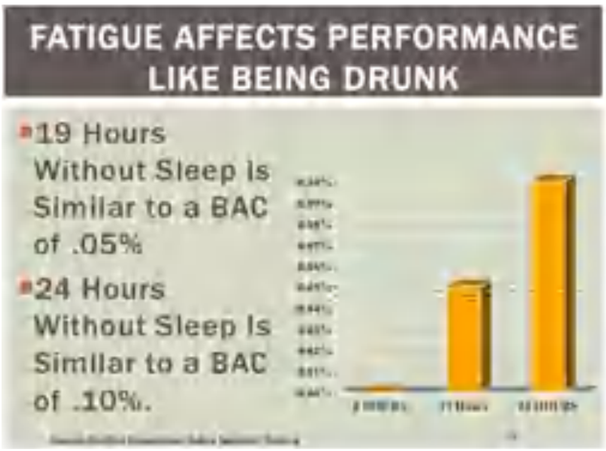


The investigation into the 2009 Asiana B777 accident at San Francisco identified that the flight crew had experienced fatigue which likely degraded their performance during the approach and became a factor in the probable cause of the accident. An excerpt from the probable cause statement reads: "…the accident occurred during the pilots' circadian trough, a period about midway through the normal sleep period when a person's physiological state of arousal is normally at its lowest."

Sleep disorders

A number of sleep disorders like sleep apnea, insomnia, restless leg syndrome or snoring can prevent restorative sleep, even if enough rest time is provided. Sleep disorders are particularly dangerous for shift workers like cabin or flight crew with restricted sleep opportunities. The early identification of a sleep disorder can ensure that a person gets the required support to ensure enough quality sleep to maintain a healthy hormone level, body weight and mood.

Wakefulness, alcohol and performance



Everybody has experienced the effects of fatigue at some point in their life. While family life provides many challenges to daily quality sleep, in young adults it is often self-inflicted when life has more to offer than can be achieved during daylight hours. Research suggests that fatigue alone contributes to 10 to 40% of all road accidents and to 5-15% of all fatal road accidents. To understand these numbers, laboratory experiments were conducted to compare wakefulness with blood alcohol levels, whose effects have been well researched. It was found that performance levels after 21 hours of wakefulness correlates to a blood alcohol level of 0.05% blood alcohol concentration (BAC). 24 hours of wakefulness equate to over 0.1% BAC. It is therefore not surprising when the results indicate that fatigue is 4 times more likely to cause workplace impairment than drugs or alcohol, and that the fatality rate increases after 9 hours of work. While we would not consider turning up at work under the influence of alcohol, why do we accept being fatigued at work to a level that reduces our mental performance?

Sleep vs wakefulness

What is a healthy relationship between sleep and wakefulness? Studies of this topic suggest that 8 hours of sleep prepares the body for 16 hours of wakefulness, or each hour of sleep prepares for 2 hours awake. Prophylactic nap lengths of 2, 4 or 8 hours however can on average positively impact alertness and mental performance for double the time of the nap. It also found that reducing sleep times from 8 hours to 6 hours, reduces the wakefulness to 12 hours rather than 16 hours. The study suggests that for this reason the sleep achieved in the prior 48 hours becomes relevant to calculate a fatigue level.

The investigation into the runway excursion at Keflavik used a tool to mathematically estimate the flight crew's fatigue and human performance. The tool is called Fatigue Avoidance Scheduling Tool, FAST, and predicts psychomotor vigilance tasks, the average speed of mental operations, likelihood of attention lapse, average reaction time and the amount of remaining useable sleep, considering homeostatic sleep pressure.

FAST predicted for the Captain and Co-pilot that at the time of the accident they operated at 75% or lower ability to focus, 85% average speed of mental operations, were four times more likely to suffer from lapses in attention and were likely to have a 133% longer reaction time. Both pilots had less than 8 hours of sleep in the 24 hours prior to the accident. They had been awake continuously for 19 hours, and were working during their circadian low performance period.

Although the crew was augmented by an extra crewmember , no pilot had used the crew rest area, which was a three-seat row in the back of the aircraft, curtained off from the passengers view. According to the pilots, *"remaining in the cockpit provided a more suitable resting environment".* The airline had sold a ticket for one of the crew rest seats to a passenger.

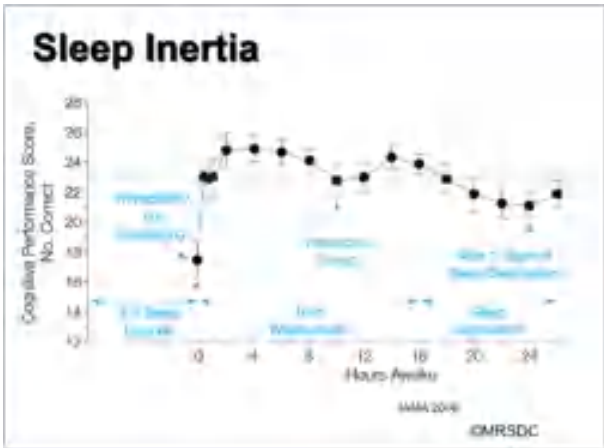
The investigation concluded that: *"…it is very likely that the crew was fatigued and that the fatigue led to performance impairments. The impairments of increased reaction time and narrowed attention may have had a direct impact on the landing and its outcome."*

Sleep inertia

An important factor to consider when discussing fatigue, is the effect of sleep inertia. Sleep inertia is a state in which a person's alertness and psychomotor ability is temporarily impaired. Sleep inertia commonly occurs when a person wakes up from a Stage III or Stage IV REM slow wave sleep. The lengths and severity of the effects vary between individuals but can last from a few minutes up to two hours after waking up. The effects seem to be more intense when waking up near the low in body temperature (WOCL), as compared to peak body temperature.

An Air India Express Boeing B737 accident in Mangalore in May 2010 occurred when the Captain decided to continue an unstable approach, dismissing the Co-pilot's repeated requests for a go-around. The accident was contributed to by the Captain's impaired judgement due to the possible effects of sleep inertia. He had slept in his seat for 1 hour 28 minutes until he woke up 21 minutes before the accident, at a time in his circadian body clock, which was near his window of circadian low.

The investigation reported that: *"In view of [the] long duration of sleep, there was a distinct possibility of Captain [name] being in deep sleep (Stage III or Stage IV sleep) before his arousal. The sleep inertia was likely to be more intense since it had occurred in WOCL, when the core body temperature is normally at its [lowest]. Such sleep inertia might well have persisted till the aircraft had crashed."*



Work roster vs Family Life

Flight and duty time regulation provides organizations with the maximum levels considered safe. This should not be considered the standard for crew rostering as it may not take sufficiently into account aspects like trans-meridian flights and time zone changes. Organizations must comply with regulations, but must also aim to develop a sustainable crew roster. A sustainable crew roster protects the crewmember's health by preventing long-term fatigue and also aims to promote a healthy work-life balance which provides the crewmember with enough time to care for their family. If a crewmember has to decide to either be a committed employee or a good spouse or parent, the roster is not sustainable. Also, while life seems simple without children, where sleep can be achieved any time, having a baby throws another person's sleep-awake pattern into both parents life and may further restrict the provided sleep opportunity. This is a time where fatigue management training can be useful for both parents. Organizations could provide fatigue training to crewmember's partners for a better understanding of the effects of fatigue, circadian body clock, homeostatic sleep pressure and the WOCL, and to actively support their partner's fatigue management.

An individual can prepare for shift work by:

- Apply the lessons learned during fatigue management training
- Check with a doctor whether a sleep disorder exists when chronically tired

- Use opportunities to get enough quality sleep
- Practice a healthy lifestyle with regular exercise, a nutritious diet and maintain a healthy weight
- Feed your circadian body clock with 30 minutes of sunlight every day
- Manage stress in constructive ways, exercise regularly or meditate

Where to go from here?

ICAO, IATA and IFALPA suggest that there are responsibilities to the crewmember and the organization equally. While the crewmember is responsible for their health, fitness level and to use duty rest time appropriately, the organization is responsible to accept fatigue as a hazard to their operation.

Accordingly, the organization must manage this risk as it would for any other identified risks using the tools provided in the risk management process. This can begin with a process to identify where and when fatigue is most prevalent in the operation, based on collected reports in the organization's database. A good and open reporting culture is imperative for the collection of relevant data. Once the data is analyzed, methods can be introduced to measure the level of fatigue. This can be achieved through fatigue reporting forms, self-assessment of tiredness at different stages of the flight, sleep monitors or polysomnography.

Fatigue training programs for crewmembers and managers are common and regulated to ensure that everyone understands how to manage fatigue on a personal level. There are ways to support crewmembers wakefulness, even in a challenging operational work roster. A roster system which is published well in advance, is flexible to facilitate change requests, and incorporates findings from recent studies, or a biometric fatigue system, can reduce crew fatigue levels.

A sustainable roster takes into account:

- Duty time and number of sectors
- The circadian body clock
- East-bound and west-bound travel and the number of time zones crossed
- Acclimatization time at destination and at home base
- Sleep debt from the previous 48 hours
- Crew fatigue reports on certain sectors or rosters
- Long-term projection

Introducing FRMS into SMS

The NTSB acknowledges that it would be very difficult, if not impossible, to completely eliminate flight crew fatigue in the operation of long-distance and trans-meridian flights. However, it is possible for an airline to collect data on pilot fatigue, make adjustments in scheduling and review factors like the quality of crew hotels, crew commute and the quality of crew rest areas to maximize pilot rest and to minimize the fatigue level during high-workload and safety-critical phases of the flight.

Traditionally, flight and duty time limits were prescriptive controls to simply manage the risk of fatigue. While these limitations may work for some operations, an FRMS provides an alternative approach which allows operators to improve the system through integration of results from fatigue science, or collected data.

An FRMS is a holistic approach to fatigue and uses some controls from an SMS, including risk assessment, mitigation strategies, training and education, monitoring and continual improvement. This has the advantage of allowing fatigue detection, prediction and prevention.

One tool for the FRMS is the so-called "biomathematical model", which is simply a set of calculations that predict the fatigue level in matrix form based on questions about the sleep history, time of day and workload. Some operators use a similar system to indicate to the flight crew if a fatigue related risk is evident or predicted for the upcoming flight duty.

ICAO advocates the development of the FRMS incorporated into an operator's SMS, which uses the processes already in place for risk assessment, mitigation strategies, training programs, monitoring systems and continuous improvements.

ICAO defines an FRMS as: "a data-driven, flexible alternative to prescriptive flight and duty time limitations which is based on scientifically valid principles and measurements. It requires a continuous process of monitoring and managing fatigue risk."

Is fatigue management regulation effective?

Regulating flight duty times is difficult because not only are there many different requirements in various countries, for example countries of the EU, these requirements can also greatly vary within just one country.

How can a commercial hot air balloon pilot, a power line inspection helicopter pilot and an Airbus A380 Captain on a 17-hour flight from Dubai to Auckland be sufficiently considered in regulation? Fatigue science applies to all three, but the circumstances could not be more different. The hot air balloon pilot has one flight a day, like the A380 pilot, but not many hours. The power line inspection pilot flies many hours in a day, like the A380 pilot, but is unlikely to end up resting in a four-star hotel.

The challenge for regulators is to find a system that covers all of these commercial operations and reduces each pilot's fatigue level.

A recent safety study by the London School of Economics and Eurocontrol identifies that 60% of European pilots are still fatigued, but only 20% think that fatigue is taken seriously by their employer.

One year after the introduction of EASA's flight time limitation rules, how much safer is the industry? Critics argue that the regulation leaves a lot to interpret, which often is to the detriment of the pilots and to the advantage of the organization. How clear is the guidance material and does an approved FRMS actually reduce fatigue, or is it merely used to justify maximum duty times for their pilots?

Fatigue management regulation is a starting point and while it may be arduous to amend regulation, we need to remember that regulations are there to ensure our safety, based on the best available information at the time. With changes to the industry, for example the introduction of longer flights, larger aircraft, significantly different rosters, or just better knowledge of fatigue related accidents, regulation must keep up.

A good indication for the relevance of specific regulation is the number of exemptions issued by the regulator to the industry.

The airlines need to take responsibility to provide crewmembers with a sustainable roster, which respects a healthy work-life balance. This is the best investment towards producing and retaining a loyal employee, particularly in a time of international pilot shortage.

Mohammed Faisal Al Dossari

Acting Director
GCAA - ANA Department

GCAA Regulatory Framework for Helidecks (Offshore Oil and Gas Industry)

When reflecting back on the history behind the now established General Civil Aviation Authority (GCAA) regulatory framework for the oil and gas industry, it is very apparent that the journey has been a learning one, both for the GCAA and for industry. The journey however is not over and together with the oil and gas industry, operations involving helidecks are providing safety benefits not only now, but are set to continue to do so, in the years ahead.

The GCAA has recognized its responsibility to provide regulation and safety oversight to those "aerodromes" including heliports and offshore helidecks. This oversight is not mandated by ICAO, which only requires oversight of facilities providing international operations, or public use facilities.

The catalyst for GCAA action was the recognition of the continuing increase in non-international aviation and helicopter activity in the UAE. Turning the clock back to 2010, the GCAA, Air Navigation & Aerodromes Department conducted a detailed "Heliport/Aerodrome Survey". The result identified a significant number of locations both on-shore and offshore.

The objective of the survey was to establish the provision of regulation and regulatory oversight for all heliports/aerodromes in the UAE, including private use and offshore operations. This eventually led to the introduction of dedicated regulation and GCAA regulatory oversight for heliports and helidecks, which was not at that time within the scope of the GCAA.

The finer points of the survey resulted in a 5-Stage Implementation Plan, which fell under the direct focus of the GCAA through a PMO initiative. Implementation of the plan commenced in May 2012 with a focus on three main areas:

a) Off-shore helideck operations for the oil and gas industry.

b) Land-based surface-level and elevated heliports (Air Service operations requiring Certification) and private use (requiring Landing Area Approval).

c) Landing areas used for private fixed-wing operations.

The foundation for GCAA regulation was ICAO Annex 14, however, it soon became apparent that additional "Acceptable Means of Compliance" and "Guidance Material" were both required to aid and educate heliport and helideck owners, where aviation was not their front-line business. The eventual outcome was the publication of CAAP 70 (Heliports) and CAAP 71 (Helidecks: Offshore).

Oil and Gas Industry – Helideck: Offshore

The implementation of regulation for the oil and gas industry has had its challenges and to help, the second edition of CAAP 71 incorporated new information presented by ICAO from the new edition of the ICAO Heliport Manual. This was unveiled at the ICAO Heliport Seminar, sponsored by the GCAA and held in Dubai during December 2015.

The oil and gas industry is the backbone of the UAE economy. Regulatory oversight is complicated by the number of installations there are, which run into the hundreds, and the differing types (such as super structures – fixed platforms; unmanned helidecks; mobile drilling rigs; semi-submersible rigs, jack-up drilling rigs; drilling ships and barges). All present challenges for the operator, particularly with the various activities associated with the rigs themselves in the exploitation of oil and gas resources. It was therefore vital to incorporate worldwide best practices into CAAP 71, as well as training requirements and the need for a structured learning program, as regulation.

The model for GCAA regulatory oversight has also proved challenging, with the phrase "thinking outside the box", providing the answer. The result, after much deliberation and "testing" of the model with industry, was to focus regulatory oversight on the major oil and gas organizations, known in the industry as the "OPCOs". This led to a model whereby the GCAA provides approvals to the Primary Accountable Organizations, which simplistically put, are required to provide a Safety Management System (SMS) to support the installations they are responsible for and in addition, to provide supporting policies and procedures for compliance with regulation. Only when the criteria are met, will regulatory approval be provided.

It is important to recognize that conditions off-shore vary considerably, as do the risks. For example, not only does the environment present certain challenges to the helideck operators and pilots alike, but the effect of it on such issues as, maintenance, bird guano (particularly for unmanned installations), structural design, and operations to unmanned sites, are all significant. It is worth mentioning that still today, there exist a number of wooden structures, some now withdrawn from use and others undergoing an aluminum replacement program. All elements have to be considered, hence the inclusion of the requirement to conduct a Safety Assessment as part of the GCAA approval process.

On reflection, it is important to state that throughout this process of developing regulation and regulatory oversight, consultation with industry has been crucial to its success. The production of CAAP 71 received wide circulation as a draft and eventually as a notice of proposed amendment (NPA). The result is a document which holds all the applicable information, across the relevant GCAA departments. The oil and gas industry has embraced the implementation of regulation and to working towards compliance from every aspect.

Overall, since implementation in 2015, results are already indicating safety benefits, both for on-shore and offshore operations. Standardization, and a rise in safety standards is occurring across the UAE and GCAA oversight continues to offer industry support and direction for achieving compliance with regulation.

Elizabeth Mathews

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Analysis of Language Related Factors in Aviation Accidents Part 1

Did language proficiency and language use play a contributory role in the 2006 collision of an Embraer Legacy 600 and a Boeing 737-800 over the Amazon rain forest? A linguistic analysis of the evidence provided in the accident investigation reports suggests that a number of subtle — but significant — language factors helped create an atmosphere in which a series of communication failures were allowed to develop.

However, most accident investigations — and this one was no exception — do not adequately examine language factors because accident investigators typically do not have the background training required to perceive any but the most blatant language errors.

The Brazilian Aeronautical Accident Investigation and Prevention Center (CENIPA) led the investigation of the Sept. 29, 2006, collision of the Legacy — just purchased by ExcelAire Services, a U.S. charter and aircraft management company — and the Gol Transportes Aéreos Boeing 737. The accident killed all 154 people in the 737; the seven people in the damaged, but still controllable, Legacy were uninjured (ASW, 2/09, p. 11).

CENIPA, in its final report on the accident, said the loss of situational awareness by the Legacy pilots and by the air traffic controllers was among factors leading to the midair collision. The U.S. National Transportation Safety Board (NTSB) questioned some of the report's findings and published its own summary and comments about the accident.

The CENIPA report is particularly lengthy and detailed, not unexpected for an investigation of an accident that had required an extraordinarily intricate chain of unlikely events to link up so precisely that a breach in the multilayered safety wall opened.

On the other hand, interrupting that chain of events may have been as simple as an air traffic controller saying to the Legacy pilots, "N600XL, check your transponder."

Unanswered Questions

Accidents are almost never the result of one single error. The CENIPA report, and the NTSB responses, detail a complex host of factors that led the American, English-speaking pilots ferrying the new Legacy business jet from São Paulo, Brazil, to Fort Lauderdale, Florida, U.S., by way of Manaus to fly a northwest heading at 37,000 ft — on a collision course with the Boeing 737 — on a route on which northbound aircraft normally fly at 36,000 or 38,000 ft. One significant factor was air traffic control's (ATC's) loss of the transponder replies from the Legacy, approximately 54 minutes before the collision. The cause of the loss of the transmissions is unclear, but the investigation teams, after rigorously testing multiple theories, finally concluded that the pilots had most likely inadvertently shut off their transponder. Additionally, CENIPA found that distractions on the flight deck interfered with the crew's duties to monitor their instruments and maintain an awareness of ATC communications.

One question left unanswered concerns the controllers' response to the transponder failure. CENIPA noted that ATC "did not perform the procedures prescribed to contact the aircraft when the transponder signal transmission was interrupted, a contact which was mandatory for the maintenance of the aircraft under RVSM [reduced vertical separation minimum] vertical separation parameters."

What is not clear is why air traffic controllers who noticed the loss of the transponder transmissions did not notify the pilots. In its summary response to the CENIPA report, the NTSB said that the "basic investigative question centers on how the primary mission of ATC to separate aircraft was unsuccessful," finding that ATC did not take adequate action to correct a known lost communication situation with the Legacy, and that inadequate communication between ATC and the flight crew was a contributory factor in the accident. The NTSB also said that the causes behind this failure were not "sufficiently supported [in the CENIPA report] with analysis or reflected in the conclusions or cause of the accident."

This review intends to take up where the CENIPA report left off and to move in a direction suggested by the NTSB: to provide a more careful linguistic analysis of the evidence for "inadequate communication between ATC and the [Embraer] flight crew" that was determined to have been a contributory factor.

Language Factors

A hallmark of aviation accident investigations is that they are generally meticulous and thorough. Trained and experienced specialists methodically gather information and evidence according to published protocols. The information is analyzed by technical specialists, and the team draws conclusions about the likely causes of the accident, based on the best interpretation of the evidence gathered.

There was no failure in CENIPA's willingness to look at all issues, including possible language factors, in this accident, and the agency said, "It is important to analyze the attempts to communicate made by both sides."

CENIPA reported the communication failures involving the controllers and the pilots of the business jet and their linguistic challenges.

Nonetheless, a systematic linguistic review of all the information available in the report uncovers a disparity between how language proficiency as a possible factor in this accident was investigated, compared with the deliberate, more intensive, and expert investigation of other human and operational factors. For example, a number of hypotheses to explain the loss of the transponder signal were systematically tested, with the procedures and results detailed in more than eight pages of the report. In contrast, language proficiency and communication as a possible contributory factor does not appear to have been formally, systematically or expertly addressed.

As a result, it remains unclear how language interacted with other factors to — as the report said — "generate a scenario favorable to the collision" over the Amazon.

A linguistic review of the evidence provided in the accident reports suggests that language use was a more significant factor in the chain of events leading to this accident than the accident investigation teams were able to uncover. Just as the purpose of aviation accident investigations is not to assign blame, neither is the purpose of this review to criticize the accident investigation or the reports.

Language use as a contributory factor has been inadequately investigated in this — and most — accidents, precisely because language is complex, because the impact of language factors often can be subtle, and because accident investigators typically have neither the tools nor the training to systematically probe, uncover, and analyze possible language-related factors in aviation accidents and incidents. As a result, safety gaps involving language are inadequately addressed.

Review of Reports

One of the challenges to identifying and analyzing possible language factors in accidents is that references to language are not standardized and are often included under the too-broad category of "communications," whereas communications can include a host of issues unrelated to language use, such as poor radio reception.

In the CENIPA report, there are approximately 28 references to language, language proficiency or communications.

Two of the more than 60 safety recommendations in the CENIPA report correspond to language proficiency:

- The Airspace Control Department shall ensure that all "controllers have the required level of English language proficiency, as well as provide the means for that purpose"; and,
- The Department of Teaching shall "establish a minimum level of proficiency relative to the English language."

The CENIPA report said that "communications between the control units and the [Legacy] crew presented failures," which were grouped as follows: configuration of the controller's console; standard phraseology, as specified by the International Civil Aviation Organization (ICAO); English language phraseology; operational procedures; and organizational problems.

At the time of the accident, the report says, the most recent English test of the air traffic controllers at the Airspace Control Detachment of São José dos Campos was reported to have been administered in 2003, with five controllers earning "non-satisfactory" results, one scoring "satisfactory within minima," and three self-reporting difficulties in the English language. The information regarding controller English language proficiency is unclear and non-standardized.

No information on English proficiency was reported for the Sector 5 controller who transferred control of the Legacy to Sector 7 at what CENIPA and NTSB agreed was an exceptionally early point, a fact highlighted as a latent failure in the events leading to the accident.

The report included little information on the language proficiency of the pilots. However, the document noted that GOL requires a high level of English proficiency as part of its pilot selection process and that the first officer on the business jet reported “difficulties with the ATC use of the English language”.

The report documented that both the controllers and the business jet pilots failed to communicate key information appropriately.

A miscommunication between the pilots and the controller at São José ground control is identified as the “first failure in communication between the pilots and air traffic control.” The report added, “An insufficient training of the standard phraseology and the English language was clearly observed in the communications between São José ground and [the Legacy]. This insufficient training was also noticed in other phases of the flight.”

The communication gap involving the São José ground controller centered on the delivery of the clearance information. The CENIPA report said, “Another problem … relates to the English language phraseology. On two different occasions, the [Legacy] crew tried to learn the altitude to be maintained at the OREN SID [the OREN standard instrument departure], but the pilot did not get a correct answer from the ATC unit.”

The report also cited an earlier apparent problem in communication, when the ground controller at São José “said that later on, when reading thte transcription of the communications with [the Legacy], he noticed that the pilot did not understand ‘Pocos de Caldas’ [a city in southwestern Brazil]. Nevertheless, the pilot accepted the instruction.”

The CENIPA report said that the crew dynamics of the Legacy pilots were a significant factor in the accident, and that of special significance was the crew’s “lack of concern with the air traffic control communications.” The crew flew for 57 minutes without establishing or receiving any ATC communications, the report said.

CENIPA found that “the lack of situational awareness also contributed to the crew’s not realizing that they had a communication problem with the ATC,” the report said. “Although they were maintaining the last flight level authorized by the [Brasilia Area Control Center], they spent almost an hour flying at a nonstandard flight level for the heading being flown, and did not ask for any confirmation from the ATC.”

Regarding ATC communication to the Legacy, CENIPA and the NTSB agreed that a number of critically important communications should have occurred but did not:

- ATC did not issue a level change instruction when the airplane crossed the Brasilia VHF omnidirectional radio (VOR);
- ATC did not notify the Legacy’s pilots of the lost transponder signal;
- ATC did not provide the separation required in response to loss of transponder in RVSM situations; and;
- ATC did not take adequate action to correct a known lost communication situation with the Legacy.

A related factor, determined to be a latent failure, was that the Sector 5 controller handed off the Legacy crew to the next sector at an unusually early point, well before the aircraft crossed the Brasilia VOR — the point at which the level change was scheduled to occur — and 60 nm (111 km) before the sector boundary.

In addition to the communication and language factors identified by CENIPA, an analysis of the cockpit voice recorder data uncovered other linguistic anomalies not highlighted in the report.

For example, a routine exchange with the Sector 5 controller revealed brief but compelling evidence of probable English language insufficiency.

Although the message was brief and consisted entirely of routine phraseology (so that it should be very familiar to the controller), the controller stammered and repeated himself, compounding the challenge to understanding English spoken with an accent not easily understood by the Legacy pilots.

In response, although the Legacy first officer replied, “Roger, radar contact,” the area cockpit voice recording registered the pilot’s expression of frustration: “I’ve no idea what the hell he said.”

An additional communication difficulty occurred at São José, when a Legacy pilot failed to use standard ICAO phraseology to communicate the number of persons on board the flight. “Souls on board,” he said, instead of the ICAO-required “persons on board.” Although this was a minor and inconsequential exchange, it nonetheless revealed a lack of awareness of the ICAO requirement to use standard ICAO phraseology and of the threats inherent in cross-cultural communications.

Language as a Human Factor

After summarizing the accident investigation teams’ findings regarding language proficiency, it was possible to analyze the information that was available to them. Although these references to language proficiency, language use and communication problems were included in the CENIPA report, the information is not gathered, presented or analyzed systematically. In essence, CENIPA uncovered evidence of linguistic factors that were at play but did not establish the relationship between language proficiency and use, and the key communication failures that contributed to the chain of events.

The ease with which we normally use our first language belies the complexity of the cognitive, neurological, social, behavioral and physical processes and phenomena that interact to allow humans to produce and process language. A superficial review of communications fails to uncover the subtle cues that shed light on why the communications between the Legacy and ATC failed so significantly. All the communications bear analysis at multiple levels of linguistic inquiry: at the level of phonology (or sound), lexis (word choice), syntax (structure), semantics (meaning), pragmatics (interplay of context and meaning) and more.

A more detailed linguistic analysis suggests that inadequate language proficiency, a low level of awareness of the threats inherent in cross-cultural communications and inadequate communication strategies were the weak foundation upon which the series of unsuccessful communication events were able to develop. A complete linguistic analysis is too lengthy for this article; however, a partial analysis will point to the conclusions drawn here.

It is useful to start by looking at language factors in the context outlined by Sexton and Helmreich in their discussion of language in the cockpit: "The aviation industry has embraced the notion of assessing pilot ability to manage threats and errors in order to achieve safe and efficient flight, and problem solving communications are the verbal manifestations of threat and error management" (italics added). Threat and error management requires not only pilot-to-pilot coordination and communication but also problem-solving communications between pilots and controllers.

The evidence shows that both the Legacy pilots and the controllers contributed to the communication failures that occurred at numerous points along the business jet's route. In fact, ICAO language standards are applicable to both speakers of English as a first language and speakers of English as a second, or foreign, language. Both groups share equally the ICAO requirement — outlined in ICAO's standards and recommended practices (SARPs), Annex 1 Personnel Licensing — to not only demonstrate English proficiency at the ICAO Operational Level 4 but also to:

- "Use appropriate communicative strategies to exchange messages and to recognize and resolve misunderstandings";
- "[Deal] adequately with apparent misunderstandings (by checking, confirming, or clarifying information)";
- Communicate effectively;
- Communicate with accuracy and clarity;
- "Use a dialect or accent which is intelligible to the aeronautical community"; and,
- Be able to manage "a situational complication or unexpected turn of events".

Conclusions

The linguistic evidence reveals that the communication failures stem from an interplay of a number of factors.

To start, the Legacy pilots demonstrated a lack of awareness of the applicability of ICAO language requirements for native English speakers, a lack of awareness of the threats inherent in cross-cultural and cross-linguistic communications. Additionally, they appear to have responded to several instances of difficult or failed communications with controllers with a degree of inhibition not uncommon to native English speakers when encountering workplace communication breakdowns with non-native English speakers. They failed to "deal adequately with apparent misunderstandings (by checking, confirming or clarifying information)."

The evidence also suggests that the enroute controllers at Sectors 5 and 7 had inadequate English language proficiency and may have experienced a resulting degree of "communication apprehension," a factor that could explain the otherwise nearly inexplicable failure of a series of three controllers to communicate critical and required information regarding required flight levels and the loss of transponder replies — communication failures that directly contributed to the collision. This possible explanation for the failure of three controllers to communicate critical information would have been a valid investigative question in this accident.

The accident investigators were hampered by a number of factors in their ability to document or confirm the English language proficiency of controllers involved in the accident; among these factors were the unavailability of standardized English language testing and limited access to the controllers for interview after the accident.

The legal prosecution of one of the controllers and, in particular, his defense against the legal charges — that "he does not speak English and was obliged to coordinate a flight involving foreign pilots"3 — provides external support for the hypothesis that inadequate English language proficiency underlay this controller's failure to comply with required communication procedures.

In summary, there is evidence that factors related to language proficiency, language use and language awareness may have been the weak foundation upon which the series of assumptions, errors and dropped responsibilities leading to the accident were allowed to develop.

The linguistic analysis of the information uncovered by CENIPA and the NTSB does not change the report's fundamental conclusions. Whether one holds that the primary error involved pilots who failed to maintain proper vigilance and to notice that they were flying a nonstandard altitude for the direction they were flying, or controllers who failed to maintain proper separation between aircraft under their control, it is clear that both sides had an opportunity to interrupt the causal chain. Doing so would have required problem-solving communication in plain English.

The possibility that communication apprehension based on self-awareness of inadequate English proficiency was the underlying cause of the controllers' failure to communicate essential information is an inadequately investigated factor that lies at the heart of this accident investigation. If insufficient English language proficiency and inadequate language awareness were holes in the last barrier to the accident, then only by accurately perceiving the full extent of underlying causes of the communication failures can we adequately implement safety improvements.

Although the final accident investigation report on the 2006 collision of a Boeing 737-800 and an Embraer Legacy 600 over the Amazon identifies findings involving communication and language, the report does not draw a connection between inadequate English language proficiency and the communication failures cited as causal factors (see, "Language Gap").

In particular, there is evidence that air traffic controllers had inadequate English language proficiency and may have experienced a resulting degree of "communication apprehension," a factor that could explain the otherwise nearly inexplicable failure of at least two controllers to communicate routine, key and required information.

The Legacy pilots, in turn, demonstrated a lack of awareness of their responsibility to adhere to International Civil Aviation Organization (ICAO) language requirements and of the threats inherent in cross-cultural and cross-linguistic communication. In addition, they demonstrated inadequate communication strategies, perhaps partly as a result of a degree of inhibition in response to several instances of difficult or failed communication with controllers.

Taken together, these factors helped establish the latent conditions upon which the active operational failures depended to generate the unlikely but calamitous result — the Sept. 29, 2006, collision of the two aircraft, which killed all 154 people in the 737.

Notes

1. Except where otherwise noted, all information and data in this review come from the Final Report A-OOX/CENIPA/2008 of Brazil's CENIPA and the NTSB summary and comments, DCA06RA076A.

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Pilot Monitoring

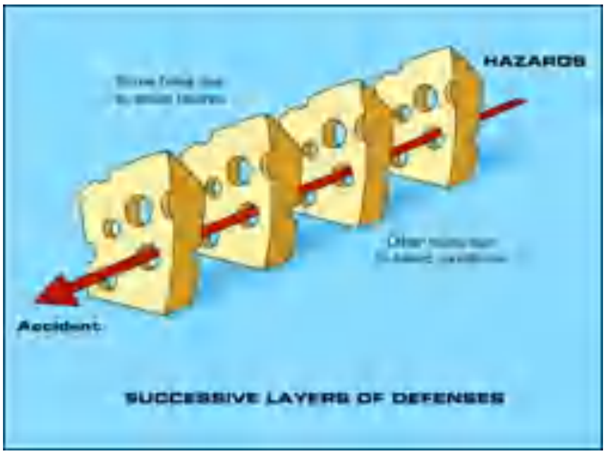
Introduction

The flight deck team normally consists of two pilots who both have an important role in ensuring that the aircraft remains safe. On some flights, for example Augmented or ultra long range (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 who 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 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 examine some examples 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 figure 1, 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.

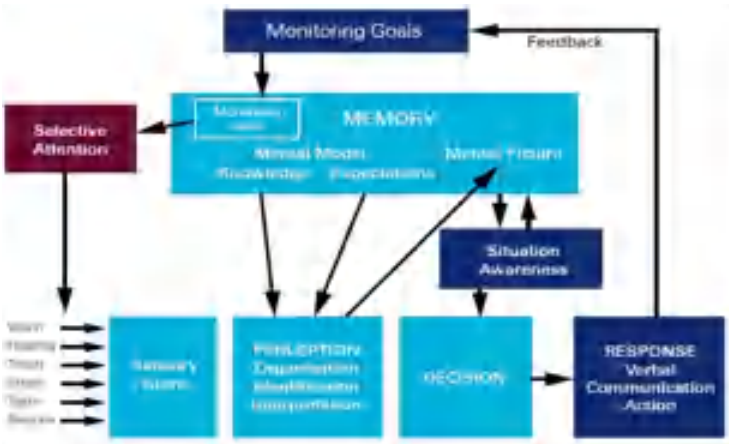


Figure 1. Monitoring Goals

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 **situational 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, **prioritization** 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 Observations

Twenty-one 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 are not 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 in figure 2 shows areas where the risk is increased and therefore the monitoring has to be at a high level.

Figure 2. Vulnerability

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 root 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 (figure 3) and also areas of low risk when 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.

Figure 3.

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 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 Monitoringt	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. Ref. 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.

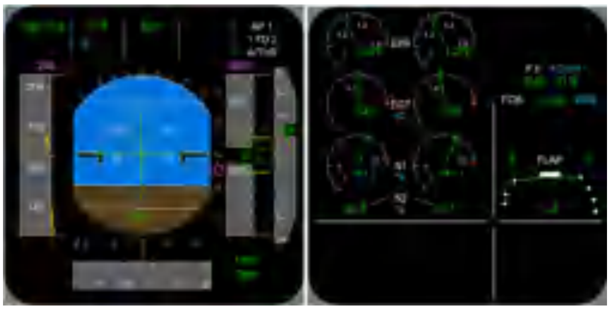
It is worth noting that a key factor in these accidents was speed and as we all know a lack of speed in an airliner is not conducive to staying airborne!

An Example of Lack of Correct Pilot Monitoring;

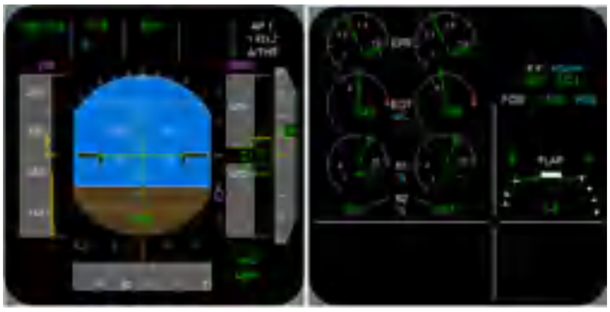
In the commercial aviation environment ineffective Pilot Monitoring can result in such things as flap overspeeds, gear overspeeds, altitude busts, taxiway incursions, unstable approaches, no reverse selection on landing or other undesired aircraft states (UAS). Below is an example to highlight a lack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

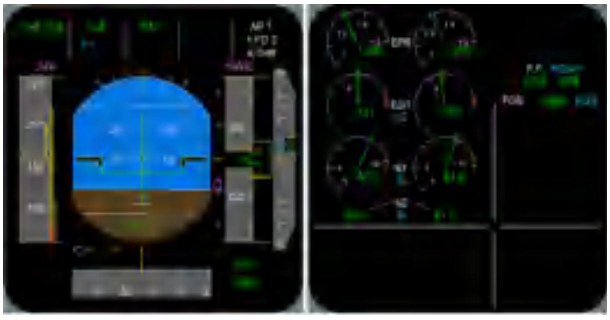


"Speed Checked, Flap- Zero" – The opportunity for First Officer (PM) to trap the error and prevent the undesirable aircraft state.



Flap almost retracted, slats retracting, speed well below VLS.

Speed well below VLS, Vprot and V Alpha Floor increasing as slats fully retract.



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

Middle East and North Africa
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Air Safety Investigators

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From 7th - 9th November 2017

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Thomas Fakoussa
CPT/CRM Trainer

Startle Effect - Experience of a Flight Instructor

Many people, especially parents have had the experience, when observing children at play, that children often become completely absorbed in their actions. If, during play, an unexpected signal such as a voice, or an unexpected sudden movement or they feel an unexpected touch e.g. on the shoulder, they react with surprise and usually just stare at you (the disturber) in silence and are speechless. Then after some time, if the disturbance continues, they will raise their voice in protest – "eeh" or will scream – "NO!" So, being surprised by unexpected perceptual inputs is a normal reaction of our brain system. The brain system is the central processing unit (CPU) for our input (perception) and output (action/reaction). While action is the result of a more or less conscious (slow) process, a reaction to an unexpected input is always non-consciously produced and therefore a fast action, or an automatic reaction. While a reaction, some call it reflex action, is processed in microseconds a conscious action usually will take at least one to two seconds. To understand the difference between a conscious "action" and a non-conscious "reaction" just listen to the way a crew works with a challenge-response checklist.

Example: As a captain I carried out some experiments to check the safety of our pilot training. We had a callout at 500ft above ground, which we termed the "wakeup!!" call. To check the attentiveness of my co-pilots (and several times with my captains) I would give the 500 ft call ("500") at 800 ft above ground. In about 70% of the cases the answer to the call would be: "checked". Also the other way round I would call "500" at 300ft above ground and receive the same answer: "checked". Only about one third of my colleagues noticed that I did not "wake them up" at 500 ft with my call, and they would react to the call instead. This underlines my experience with conscious actions and reactions that are non-conscious or reflex actions.

Startle effect sets in extremely fast. Therefore, reaction to startle is a reflexive action, rather than a considered conscious action. The part of the brain responsible for reflexive reaction is called the reptile brain, scientifically called the brain stem. The brain stem is responsible for our protective reflexes, or reactions. For millions of years we have been programmed to survive sudden life threatening and difficult situations by employing reflex actions.

An example of a difficult situation for this reptile brain to process is an input where the pilot pulls on the stick and he perceives that the speed and sink rate increase. The brain stem is programed to expect the aircraft to climb when the stick is pulled. Experiencing a completely unexpected and different result than usual, it sends a signal to the conscious part of the brain asking: "what am I to do now?" that takes time. Remember the child looking at you speechless and surprised? Now the conscious part tries to analyse the situation. With a lot of experience, it might find an answer quickly, but with little experience, the answer will take more time. Flight instructors, as well as driving, sailing and other instructors, have frequently seen those different ways of dealing with "new" situations, which means the situation is new for the brain, and it has no stored data to compare the situation against.

Once the conscious part of the brain has discovered that it is upside down, it communicates the results of its analysis to the areas of the brain that control motor skills and asks that the aircraft be rolled so that the pilots' head is up and his feet are below his head. Now the reptile brain can take over again. This is a simple example of how data is processed in unexpected and difficult situations.

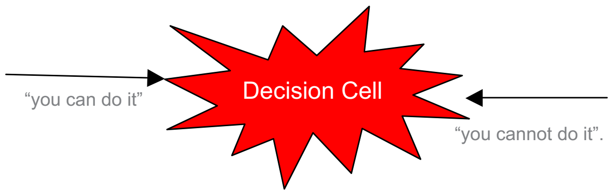
It is interesting to look at different personalities and their basic personal action/reaction programing, their characteristic behaviour. Again let us look at the experience of flight instructors: some students, when getting themselves into difficult situations, have a tendency to give up quickly, while other students in the same situation start "fighting" to regain control. Despite the fact that both students are experienced to the FACTS/ DATA level, given the same situation they both reacted very differently.

The cause of the students' different reactions lies not in the situation as such, but in the individuals' interpretation of that situation. For one student the interpretation was "huh-don't know what to do!" while the other student interprets: "let us see if I can handle it." These different interpretations are based on our earlier life experiences as a baby, child, pupil, student etc. in those days when we were "programed" to behave in certain ways. Had my parents programed me as "let me do that. You cannot do that" from my early days, than the 20 year old student will be waiting for somebody to say "I will do that for you." He will just let go of the controls. He will feel that he cannot carry out the task anyway. The programming of the "fighter" student was the opposite. He was told many times: "You can do it. Just keep trying. You have the guts to do it."

We call these two extreme types winner and loser. Basically, we are all winners and losers at the same time. Try giving me a violin and ask me to play. You would run away screaming and I would feel lost, because I cannot play the violin and I find it impossible to learn. However, give me a student with so-called "problems" and I can turn him, in most cases within an hour, into a "non-problem" pilot. Therefore, in that area I am a winner. As long as we have a good balance in different areas of winner and loser, we feel quite ok.

The problem starts with pilots seeing themselves as complete losers, or complete incontrovertible winners. In some models, the winners are called invulnerable, arrogant, pretentious, or authoritarian. At the opposite extreme would be the looser with an attitude of "I am a looser in so many areas". This pilot would not be able to be assertive, or daring, or acting. In some models, they are called "laissez faire", and at the extreme end would be termed as "depressed".

How do these individual factors influence reaction to "startle"? Let us assume that there is a single brain cell, which gets input from both sides of these extreme and opposite character traits. So one input leads to "you can do it", while the other input leads to "you cannot do it".



Another more technical example would be to consider a spring pulling a car forward, and then attach another spring pulling the same car backwards with equal force. Where does the car move? Nowhere, it is in stuck mode. Now instead of a car we take a brain cell and obtain the same result if the output of one input is yes, and the other is no, AND both have equal strength.

So being in stuck mode has many different reasons, circumstances, causes, ingredients, interpretations etc. and this variety is reflected in our different descriptions for that state of mind to describe the new and unexpected: surprised, baffled, frightened, scared, shocked, daunted, horrified, appalled, puzzled, speechless, paralyzed, etc.

This variety of terms is just a reflection of the many inputs that will decide a persons' reaction. In addition, it shows the different interpretations and different data processing of the same situation in our individually programmed CPU, the brain.

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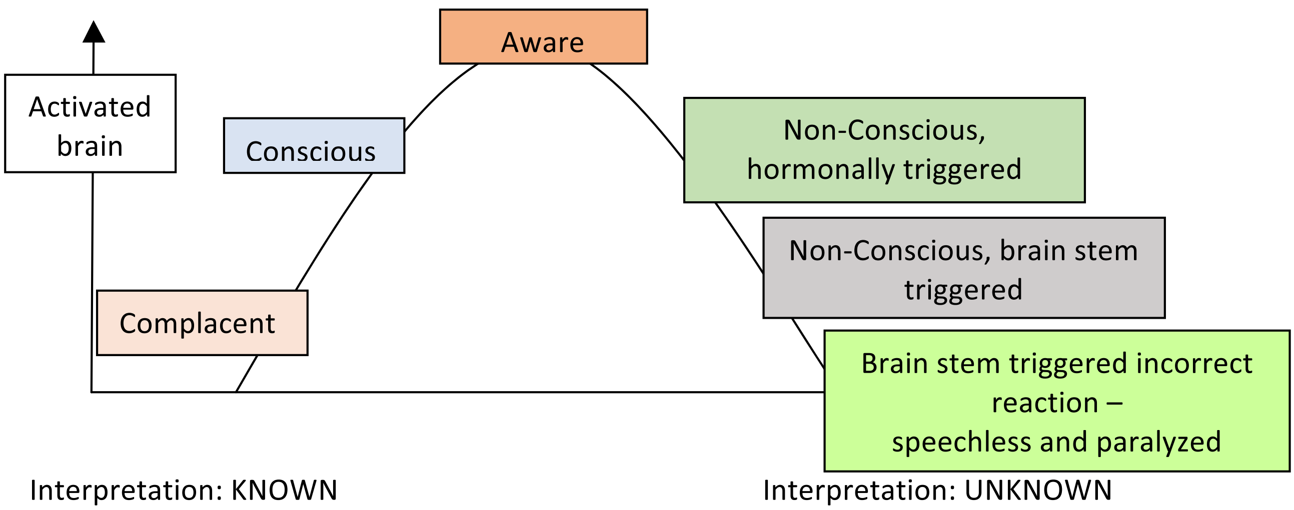

As a flight instructor, it was normal to find students sometimes paralysed and speechless. In my courses for instructors, I always asked the participants whether they had observed similar reactions and the majority knew precisely what I meant, as they had experienced similar individual reactions with their students. As the student experiences more and more flight situations, the number of "new" situations becomes less and less and therefore the student adopts a more action-oriented response. However, even with considerable flight hour experience, the day might come when that individual person becomes paralysed, or startled.

Example: Let us assume you are now the pilot of a B737, or A320. Your career started in the Air Force and you were a fighter pilot. You spent 50% of your flight time in aerobatics and you are now working for an airline where you have become bored with the wings level, maximum 25° bank, and stay smooth for passenger comfort, flying. Your colleague is a regular student from a flight school and has accumulated 5000 hours on type, but had never undergone unusual attitudes training. He is a typical pilot who has flown for many years "automated, wings level, maximum 25° bank and stay smooth for passenger comfort". Both pilots enjoy the smooth ride at flight level 370 in blue sky and sunshine. Suddenly one engine runs down quite rapidly while at the same time on one side the speed brakes have popped up and on the other side the flaps have extended. Your aircraft is rapidly upside down and as you can imagine so are your instruments.

Dear reader, this is an example to illustrate how the brain works and not what technical systems can do, or not do.

Now, let us look at the two different brain interpretations. One pilot might become excited and think: "Wow, that is great, now finally I can see what this machine can do, let's go for it." The other pilot may have a much different response "Oh my god what is that? What do you do with the controls in such a situation?" This pilot has been startled or paralyzed and no more thinking is possible at that stage.

If you think about some of the accidents where pilots experienced similar unexpected conditions of flight e.g. hardovers, you might remember the different outcomes and also the need to reintroduce or to reinvent the wheel of upset recovery training for all pilots, be they commercial, business, or general aviation.

Does it really matter to the pilot community,; surprised or startled, shocked or paralysed? Would it not be a lot better, just to train the unexpected effect as much as possible out of the student's individual brain system? Unfortunately, that would also require us to go back to the good old days of training with hands on the controls and to improve the self-confidence of the pilots to be able to manually handle a computerized and automated aircraft. To be able to do that the instructors have to be trained to gently transform losers into winners and "invulnerables" into well balanced pilots. There is lot of work to be done by the regulators and the accident investigators to pinpoint the real underlying causes and to find counteractive measures, which the aviation industry will accept.

Captain Mark Burtonwood

Senior Vice President of Group Safety
Emirates

Managing Safety at Emirates

As the world's largest international airline, Emirates has become synonymous with comfort and luxury. But its priority has always been safety. Over 50 million passengers travelled on Emirates last year to its global network of over 150 destinations, and as the passenger and destination count continue to grow; managing safety at the airline inevitably becomes even more critical. Captain Mark Burtonwood, Senior Vice President of Group Safety at Emirates, shares how he and his team implement and maintain a culture of safety.

How do you implement a culture of safety at Emirates?

Safety in aviation is especially crucial when you are responsible for over 65,000 colleagues and over 50 million passengers each year.

We maintain a culture of safety at Emirates by making safety the responsibility of all employees. Safety is one of our corporate values, which is supported by our senior management. As emphasised by His Highness Sheikh Ahmed bin Saeed Al Maktoum, Chairman and Chief Executive, Emirates Airline and Group, our objective is to "protect our customers, staff and assets through a ceaseless commitment to international and all other appropriate safety standards". This is reinforced by President Sir Tim Clark, who has signed our safety policy and is the accountable manager for Emirates' Safety Management System (SMS).

Everyone is encouraged to identify hazards, intervene if appropriate and report any concerns.

All our colleagues have access to the company online safety reporting system called SiD and are actively encouraged to report all safety hazards and events. We've had great success with above industry-average reporting levels.

What recent changes have been made to safety management?

We formally introduced a new system to enhance safety best practice and compliance within the company in 2012, called the Emirates' Safety Management System (SMS).

It is designed to align with the International Civil Aviation Organization (ICAO) recommendations and meet the regulatory requirements of the national authority, the GCAA. Emirates' SMS has four components and 12 elements which cover Safety Policy and Objectives, Safety Risk Management, Safety Assurance and Safety Promotion.

The formal structure of Emirates' SMS is vital to effective and safe operations across our diverse and expansive organisation. Our safety communication and training makes sure that every employee understands their responsibilities and the role they play in the overall safety of the airline.

The company SMS manual has been conveniently made available on the company intranet where all employees can access it, both in the office and remotely. We also have an SMS Procedures Manual to support this.

Tell us how Emirates' SMS works.

The success of our SMS lies in the hands of every Emirates employee and we provide regular training and communication to encourage them to participate.

Group Safety give support and guidance to the various departments in the implementation of the company Safety Management System (SMS).This includes helping them to understand hazard identification, classification and risk management, advice on risk assessments and maintenance of the risk register. Group Safety also ensures regulatory compliance locally and internationally, constantly striving to go beyond compliance standards in all areas of safety management.

We encourage a top-down approach from senior management in each business area. Department heads are responsible for leading the management of safety and encouraged to ensure that risk management activities are ongoing and reviewed continuously. They are responsible for making important tolerability decisions with the aim to maintain a safe operation at all times.

What hazard identification strategies do you have in place?

We have three strategies in place - reactive, proactive and predictive. The reactive involves the analysis of past events. Hazards are identified through investigation of safety occurrences. Incidents and accidents may be indicators of system deficiencies and therefore can be used to determine the hazards that either contributed to the event or are latent.

Our proactive strategy involves the analysis of existing or real time situations, which is the primary job of the safety assurance function of our SMS with its audits, evaluations, employee reporting, and associated analysis and assessment processes. This involves actively seeking hazards in the existing processes.

And lastly, our predictive strategy involves the gathering of high quality data in order to analyse and identify possible future outcomes or events, analysing system processes and the environment to identify potential future hazards and initiating mitigating actions.

Together, the different methodologies help us to prepare for any incident, learning from past events and pre-empting future ones.

What sort of SMS training do you offer?

Every Emirates employee receives a safety training session during their induction. We also have online courses for different audience groups from across the company.

Group Safety tailors training content to suit the needs of each business area. For example, our Safety Promotion & Training team runs regular risk assessment workshops for groups of employees. We also run train the trainer sessions in which we show people from different parts of the business how to train employees in their area. We equip them with the knowledge and skills they need to identify hazards and reduce the risks in their department.

How do you communicate about safety to employees?

We try to be as innovative and creative as possible. We want to engage people and get them interested in safety so that they become safety leaders in their work area. We've held a very successful Safety Cinema and a Safety Market Day. We have plans for a Corporate Safety Game (based on the wheel of fortune concept) in the future. We run webinars for flight crew and cabin crew.

We also use a mix of internal channels including our company intranet, print and digital newsletters and our corporate social network. We also develop collateral like posters, z-cards and leaflets to support our initiatives.

Group Safety runs a number of different face-to-face safety campaigns across the business, which are all driven or supported by data analysis.

For example, our Flight Safety team recently organised a campaign in the arrivals area/ zone on call sign similarity for flight crew. Facilitated by Flight Safety, Flight Operations Support and Dubai Air Traffic Control, we highlighted what we're doing to reduce the risk and ways flight crew can help. Flight crew were encouraged to stop and talk to the team on hand, share their experiences and read the information available.

Our Cabin Safety team organises regular campaigns for cabin crew raising awareness of preventing oven fire, smoke and fume events on board, the importance of securing the cabin effectively, and how cabin crew play an important role in our SMS. These campaigns help us to maintain our Safety Performance Targets.

Flight Crew, Cabin Crew, Engineering and Ground Operation employees receive weekly communication from Group Safety. These weekly updates include a summary of the safety reports received the previous week with an update of the follow-up activities.

Group Safety also obtains safety information from external sources through our membership of organizations such as MENASASI and the IATA Safety Group (SG), organizations where Captain Burtonwood is a Board member, and the Flight Safety Foundation where he is a member of the International Advisory Committee (IAC). Captain Burtonwood is also a Fellow of the Royal Aeronautical Society (FRAeS).

How do you think the role of Flight Safety will evolve in the coming years?

Risk management, safety investigations and debriefs, safety assurance, and safety promotion activities will always be part of what we do.

In the future, there will be an increasing focus on the use of big data for predictive safety management. Data received from safety reports already goes through a detailed analysis process, enabling us to present useful and relevant safety information – we are committed to further improve this. To achieve this there will be a focus on talent, technology, and culture. With the right people, tools and equipment, and an open-minded forward thinking approach we can make a big difference.

We will continue to be leaders in the area of safety management systems, sharing safety knowledge both internally and externally.

Safety is everyone's business ■


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