THE INVESTIGATOR
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AIR ACCIDENT INVESTIGATION SECTOR – UAE GENERAL CIVIL AVIATION AUTHORITY

EXPECT THE UNEXPECTED

The lessons learned from an unforeseen balloon accident

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الهيئة العامة للطيران المدني
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His Excellency Saif Mohammed Al Suwaidi,

Director General,
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FROM THE BEGINNING of the 21st century, a 'total system approach' has begun to evolve across the aviation industry and at State level. The Safety Management System (SMS) and State Safety Programme (SSP) have been implemented with efficiently integrated data collection and analysis capabilities with clear pre-set safety performance indicators and targets.

It becomes essential to improve the objective of investigation to integrate efforts at the State-aiming at improving safety. The management of the SSP is the State multi-aviation agency's responsibility, where the national aviation authority is responsible for the implementation of the largest part of the SSP, whereas the aircraft accident investigation authority's responsibility to the SSP is achieved by linking accident causation to SSP-related factors.

The best and most credible document to exhibit this link is the Final Report that documents hazards and risk assessment and ends up with risk-based safety recommendations. Therefore, transmittal of the Final Report to the concerned States and to ICAO becomes highly essential.

For air accident investigation to be more effectively interlinked with the SSP, ICAO as well as State-level guidance material, it needs to be improved to show areas and models of AIG SSP interface. This will establish a strong foundation for the aircraft accident investigators in addition to their competency training in the 'total system approach'. Guidance material will also be beneficial for the investigation authority in terms of enabling the authority to build database and utilise it for risk-based analysis.

The UAE air accident investigation system applies the 'total system approach' in all investigations. The investigations are now advanced towards in-depth analysis of 'human' and 'organizational' factors. The Final Reports contain insight analysis of the organization SMS and its systemic deficiency. By establishing root causes, our investigations contribute significantly to the enhancement of the SMS as well as the SSP.

AVIATION IS AN undertaking that entails risk. The main aspect of a flight that contributes to risk is the complexity of the aircraft's onboard systems. Other environmental factors include bad weather, crowded skies, interaction with air traffic control, unexpected events such as technical failures, medical emergencies, diversions due to airport closures, among others.

The aviation system is tightly connected and a failure in one part of the system can lead to consequential failures and unanticipated air safety ramifications in other systems. As complexity grows it becomes more difficult to design failsafe systems that are unlikely to fail in all possible circumstances. With increasing complexity comes an inevitable increase in unpredictability. In the future, a greater proportion of the causes of aircraft accidents will be from these unforseen adverse safety outcomes.

In a small number of occasions when unexpected events occur, the complexity and close interconnections of the aviation system can combine and contribute to change what should be a normally safe outcome into the occurrence of an incident or accident.

Flying is an efficient, fast and affordable way of making the world accessible to many millions of people. It is now very safe and has become a frequently used mode of transport and very few travellers imagine a negative outcome of travelling by air.

Those of us who are involved in safety investigation understand the concepts of hazard and risk. We have the realization that not only can negative outcomes occur, but that they will occur. We are familiar with the concept of an acceptable level of safety. Does this concept extend to accident-free flight operations? No, it cannot.

Statistically, we expect one fatal aircraft accident to occur in approximately every three million flights. Beyond this statement are the imponderables; will the accident be catastrophic? Will the crew be able to carry out a controlled, or partially controlled landing? If so, what are the chances of survival? If the initial accident impact is survivable, will it be possible for the crew to evacuate the aircraft successfully in the event of a post-impact fire? There are many permutations. There are too many for us to imagine.

What happens on those rare occasions when accident prevention has failed? Investigators with the required qualifications, skills, knowledge and experience are called to action.

On the actions of aircraft accident investigators will rest not only the successful outcome of the investigation but also the opportunity to, in some measure, provide an element of closure for the relatives and friends of those who were involved should there have been fatalities in the accident.

Mohammad Faisal Al Dossari,

Acting Assistant Director General,
Air Accident Investigation Sector

EXPECT THE UNEXPECTED

Lessons learned from a fatal balloon accident in the Northern Territory of Australia

WRITTEN BY

HANS MEYER,
Senior Air Accident Investigator, GCAA

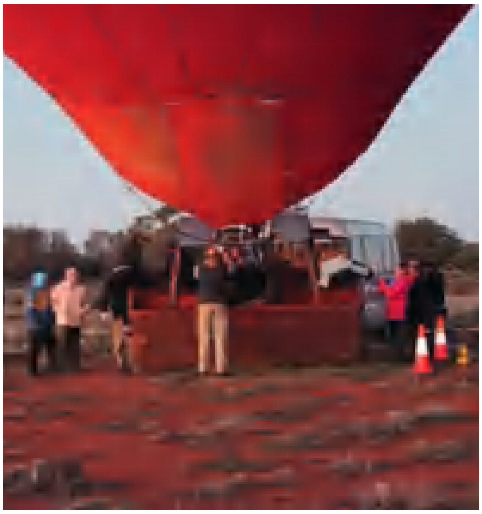
IT CANNOT BE EXPECTED that a passenger will be aware of all of the hazards and risks involved in any of these activities and it is the responsibility of the operator to inform the passengers about all known hazards during the pre-flight safety briefing.

But what about the unknown hazards?

This article describes a fatal accident that occurred in the Northern Territory of Australia in 2013. The Australian Transport Safety Board (ATSB) carried out an investigation. In hindsight, the accident was not easily foreseeable, but maybe it was predictable.

On 13 July 2013 at about 5:30 in the morning, a bus with a balloon pilot and a driver, who also acted as a ground crew member, picked up 10 passengers on the outskirts of Alice Springs, for a chartered balloon flight. As the bus travelled toward the planned departure site, the balloon pilot provided the passengers with a safety briefing that highlighted some of the hazards involved in preparing for the flight and those that could be expected during the flight itself. The briefing included a requirement for the passengers to remain clear of the fan which was used to inflate the balloon.

On arrival at the planned launch site the balloon crew assessed that the location was unsuitable due to the wind direction and the presence of power lines in the departure direction. They decided to move to a location 2 km away. On arrival at the second site the crew found that the wind speed for the departure was fairly high. The pilot knew that the wind speed often dropped around sunrise, and he decided to delay the balloon launch. Sunrise was at 7:17 am on that day.

Passengers pre-boarding into the side of the basket farthest from the inflation fan. (Note: the pilot on the left hand side adjusting the fan position)

While everybody was waiting, the pilot used the additional time to conduct another passenger safety briefing that reiterated how the flight was to progress and what the known hazards were. The passengers were specifically told to remain clear of the inflation fan, and that they were not permitted to be in the area between the balloon basket and the bus during inflation. This restriction was to minimize the risk of injury should the basket move. The passengers were also informed that, due to the wind, they would enter the basket while it was positioned on its side and before the balloon was fully inflated.

Passengers were divided into two groups of five and allocated their positions in the basket. The pilot and the gas bottles occupied the central area of the basket, so passenger boarding was only possible from either end of the basket.

Following assessment that the wind speed was within the allowable limits, the balloon cold-air inflation process commenced at about 7:00 am, using the inflation fan. Two of the passengers assisted with the inflation by holding open the balloon's mouth. As the balloon inflated, the ground crew member went to the top end of the balloon envelope to take control of the crown line. The top of the envelope was over 50 m away from the basket and out of sight of the pilot and passengers.

Once the balloon was inflated sufficiently for the balloon mouth to support itself, the assisting passengers moved to their allocated sides of the basket, ready for boarding. The pilot then accelerated the inflation process by using the burners to heat and expand the air within the balloon envelope.

As the balloon inflated, it gradually rotated to the left and aligned itself with the wind. As a result of that movement, the basket was pulled around closer to the inflation fan. In response to the basket movement, the pilot repositioned the fan away from the basket a number of times to ensure continued efficient inflation of the balloon.

"The passengers were specifically told to remain clear of the inflation fan, and that they were not permitted to be in the area between the balloon basket and the bus during inflation. This restriction was to minimize the risk of injury should the basket move".

HOT INFLATION OF THE BALLOON

At around 7:15 am, the pilot instructed the passengers who had been allocated basket positions farthest from the inflation fan to commence pre-boarding. After several passengers had entered the basket, the pilot directed the passengers who had been assigned locations closest to the fan to begin pre-boarding. The pilot reported that he monitored the passengers as they entered both ends of the basket. During the loading process he remained on the fan-side of the basket close to the balloon burner frame, approximately 1.5 m to 2 m away from the fan. The recollection of the passengers was that the distance between the basket and the fan was between 1 and 2.5 m.

The first passenger to enter the basket on the fan-side stated that they had gained access by moving through a gap between the fan and the basket as they did not wish to be subjected to the force of the air that would have resulted from passing in front of the fan.

As the second passenger approached the basket, a scarf they were wearing was drawn into the operating fan and rapidly become entangled around the fan blades and the fan driveshaft. As a result, the passenger was drawn into contact with the fan's steel guard and the scarf worn by the passenger was pulled tightly around the passenger's neck. The pilot reported that, in response, he immediately shutdown the fan and called out

to the ground crew member for help. He stated that he did not recall that the passenger had been wearing a scarf.

Most passengers indicated that prior to the actual day of the flight they had been advised to wear warm clothes. Some passengers mentioned that items such as beanies, scarves and gloves had been suggested.

The passenger who became entangled in the fan wore a scarf that was wrapped twice around her neck and was loosely knotted such that it could not be quickly removed if caught. The scarf had long, lightweight tassels on each end, some of which extended just beyond the bottom of the passenger's coat.

Despite the provision of first aid and subsequent medical treatment, the passenger succumbed to her non-survivable injuries several days later.

Shortly after this accident, the ATSB forwarded a Safety Advisory Notice to all Australian balloon operators highlighting the circumstances of the accident and advising that they review their risk controls in relation to the safety of inflation fans. With the assistance of the Professional Balloon Association of Australia, and the Australian Ballooning Federation, the notice was also provided to all of their members. The Australian Ballooning Federation and Northern Territory WorkSafe also issued safety alerts highlighting the danger of fan entanglement.

The cold-air inflation fan with remnants of the scarf worn by the passenger (pre-existing minor cage damage highlighted)

Modified fan guard with reduced mesh size

The balloon operator made a number of changes to prevent the occurrence of a similar accident in the future. All of the fan guards were modified to reduce the likelihood of entanglement, a passenger exclusion zone was established in the vicinity of the fan, and a crew member was assigned whose sole duty was to operate and supervise the fan. A caution about the danger of entanglement in the fan was included in the passenger briefing card.

With hindsight, the hazard posed by a long scarf as a hazard could have been identified and the accident could have been prevented by the crew or by any of the passengers, if they had been aware and paid more attention to the situation at the time. However, the investigation of accidents has identified that situational awareness is easily lost when additional factors are introduced. These could be the fatigue level of the crew and passengers during the early morning hours, changes in the equipment arrangement while the passengers were waiting to board, focus on the basket movement due to the wind, the workload of the crew during balloon inflation, and the time pressure due to the limited operational window for a balloon departure due to the rising temperature after sunrise. Some of these factors are not controllable. For others, like the assumption that all hazards are known to the operator, preparation can be made and vigilance can be exercised.

Who is responsible for your safety? ⭘

For more information and the full investigation report, please refer to the ATSB website at: *https://www.atsb.gov.au/publications/investigation_reports/2013/aair/ao-2013-116/*

THE EC 225 LP ACCIDENT
NEAR TURØY IN NORWAY

On 29 April 2016, the Main Rotor suddenly detached from an Airbus Helicopters EC 225 LP Super Puma, registration LN-OJF, operated by CHC Helikopter Service AS. The helicopter transported oil workers for Statoil and was en-route from the Gullfaks B platform in the North Sea to Bergen Airport, Flesland. The flight was normal and the crew received no warnings before the Main Rotor separated. All 13 persons onboard perished instantly when the helicopter hit a small island and continued into the sea. Losing a Main Rotor is unacceptable. This was the second rotor loss for this helicopter type.

THE ACCIDENT SITE

Wreckage parts were spread over a large area both on land and in the sea. The Main Rotor landed on an island about 550 meters north of the crash site. The impact forces destroyed the helicopter, before most of the wreckage continued into the sea. Fuel from the helicopter ignited and caused a fire onshore.

There were many witnesses to the accident. Further, the Combined Voice and Flight Data Recorder (CVFDR) was retrieved from the seabed and successfully downloaded. Additionally, with information from the Vibration Health Monitoring system, the accident sequence could be reconstructed.

However, it was necessary to recover as many pieces as possible to ascertain out why the Main Rotor separated, and parts from the Main Gearbox and its attachments had special focus. On the second day, the main wreckage was lifted from the sea and the Main Rotor was recovered. A number of key parts from the main gearbox were also found at this time, including two segments of a fractured second stage planet gear that later was of vital importance.

A large search operation was initiated which included the Norwegian Civil Defence who scoured onshore using metal detectors. Divers from the Norwegian Armed Forces and the Bergen Fire Department performed in total 354 dives, a Remotely Operated Vehicle (ROV) was used in areas not covered by kelp forest and a purpose built magnet sledge was used to search for steel parts on the seabed. Since the accident the Navy divers have used the area for training purposes and the last major part, the second stage planet carrier, was found and recovered as late as February 2017.

Photo taken from private video

BUILDING A ROBUST INVESTIGATION TEAM

Building a robust investigation team is of vital importance. In accordance with International Civil Aviation Organisation (ICAO) Annex 13, the French accident investigation organisation (BEA) was notified as the State of design and the State of manufacture. The BEA appointed an Accredited Representative to lead a team of investigators from the BEA and advisors from Airbus Helicopters, Safran Helicopter Engines and later the French bearing manufacturer. In accordance with Regulation (EU) No 996/2010, the European Aviation Safety Agency (EASA), the Regulator responsible for the certification and continued airworthiness of the helicopter, was notified of the accident and participated as advisor to the AIBN. The Norwegian Civil Aviation Authority (CAA-N), the operator CHC Helikopter Service AS and the Norwegian Defence Laboratories (NDL) were also advisors and part of the team.

The Air Accidents Investigation Branch in the UK (AAIB) together with the metallurgical laboratory at QinetiQ, Farnborough in the UK had relevant experience from the investigation of a similar fatal helicopter accident off the coast of Scotland in 2009 involving an Airbus Helicopters AS 332 L2, registered G-REDL. For that reason, they were asked to assist during the investigation. The AAIB appointed an Accredited Representative and advisors from QinetiQ as part of the team. Later, advisors with expertise in tribology and certification of helicopters joined the team.

The German accident investigation organisation (BFU) was notified as the State of manufacture of the fractured gear bearing.

The transparent cooperation between these team members turned out to be a success. Documents where shared via controlled access to a secure file cloud.

CHALLENGES FACED DURING THE INVESTIGATION

Shortly after the accident, the EC 225 LP helicopter was grounded by the CAA-Norway and CAA-UK. Early June 2016 the AIBN gave a safety recommendation asking EASA to take immediate action to ensure the safety of the Main Gear Box. EASA issued a flight prohibition for both helicopter types, AS 332 L2 and EC 225 LP. The flight ban was lifted by EASA five months later, based on an agreed corrective actions package for return to service (RTS) between EASA and Airbus Helicopters. In this situation, EASA had at least two different roles. One as being responsible for the continuing airworthiness, the other as an advisor for the Norwegian Accident Investigation Board. The pressure was high on all parties involved, and influenced to some degree the sharing of information. From the Norwegian Accident Investigation Board perspective, it sometimes seemed that lifting the flight prohibition was the first priority.

The Norwegian Accident Investigation Board also experienced that patience is necessary when asking for certification and design information. The AIBN understands EASA's obligation to follow its procedures as a public administrative body. However, the AIBN had to wait for two to six months before receiving some of the documents from EASA. Further, it is understandable that design information is sensitive proprietary information, but to study requested documentation at Airbus Helicopter's premises it is not an effective way of reviewing such information. Additionally, legal issues drew resources away from the investigation. The AIBN notes that Regulation (EU) No 996/2010 states 'free access to any relevant information or records', whereas ICAO Annex 13 states 'unhampered access to wreckage and all relevant material'. Safety recommendations SL No. 2018/10T and SL No. 2018/11T were issued based on this experience.

The main wreckage during recovery

THE METALLURGICAL INVESTIGATION

Two recovered segments of the fractured second stage planet gear, that make up approximately half of a gear, got special attention. Detailed metallurgical examinations carried out at QinetiQ, Farnborough in UK, confirmed that the gear had fractured due to fatigue. The different examinations revealed the sequence of break-up of the gearbox. The fractured gear clashed teeth with other gears and caused an abrupt seizure and rupture of the gearbox, which lost its structural integrity.

The fatigue fracture initiated from a surface micro-pit in the upper outer race of the bearing (inside the second stage planet gear), propagating subsurface while producing a limited quantity of particles from spalling, before turning towards the gear teeth and fracturing the rim of the gear. Four spalls were observed centred along the line with maximum contact pressure.

It is probable that the failure was initiated by debris caught within the bearing and scratching one or more rollers. This probably caused a band of local work hardening and associated micro-pitting at the outer race. The AIBN concludes that the fatigue fracture was neither a consequence of a mechanical failure or misalignment of another component, nor due to material unconformity. More research is needed in order to understand the fatigue behaviour for the material. It has not been possible to determine a conclusive crack propagation rate, but it must have developed within a maximum of 260 flight hours since the gearbox was inspected and repaired at Airbus Helicopters. The repair was done following a road transport incident.

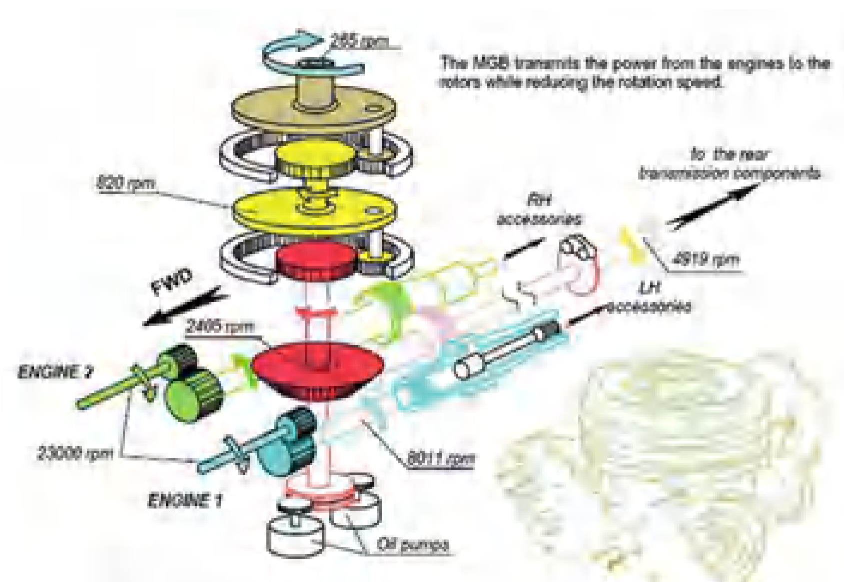
Photo of the accident area taken at 1500 hours 29 April 2016. The helicopter flew over the Turøy Bridge seen to the left. View from south

CERTIFICATION AND CONTINUED AIRWORTHINESS

The helicopter Main Gearbox is both a mechanical drive train and a structural element without any redundancy. Any structural failure during flight will be catastrophic. The helicopter Main Gearbox must be regarded as one of the most safety critical components in the aviation industry.

The EC 225 LP is latest member of the Super Puma family that started with the SA 330 in 1970. The EC 225 LP is derived from the earlier AS 332 L2. The 2004 certification of the EC 225 LP is based on JAR 29 Change 1. The second stage planet gears were certified against FAR 29.571 Fatigue Evaluation of Flight Structure paragraph c) replacement time evaluation: 'It must be shown that the probability of catastrophic fatigue failure is extremely remote within a replacement time furnished under section A29.4 of Appendix A'.

Crack initiation and propagation with limited spalling, was not expected or foreseen during design and type certification in 2004. It was assumed that if rolling contact fatigue occurred, spalling would result and be detected prior to gear failure. The AIBN believe that more could have been learned from the AS 332 L2 accident in 2009. The AS 332 L2 and EC 225 LP have nearly identical gearboxes.



Main Rotor Gearbox dynamic components

The main rotor and rear suspension bars as found on the island Storskora

Using all information and hypothesis might have challenged the design basis. Even though small changes were made to the MGB following the 2009 accident, the certification aspects were not adequately reviewed.

Less than 10 % of all second stage planet gears in the EC 225 LP and AS 332 L2 helicopters ever reached their intended operational time before being rejected during overhaul inspections or non-scheduled MGB removals due to signs of degradation. Airbus Helicopters did not perform systematic examination and analyses of unserviceable and rejected second stage planet gears in order to understand the full nature of any damage and its effect on continued airworthiness.

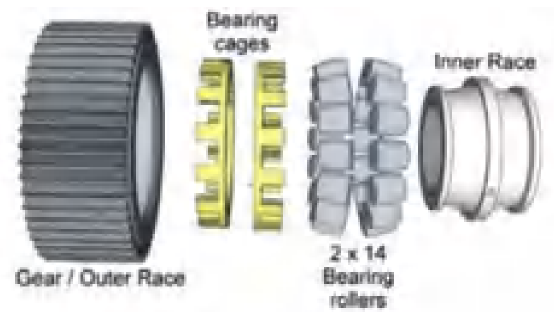
Two catastrophic events (G-REDL and LN-OJF) and the service experience with many planet gears removed from service after relatively short service exposure, may suggest that the operational loading environment, on both AS 332 L2 and EC 225 LP, is close to the limit of endurance for the design.

The EC 225 LP satisfied the requirements in place at the time of certification. However, the AIBN has found weaknesses in the current EASA Certification Specifications for Large Rotorcraft (CS-29) and the Accident Investigation Board Norway AIBN have issued nine safety recommendations addressing these shortcomings.

The following safety recommendations are made in order to enhance Certification Specifications and Continued Airworthiness of Large Rotorcraft:

SL NO. 2018/01T

The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) research into crack development in high-loaded case-hardened bearings in aircraft applications. The aim of the research should be the prediction of the reduction in service-life and fatigue strength as a consequence of small surface

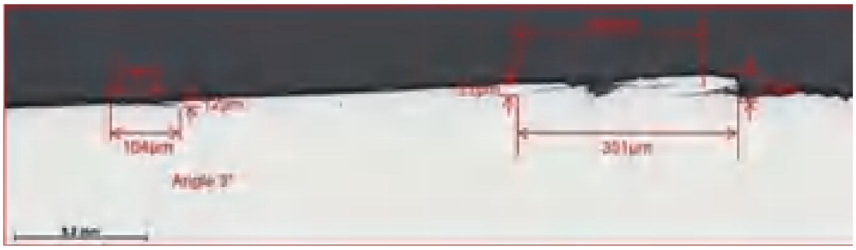


The two segments of the fractured second stage planet gear and an illustration of the second stage planet gear

Source: AAIB/NDL/AIBN

Source: AIBN/QinetiQ

Segment of the bearing outer race showing spall 1, 2, 3 and the through thickness fracture.



Source: AIBN/QinetiQ

Micro-pit in front of spall 1

damage such as micro-pits, wear marks and roughness.

SL NO. 2018/02T

The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) assess the need to amend the regulatory requirements with regard to procedures or Instructions for Continued Airworthiness (ICA) for critical parts on helicopters to maintain the design integrity after being subjected to any unusual event.

SL NO. 2018/03T

The Accident Investigation Board Norway recommends that European Aviation Safety Agency (EASA) amend the Acceptable Means of Compliance (AMC) to the Certification Specifications for Large Rotorcraft (CS-29) in order to highlight the importance of different modes of component structural degradation and how these can affect crack initiation and propagation and hence fatigue life.

SL NO. 2018/04T

The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) revise the Certification Specifications for Large Rotorcraft (CS-29) to introduce requirements for MGB chip detection system performance.

SL NO. 2018/05T

The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) develop MGB certification specifications for large rotorcraft to introduce a design requirement that no failure of internal MGB components should lead to a catastrophic failure.

SL NO. 2018/06T

The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) develop regulations for engine and helicopter operational reliability systems, which could be applied to helicopters which carry out offshore and similar operations to improve safety outcomes.

SL NO. 2018/07T

The Accident Investigation Board Norway recommends that European Aviation Safety Agency (EASA) make sure that helicopter manufacturers review their Continuing Airworthiness Programme to ensure that critical components, which are found to be beyond serviceable limits, are examined so that the full nature of any damage and its effect on continued airworthiness is understood, either resulting in changes to the maintenance programme, or design as necessary, or driving a mitigation plan to prevent or minimise such damage in the future.

SL NO. 2018/08T

The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) review and improve the existing provisions and procedures applicable to critical parts on helicopters in order to ensure design assumptions are correct throughout its service life.

SL NO. 2018/09T

The Accident Investigation Board Norway recommends that the European Aviation Safety Agency (EASA) research methods for improving the detection of component degradation in helicopter epicyclic planet gear bearings.

THE AUTHORS:

TOR NØRSTEGÅRD
is an accident inspector of accidents at the Air Accident Investigation Board Norway (AIBN). He recently finished the investigation into the Super Puma accident near Turøy outside Bergen, Norway in April 2016 as the investor-in-charge. He graduated from the Royal Norwegian Air Force engineering academy in 1982. In the following years with the Air Force, he earned an EASA PART 66 license and worked for several airlines as a licensed aircraft maintenance engineer. He joined the Accident Investigation Board Norway in 1994 and has completed about 160 investigations as investigator-in-charge. This includes commercial air transport aircrafts and helicopters. He holds a private pilot license. In his spare time he restores historic aircraft, the latest being a 1944 German Fieseler Storch which he displays at airshows.

KÅRE HALVORSEN holds an MCs (Civil Engineer) with specialty in material science/metallurgy. Before joining the Accident Investigation Board as senior technical investigator in 1998, he worked within the aviation and oil industry since 1986. He was mainly working in the maintenance, repair, development and production departments. He has participated in, and has been investigator-in-charge, of numerous investigations. He has been Director of the Aviation Department since 2012. Besides being administratively responsible for the Turøy investigation, he managed the continuous airworthiness segment of the investigation. Outside his professional life, Kåre is fond of skiing and other outdoor activities, preferably with his family.

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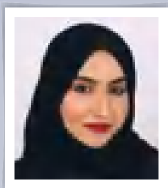

DR. NABILA
Head of Aeromedical Section
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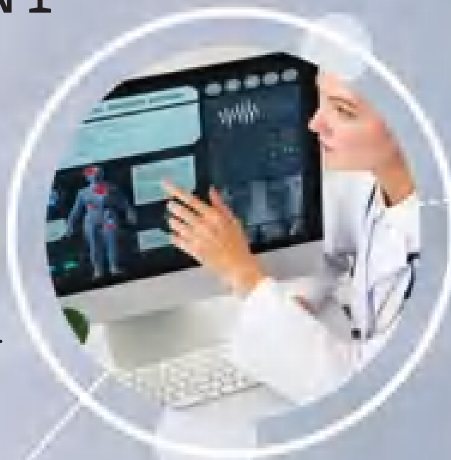
MEDICAL INVESTIGATION

AN ESSENTIAL ELEMENT OF AIRCRAFT ACCIDENT INVESTIGATION

The principal objective of accident investigation is to discover the cause and to draft safety recommendations to eliminate or control the likelihood of a future occurrence of a similar accident.



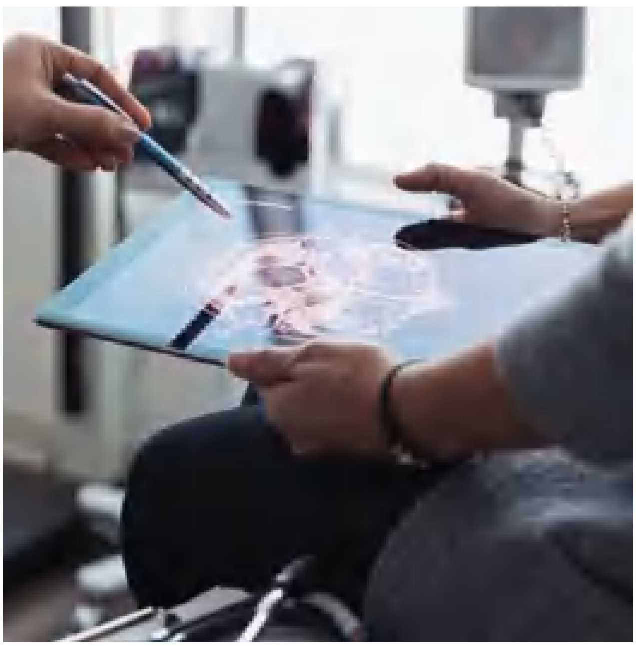
AIRCRAFT ACCIDENT investigations are multidisciplinary and a successful outcome is based on transparency, and open cooperation. The medical findings at autopsy and following ancillary laboratory studies provide a critical perspective on the overall accident investigation as to the probable cause, level of survivability based on crash forces, occupied space, and the post-crash environment, and the role of any preexisting medical condition as a risk factor.

WHY ARE MEDICAL PROFESSIONALS INVOLVED IN AIRCRAFT ACCIDENT INVESTIGATION?

There are different aspects of medical involvement in aircraft accident investigation, including the pathological aspect, which focuses on postmortem examination of the remains of the victims to determine the cause of death.

The main medical investigation functions are:

1. Medical conditions implicated in accident causation due to crew incapacitation or impairment by medical illness, whether caused by a toxicological issue, or by natural disease. Careful scientific analysis is necessary to identify any previously existing disease and to distinguish merely incidental pathologic findings from disease entities that caused disability of a flight crewmember.
2. Identification of fatally injured victims and establishment of time and cause of death which are important for civil aspects of the accident aftermath such as personal insurance, settlement of an estate, accident compensation payment, civil liability on the part of operators and other parties, and for the notification of next of kin. Other potential factors are for criminal aspects such as sabotage, homicide, suicide and deliberate misrepresentation of identity.



3. Human factors investigation to evaluate the cause of injuries related to the psychologic or physiologic factors that may have contributed to the accident. This will include or rule out any relationship to crew stress, workload or fatigue.
4. Medical evidence in accident reconstruction. Aircraft accident reconstruction is the scientific process of investigating, analyzing and drawing conclusions about the causes and events involved in an aircraft accident. In-depth analysis & reconstruction of an accident can enable identification of accident causation and contributing factors, including aspects such as the role of the pilots, the airworthiness of the aircraft and the state of the weather.The location of human remains at the accident site is very important in identifying patterns of survival versus fatality and injury patterns. Correlation of injuries to aircraft structural disruption and the deceleration sequence and correlation of occupant survival and injury with aircraft survivability factors can lead to improvements in future aircraft design.
5. Evaluate survivability aspects of aircraft design, for instance, where the use of aircraft first-aid kits, defibrillators and other safety equipment was or was not effective. The position of seats and emergency exits where lethal areas in cabin design are identified and recommendations are made for future design parameters and retrospective modifications, if necessary. Research, based on the findings of human factors investigations, may form the basis for implementing certain psychometric tools to be applied to the initial selection of flight crew or other safety-critical aviation duties and focus on the mental evaluation of the flight crew during the pre-employment physical examination.

CAN WE PREVENT THE MEDICAL CAUSES OF ACCIDENTS?

Some medical causes of accidents can be reduced;

1. Effective and efficient reporting systems for medical incidents. Reporting and regular communication between the different stakeholders in health care can help to resolve the moral, scientific, legal and practical dilemmas produced by medical mishap and near accidents. To achieve this goal, an environment fostering a rich non-punitive reporting culture must be created and actively maintained to capture accurate and detailed data about nuances of care. In particular, there should be clear and universally accepted guidelines for health care providers on when their obligation to report aeromedical concerns to authorities supersedes their responsibility to patient confidentiality and this reporting should be similar to other mandatory medical reporting such as those for infectious diseases in public health laws.
2. Reduce the risk of sudden incapacitation; The purpose of medical examinations for license holders and applicants is to identify those who are at increased risk of incapacitation. An episode of inter-current illness that may lead to incapacitation is deemed to be self-regulatory in that an ICAO standard requires of a pilot that the privilege of the license will not be exercised if he or she is aware of any medical condition that might be a threat to safety.

However, for any illness other than minor self-limiting conditions, formal assessment by a specialist in aviation medicine is required before a license holder returns on duty.

Some conditions may cause a person to suffer sudden partial or complete incapacitation. Any form of pain or discomfort may affect mental performance with a consequent effect on a pilot's ability to exercise sound judgment and make sensible decisions.

After an accident, the first indication that pre-existing disease may be present often comes from examining the medical records of the crew. A careful, complete autopsy usually will disclose any pre-existing disease that is present. Distinguishing acute from chronic disease processes is not always easy. Even a pre-existing disease that is long-standing can precipitate an acute catastrophic event and the mere presence of pre-existing disease does not mean that it was a factor in causing the accident.

However, a pre-existing disease may be only a contributing factor in an accident. Careful scientific analysis is necessary to find any previous disease and to distinguish merely incidental pathologic findings from disease entities causing disability of a crewmember. Continued regular medical examinations are carried out for license holders and applicants to identify those who are at increased risk of incapacitation. The sudden incapacitation risk of pilots is low on account of the high standards of fitness required at the initial screening medical and during follow-up surveillance.

Safety promotion activities will always have a vital role at Emirates

Mental health refers to our cognitive, behavioral and emotional wellbeing. It is all about how we think, feel and behave. The term mental health is sometimes used to mean an absence of a mental disorder. Mental health can affect one's daily life, relationships, and even physical well-being.

Mental health problems are present in aviation as in any other industry, but being labelled with a "mental health problem" in aviation might have consequences, including stigma and discrimination, grounding, additional costs associated with examinations and treatments to obtain and maintain medical certification, loss of income, and fear of loss of employment.

Possible outcomes of being diagnosed with a mental health problem include self-esteem and self-confidence issues. There can be reluctance to seek help due to medical confidentiality matters; seeking help, but declining treatment; obtaining treatment but failing to disclose the condition or treatment; having peers be hesitant to report concerns to an employer or regulatory authorities; increasing stress and isolation; experiencing adverse effects on the progress of a mental disorder and/or the exacerbation of symptoms. All of these situations can lead to an increased risk to aviation safety, and, in extreme cases, to pilot suicide.

We have seen that cognitive abilities and personality traits in pilots are crucial for training and actual flying performance. One major factor is medical fitness. Besides physical health, mental health is important because it has been found that personality or psychological disorders increase the likelihood of hazardous occurrences. The destruction of German wings flight 4U99525 in the French Alps in 2015 is a prime example. Co-pilot Andreas Lubitz deliberately flew the aircraft into the ground and killed all 150 occupants. The Investigation concluded that the motive was suicide, given that there had been a history of mental illness dating from before his selection as a pilot and it was also stated that prior to the event, he had been "experiencing mental disorder with psychotic symptoms", which was not detected through the applicable "process for medical certification of pilots". A conflict between the principles of medical confidentiality and the wider public interest was identified.

HOW CAN WE IDENTIFY A PILOT WITH MENTAL HEALTH ISSUES?

The following are key factors that contribute to a pilot's mental health. These factors may appear relatively insignificant. However, an individual pilot who displays more than one of these factors could lead the observer to suspect that they may be at risk of deteriorating mental stability:

Emotional – Pilots who are struggling with their mental health may seem irritable and sensitive to criticism, demonstrate an uncharacteristic loss of confidence or seem to lose their sense of humor.

Cognitive – A pilot may make more mistakes than usual, have problems making decisions, or not be able to concentrate. He or she may display a sudden and unexplained degradation in performance, both on and off the flight deck.

Behavioral – This could include things like arriving late, not taking rest breaks, taking unofficial time off, not joining in flight deck banter, becoming more introverted or extroverted and generally acting out of character.

Physical – Pilots who are stressed sometimes exhibit physical symptoms such as a constant cold, being tired at work, projecting an image that indicates that they have not made an effort with their appearance, or rapid weight loss or gain.

Continued regular medical examinations are carried out for license holders and applicants to identify those who are at increased risk of incapacitation.

WHAT ARE THE SOLUTIONS?

Raising Awareness –

- We at the UAE General Civil Aviation Authority (GCAA) have recognized the importance of mental health in aviation and it is given significant awareness and attention. Over the years, we have had many initiatives that addressed mental health in its various forms. All of the initiatives were accomplished jointly with our aviation stakeholders' full support. A mental health protocol was published on the GCAA website and was circulated to all the stakeholders. We organized many conferences addressing these important issues to educate and support the industry and the license holders for the betterment of aviation in general.
- We introduced a protocol in 2009 for licensed pilots and other aviators suffering from depression and we have been supporting their earliest possible return to aviation duties under certain conditions. By introducing this protocol, we managed to claim the status of being one of the few countries worldwide that has a robust system to address predicaments regarding mental health and to support the pilots, cabin crew and air traffic controllers in retaining their mental stability and wellbeing.
- In the area of prevention, safeguarding the mental health of the aviation workforce was a significant challenge. We introduced many initiatives to capture all the aspects possible in performance decline relating to mental function. For example:
- We introduced the Alcohol and Drug testing program in 2010, to decrease the risk of aviation incidents and of pilots and those in other aviation functions losing their mental stability.
- We also introduced a special battery of tests related to the neurocognitive function decline for pilots at their 60th birthday to detect an early decline, as this is an important element of this type of medical examination.
- We have increased the available resources to help pilots and other aviation personnel who may need them.
- During the routine pilot aeromedical assessment, more attention is given to mental health issues. Quick and effective methods were used to assess mental health tests that could easily be performed during the aeromedical assessments. These methods will have a minor impact on the current examinations and should not prove to be burdensome for pilots or the examining physician.

In addition, asking a pilot about work/fatigue, home, and family, may reveal stressors and specific points to enable detection as to where the issues might stem from.

Some airlines have invested in initial psychometric testing for pilots during the selection process to identify mental health issues. These tests can identify at-risk candidates, by asking them a series of questions, worded differently, about a similar subject.

In terms of culture, we recently mandated the presence of Employee Assistance Programs (EAP) within the organization. Such a program may encourage people to talk about their problems or other life conflicts, which may affect their overall health.

Alcohol and drug abuse in aviation can create problems that may jeopardize flight safety. Problematic use of substances arises when the use of one or more psychoactive substances by aviation personnel constitutes a direct hazard to air safety, or causes or worsens an occupational, social, mental, or physical problem or disorder.

The GCAA established a system to monitor the use and abuse of psychoactive substances in aviation and is regarded as a leader in this area. The GCAA has mandated this testing since 2010.

The safety benefits of introducing an alcohol and drug-testing program are;

1. It offers a mechanism to measure, manage, prevent and recover from the use of these substances.
2. It allows us to quantify an issue that to date could only be estimated based on anecdotal evidence in a worldwide context.
3. It provides a tool, together with self-referral, for dealing with substance abuse by individuals, and it allows a range of responses and remedial actions, focusing on a return to duty through EAP.
4. Testing, in its various forms, offers opportunities to identify, treat and monitor affected personnel while avoiding unsafe behavior. It is the key component within a wider, comprehensive drug and alcohol policy.

This article has covered only a small aspect of the very significant contribution of medical professionals to aviation safety and the well-being of flight crew and other aviation personnel.

WRITTEN BY

JEAN DANEY,
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XAVIER LESCEU,
Experimental Test Pilot

WIND SHEAR
AN INVISIBLE ENEMY TO PILOTS?

Weather plays a significant role in aviation safety and is regularly cited as a contributing factor in accidents. Wind shear in the form of microbursts particularly, can be a severe hazard to aircraft during take-off, approach and landing.

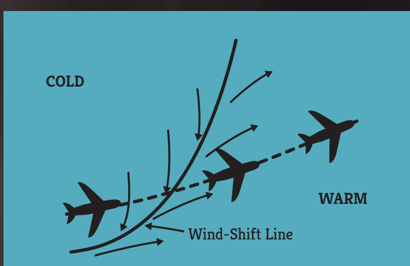
AS AVIATION HAVE developed in the last century, we were falling behind in terms of detecting and reacting to phenomena of the Wind shear.

UNDERSTANDING WIND SHEAR

Wind shear is a sudden change in wind velocity and/or direction over a short distance which can occur in all directions, but is considered along vertical and horizontal axis.

- Vertical wind shear consists 20 to 30 knots per 1000 ft. of wind variations along the vertical axis. The change in velocity or direction can drastically alter the aircraft lift, indicated airspeed, and thrust requirements when climbing or descending through the wind shear layers.
- Horizontal wind shear consists of up to 100 knots per nautical mile variations in the wind component along the horizontal axis – e.g. decreasing headwind or increasing tailwind, or a shift from a headwind. (Fig.1) shows how a penetration would appear as an aircraft crosses a cold front.

This weather phenomenon can occur at many different levels of the atmosphere; however it is most dangerous at the lower levels, as a sudden loss of airspeed and altitude can occur.

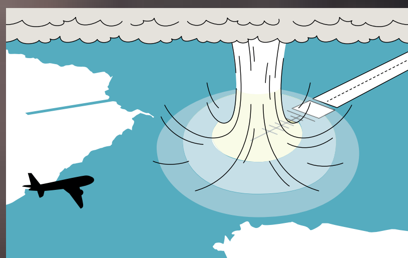


Horizontal wind shear

MICROBURST

A microburst is the most dangerous form of wind shear. It consists of a small column of exceptionally intense and localized sinking air, which descends to the ground (downdraft) and upon contact with the earth's surface, diverges outwards in all directions, thus forming a ring vortex. It is capable of producing powerful winds near ground level.

They typically form under or close to thunderstorms and cumulonimbus clouds in particular (fig.2).



Microburst caused by a cumulonimbus

Microbursts is often associated with heavy thunderstorms, embedded in heavy rain. Microbursts: a threat to aviation safety From a safety perspective, microbursts bring a threat to aircraft due to the scale and suddenness of this phenomenon. To put it briefly, microbursts combine two distinct threats to aviation safety (fig.3):

- The downburst part, that can push an aircraft downward, exceeding its climb capabilities.
- The outburst part, resulting in large horizontal wind shear and wind component shift from headwind to tailwind which reduces the lift of the aircraft.

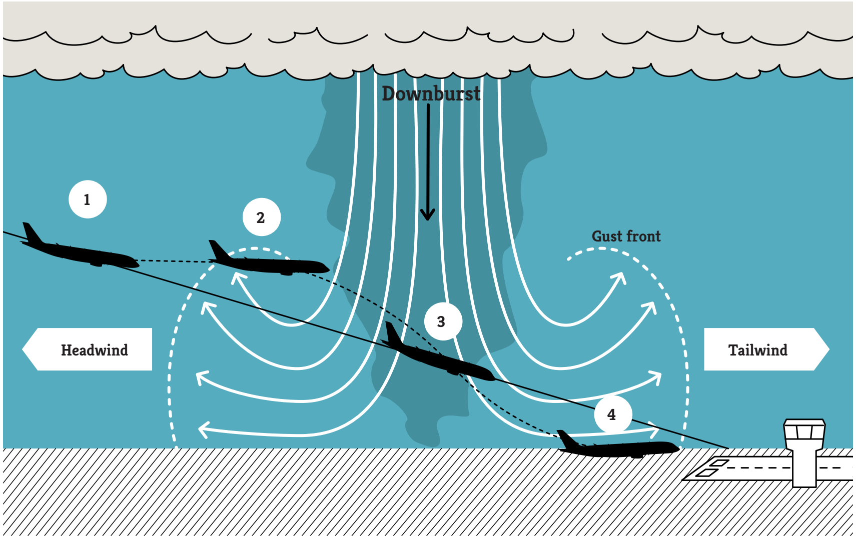
> "The change in velocity or direction can drastically alter the aircraft lift, indicated airspeed, and thrust requirements when climbing or descending through the wind shear layer."

>> Phase 1: Headwind

- When first entering a microburst, the pilot notices a performance enhancing headwind gust, which instantaneously increases the aircraft airspeed, thus causing the aircraft to rise above its intended path and/or accelerate (see (fig.3), items 1 and 2).
- To descend the aircraft back on its descent path and decrease speed, the pilot will naturally retard the engines and push the side stick, thereby forcing the aircraft to descend. (fig.2)

>> Phase 2: Downdraft

- As the aircraft continues into the microburst, it meets a sudden surge of downdraft affecting both the aircraft flight path and then the Angle-Of-Attack (AOA): the aircraft will sink and the AOA will increase (see (fig.3), item 3).
- The pilot, now traveling at a lower speed and pushed downwards, will attempt to regain the original trajectory by initiating a climb.



Effects of a microburst on aircraft performance

>> Phase 3: Tailwind

- As the pilot attempts to climb to recover his/her altitude, the aircraft now experiences a change in wind direction and encounters a tailwind.
- The tailwind gust instantaneously decreases the aircraft lift and airspeed and thus, it tends to make the aircraft fly below its intended path and/or decelerate(see (fig.3), item 4).
- A microburst is a serious threat to flight because of its direct and aggressive impact on the aircraft airspeed, altitude, Angle-Of-Attack, and thus, lift capability.

PREVENTION: HOW TO DETECT AND AVOID WIND SHEAR

Since the discovery of the effects of wind shear on aircraft performance in the early 1980's, several tools were used to predict and react to the Wind shear.

Wind shear awareness and detection

The best way a pilot can prevent an encounter wind shear is to check if it is likely to happen and to avoid it where possible. However, should an encounter be unavoidable, it is important to know the likely magnitude of the change, and be prepared to react immediately.

>> Weather reports and forecast

Many airports – particularly those that are prone to microburst and wind shear – are now equipped with a Low Level Wind shear Alerting System (LLWAS) and/or a Terminal Doppler Weather Radar (TDWR). These devices are able to detect microbursts and warn aircraft of their occurrences by sending an alert to ATC.

>> Crew observations

Blowing dust, rings of dust, dust devils (i.e. whirlwinds containing dust and sand), intense rainfall or any other evidence of strong local air outflow near the surface often are good indications of potential or existing downburst. A large difference between actual wind (on ND) and wind reported by tower can also be a good indication.

>> Pilots' reports (PIREPS)

PIREPS of wind shear in excess of 20 knots or downdraft / updraft of 500 ft per minute below 1000 ft above ground level are all good indications of severe conditions and should be avoided at any time.

Considering that these conditions develop, change or dissipate rapidly, those reports should however be interpreted with great care and judgement. A pilot must consider the amount of time since the report was made as it may have dissipated.

Therefore it is very important to remember that the aircraft ahead may experience vastly different conditions than the following one will encounter in the same airspace.

>> On-board weather radar

Generally microbursts are accompanied by heavy rainfalls, which can be detected and identified using the on-board weather radar. Those areas should be avoided.

>> On-board predictive wind shear system

Today, most aircraft models have a Predictive Wind shear System (PWS), which detect wind shear areas ahead of the aircraft, based on a measure of wind velocities ahead of the aircraft both vertically and horizontally.

If conditions worsen and the wind shear location gets closer to the aircraft, the "W/S AHEAD" amber caution turns into a red warning and is associated with an aural synthetic voice "WIND SHEAR AHEAD" during take-off, or "GO AROUND, WIND SHEAR AHEAD" at landing. This indicates aircraft is reaching a microburst.

OPERATIONAL BEST PRACTICES

The wealth of tools and indications should allow crews to gather sufficient knowledge about the weather conditions ahead and use them to prepare to react and effectively. Here are few tips:

>> Take-off

- Consider delaying the take-off until conditions improve.
- Select the most favorable runway and initial climb out path, considering the location of the likely wind shear / downburst.
- Use the weather radar (and the predictive wind shear system, as available) before commencing the take-off roll to ensure that the flight path is clear of hazard areas.
- Select the maximum take-off thrust.
- Closely monitor the airspeed and speed trend during the take-off roll.

>> Descent and approach

- When downburst / wind shear conditions are anticipated based on pilots' reports from preceding aircraft, or based on an alert issued by the airport LLWAS, the approach and landing should be delayed until conditions improve, or the aircraft should divert to a more suitable airport.
- Select the most favourable holding point, approach path and runway, considering the location of the likely wind shear / downburst condition and the available runway approach aids.
- Select less than full flaps for landing (to maximize the climb gradient capability) and adjust the final approach speed (i.e. VAPP) accordingly.
- If an ILS is available, engage the autopilot for a more accurate approach tracking.
- If a gusty wind is expected, consider an increase in VAPP displayed on the FMS CDU (a maximum of minimum approach speed (i.e. VLS) + 15 knots is allowed).
- Closely monitor the airspeed, speed trend and ground speed during the approach to detect any evidence of imminent wind shear. If the presence of wind shear is confirmed, be prepared for a possible missed approach and escape maneuver. A minimum ground speed should be maintained to ensure a minimum level of energy to the aircraft, and to ensure proper thrust management during the approach in case of sudden headwind to tailwind change. This is automatically performed on Airbus fly-by-wire aircraft by the Ground Speed mini function, when the speed target is managed.
- In anticipation of a possible wind shear event, be alert to respond immediately to any predictive wind shear advisory, "W/S AHEAD" caution or warning. And be prepared to perform a missed approach or go-around if necessary.

A microburst is a serious threat to flight because of its direct and aggressive impact on the aircraft airspeed, altitude, Angle-Of-Attack, and thus, lift capability.

RECOVERY: HOW TO RECOGNIZE AND HANDLE ACTUAL WIND SHEAR CONDITIONS

Recognition

Despite the available prevention means, an actual encounter with wind shear can happen anytime; timely recognition of this condition is key for the successful implementation of wind shear recovery / escape procedures.

>> Awareness

The following deviations should be considered as indications of a possible wind shear condition:

- Indicated airspeed variations in excess of 15 knots
- Ground speed variations
- Analog wind indication variations: direction and velocity
- Vertical speed excursions of 500 ft/minute
- Pitch attitude excursions of 5 degrees
- Glide slope deviation of 1 dot
- Heading variations of 10 degrees
- Unusual auto-thrust or auto throttle activity.

>> On-board reactive wind shear system

A reactive wind shear warning system is available on most aircraft models which is capable of detecting a wind shear encounter based on a measure of wind velocities, both vertically and horizontally. When it activates, the audio "WIND SHEAR" is repeated 3 times, and a red "WINDSHEAR" warning appears on the PFD.

The wind shear warning system associated to the Speed reference System (SRS) mode of the flight guidance constitute the Reactive Wind shear System (RWS), since both components react instantaneously to the current variations of aircraft parameters.

Windshear reactive warning displayed on PFD

Recovery technique

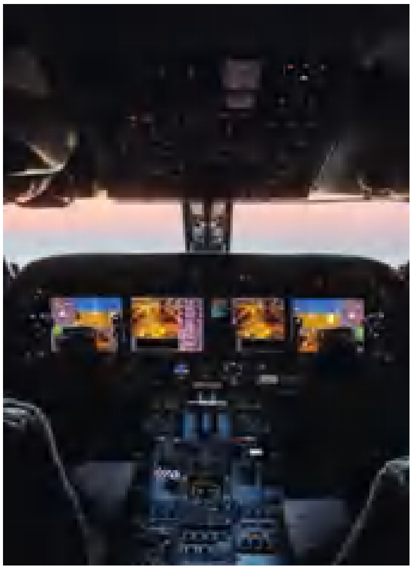
The aircraft can only survive severe wind shear encounters if it has enough energy to carry it through the loss-of-performance period. It can sustain this energy level in the following three ways:

- Carry extra speed. The aircraft does this automatically when in approach in managed speed (Ground speed mini).
- Add maximum thrust. The aircraft does this automatically with alpha floor protection, even if TOGA was already selected (do not forget to disconnect the Auto-thrust in this case, when out of alpha floor).
- If possible, trade height energy for speed. Any aircraft can do this. Proper pilot technique helps in this process.

>> During take-off

If a wind shear is detected by the RWS or by pilot observation during the take-off roll, V1 may be reached later (or sooner) than expected. In this case, the pilot may have to rely on his/her own judgement to assess if there is sufficient runway remaining to stop the aircraft, if necessary.

In any case, the following recovery techniques must be applied without delay:

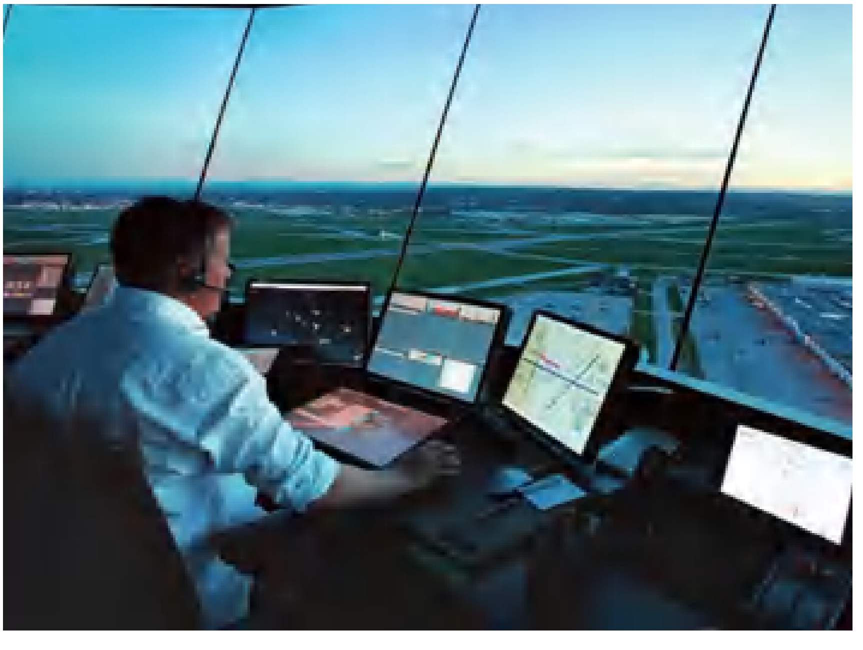


Before V1:

Reject the take-off if unacceptable airspeed variations occur (not exceeding the target V1) and the pilot assesses there is sufficient runway remaining to stop the aircraft.

After V1:

- Maintain or set the thrust levers to the maximum take-off thrust (TOGA);
- Rotate normally at VR;
- Follow the Flight Director (FD) pitch orders if the FD provides wind shear recovery guidance, or set the required pitch attitude as recommended in the FCOM.



>> During initial climb, approach and landing

If a wind shear is detected by the pilot, or by the RWS, during initial climb or approach and landing, the following recovery technique must be applied without delay:

- Set the thrust levers to the maximum take-off thrust (TOGA);
- If the Auto Pilot (AP) is engaged and provides wind shear recovery guidance, keep the AP engaged; or, if the AP is not engaged, do not engage it. Follow the FD pitch command if the FD provides wind shear recovery guidance, or set the required pitch attitude, as recommended in the FCOM;
- Level the wings to maximize the climb gradient, unless a turn is required for obstacle clearance;
- Applying full back stick on Airbus fly-by-wire aircraft, or flying close to the stick shaker / stall warning Angle-Of-Attack (AOA) on aircraft models that do not have full flight envelope protection, may be necessary to prevent the aircraft from sinking down;
- Do not change the flaps and landing gear configuration until out of the wind shear condition;
- Closely monitor airspeed, airspeed trend and flight path angle (if flight path vector is available and displayed to the PM);
- When out of the wind shear, let the aircraft accelerate in climb, resume normal climb and clean aircraft configuration.

NOTE: To recover from an actual wind shear encounter, recovery measures are indicated in the FCOM ABNORMAL AND EMERGENCY PROCEDURES. Refer to PRO-ABN-80, or FCOM Inclement Weather Operations on A300/A310/A300-600. To safely operate an aircraft in wind shear or downburst conditions, best recommendations are indicated in the FCOM SUPPLEMENTARY PROCEDURES.


Honeywell
FLIGHT
RECORDER
DO NOT OPEN

WRITTEN BY

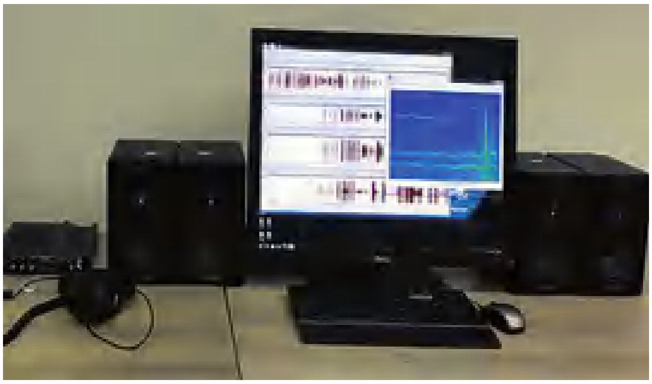
MOHAMED ABDUL BARI,
Air Accident Investigator

FLIGHT RECORDER **LABORATORY**

A Flight Recorder read-out facility provides tools and equipment to retrieve and analyze the data from the Flight Data Recorder and Cockpit Voice Recorder. The facility is essential to assist in investigating aircraft accidents and incidents.

THE FLIGHT RECORDER read-out facility or Flight Recorder Laboratory (FRL) is not only a crucial tool for air accident and incident investigations, but it also reduces the cost, time, and dependency on other investigation agencies who have to download the Flight Data Recorder (FDR) and the Cockpit Voice Recorder (CVR), and then analyze the retrieved data. The earliest retrieved data may identify a problem areas which may result in prompt safety recommendations to prevent similar occurrence.

FDR Data and Power cables



CVR multi track playback software.

FDR/CVR data recovery from Crash-Survivable Unit

CAPABILITIES

FRL capabilities are evaluated by their ability to download and analyze data from different types of Flight Recorders equipped in the United Arab Emirates' registered aircrafts. Based on this criteria, the AAIS FRL has the capability to download 98% of FDRs and 95% of CVRs. The FDR laboratory produces transcripts, analysis plots, 3D animation and De-facto standard flight data analysis which provides vital information while conducting as investigation.

The flight recorder's manufacturer standard replay equipment and playback software are not considered adequate for investigation purposes, especially those that are typically used by the airlines and maintenance facilities such as Flight Data Monitoring software produces defined parameter threshold exceedance reports monitored for aircraft fleet of their airlines. The software analysis tools used in the FRL provide elaborated data access for each parameter recorded in the FDR/CVR which gives access to all parameters recorded, the capability of the software is not limited to certain aircraft type or models, it is open to all aircraft types and configurations.

The AAIS FRL has the capability to download 98% of FDRs and 95% of CVRs. The FDR laboratory produces transcripts, analysis plots, 3D animation and De-facto standard flight data analysis which provides vital information while conducting as investigation.

When the recorders are transported to the FRL, the physical condition is assessed and documented. If no damage is identified, the specific data interface cable and power cable are used to download the raw data. AAIS FRL organizes the various types of data cables and power supply cables with assigned location and labels.

COCKPIT VOICE RECORDER PLAYBACK

The CVR download data features digital audio / acoustic multi-track recording, and it requires software to playback, edit, analyze, enhance real-time speech and perform spectral analysis. AAIS FRL is equipped with state-of-the-art software.

The undamaged recorder's data recovery is performed by connecting a PC or a hand held download device to the FDR/CVR which downloads the crash-survivable memory unit contents.

FDR ELECTRONIC DOCUMENTATION

The downloaded FDR data from the recorder is in raw binary format which requires conversion to engineering units. For example, the indicated airspeed parameter converted to knots, which is processed by mathematical equations defined accurately in a system document called in the Flight Recorder Electronic Documentation or FDR Data Frame Layout (DFL), describes the programming method used by the data acquisition system, and the functions used to convert the recorded value into the actual physical value.

In modern aircraft configuration there are thousands of parameters recorded every second and some record more than one sample per second. Each parameter data is stored in the flight recorders solid state memory in defined locations, which later requires synchronization with the configuration files.

Data acquisition units (DAU computers centralize and format the data coming from sensors, onboard computers and other instruments and then transfer it to FDRs via a dedicated digital link) are programmed to produce a continual flow

Data Analysis and Animation station

of data towards FDRs. They deal with the time sampling of parameters and their digital encoding from the actual physical value to the recorded value.

This process in AAIS FRL is done utilizing Flightscape Insight software and/or Flight Analysis System (FAS). Data validation is performed in comparison with parameters referential data analysis.

FLIGHT ANIMATION

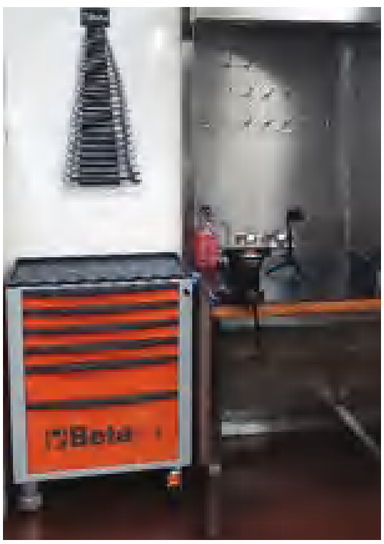
During investigation process, flight animation provides a three-dimensional visualization of the aircraft cockpit instrument panels, aircraft path, the flight control surfaces and the pilots inputs to the controls. The retrieved FDR data is composed to produce time-based events in combination with CVR data. The animation aids visual explanation for non-aviation audience, and the animation video clips are used as tool for lessons learned during training.

Flight Animation

DAMAGED RECORDERS

Air accidents that involve structural damage due to high-energy impact, post-impact fire and aircraft submerged in sea, usually result in damaged recorders. It requires special techniques and additional tools and equipment to recover the data and conduct the analysis while handling the damaged recorders. Based on the severity of damage, the recorders require advance level equipment such as x-ray scanners or precision sensitive tools to avoid further damage. The damaged recorders require specific bio-hazard cleaning facilities to de-contaminate the blood born pathogen, chemicals such as hydraulic liquids, fuel, grease, and when submerged in sea water, have a specific corrosion potential due to acidity or alkalinity. AAIS FRL has designed a stainless steel wash basin with a portable drainage water collection tank whereby the drainage water can be disposed as per the bio-hazard requirements.

Recorders with substantial damage requires the ability to disassemble them by means of teardown tools. The AAIS laboratory provides this capability through a rugged steel teardown table with compressed air controlled precision cutting tools. There is a heat control soldering station with different sizes and shapes of Integrated Circuits (ICs) soldering and de-soldering sockets for chip level recovery.



Wash basin with portable drainage tank

CONCLUSION:

AAIS FRL has acquired tools and equipment to facilitate undamaged recorders and certain- extent damaged recorders, as damaged recorder recovery is very subjective, based on the severity of damage and possibility of data recovery.

The FRL laboratories require continuous improvement to upgrade advanced tools and skills to train the personnel with structured training. The flight recorders laboratory investigators shall challenge the data validation, accurately produce analysis reports to contribute effectively to the investigations. ⭘

FAILURE TO SWITCH TASKS AND COGNITIVE LOCKUP

Task switching failure due to Cognitive lockup in Airline Pilots

APPROACH AND LANDING are critical phases of flight. The statistical summary of commercial jet airplane accidents around the world, between 1959-2016 (Boeing, 2017), reveals that 48% of fatal accidents and onboard fatalities occur during the final approach and landing. An International Air Transport Association (IATA) publication on unstable approaches (Unstable approaches 2nd edition, 2016), data from 2011-2015 shows that approximately 65% of all recorded accidents occurred during the approach and landing phases of flight, and unstabilised approaches were identified as a factor in 14% of these approach and landing accidents. Further, 31% of runway/taxiway excursions were the result of unstabilised approaches.

The highest number of accidents as per categories is runway safety related; approximately 65% of all accidents take place in the approach and landing phase. 83% of the accidents could have been avoided, which amounts to 54% of all accidents, had a go-around been carried out.

WHY DO PILOTS CONTINUE WITH AN UNSAFE APPROACH AND LANDING?

A question that arises, despite intense and detailed training, is why do pilots continue with an unstable approach and/or a long landing? Standard operating procedures (SOP) have clearly defined flight parameters for compliance and pilots are trained in the class room in theory relating to technical knowledge, Crew Resource Management (CRM) for non-technical skills and the flight simulator for procedures and skills. Threat and Error Management is the focus of all training, and awareness of hazards and measures to mitigate the risks is key learning. Pilots who fly commercial airliners need to qualify for their initial and yearly recurrent training, and demonstrate their competence in terms of knowledge, skill and behavioral indicators. Despite these defences, pilots still become trapped into continuing an unstable approach and/or a long landing.

The mitigation for unstable approaches and/or long landings is to carry out a go-around procedure which can be performed at any stage of the approach or landing, even after touchdown, until reverse thrust is selected.

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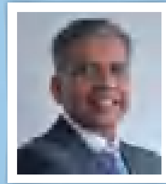


CAPTAIN AMIT SINGH, FRAeS

> **"Pilots who fly commercial airliners need to qualify for their initial and yearly recurrent training, and demonstrate their competence in terms of knowledge, skill and behavioral indicators."**

COGNITIVE LOCKUP

Moray and Rotenberg (1989) have defined the term 'cognitive lockup' as the tendency of operators to deal with disturbances sequentially. Cognitive lockup however does not occur when people can perform all their tasks consecutively.

Cognitive lockup can also be defined as holding on to a task or sticking to a problem. In terms of the task-switching paradigm, cognitive lockup can be considered as reluctance to switch to an alternative task or problem. (Meij, 2004).

ACCIDENT OF EASTERN AIRLINES FLIGHT 401

The accident involving Eastern Airlines flight 401 in 1972 is a good example of cognitive lockup. The NTSB report (NTSB,1973) indicated that the probable cause of the accident was "Failure of the flight crew to monitor the flight instruments during the final 4 minutes of the flight, and to detect an unexpected descent soon enough to prevent impact with the ground. Preoccupation with a malfunction of the nose landing gear position indicating system distracted the crew's attention from the instruments and allowed the descent to go unnoticed". The pilots got a landing gear warning signal during the approach to land. The crew cancelled the landing and began investigating the warning. In the process, they missed critical warnings about lessening altitude and the aircraft eventually crashed.

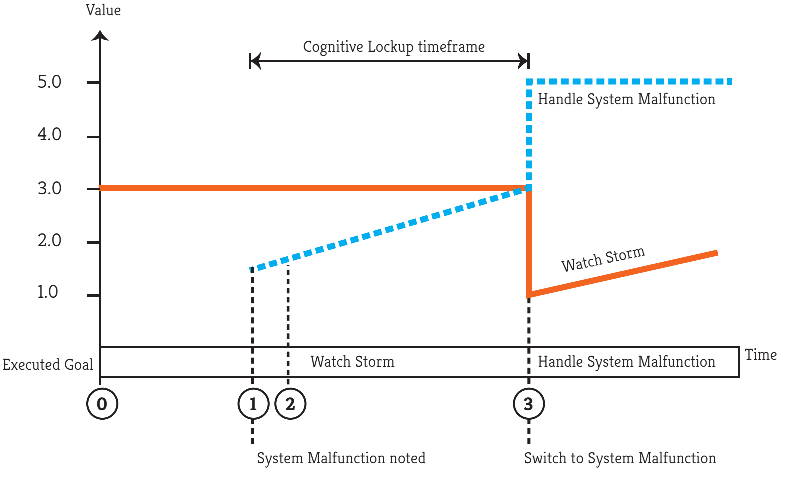
EXPERIMENTS ON COGNITIVE LOCKUP

Research on fault management in process control (Moray, N., & Rotenberg, I. 1989), reveals the onset of "Cognitive lockup" when faults in the system are simulated. When multiple faults are triggered, the sequence of preferred fault management by operators of thermal hydraulic systems is sequential. The result of the research was that operators liked to focus on and complete one fault or one task at a time. There is a strong cognitive lockup, which restricts the operator's information gathering and processing capability. The subsequent fault is noticed but no action is taken until the handling of the first fault is completed.

STUDY 1

The project, Human Model-based Analysis of Human Errors During Aircraft Cockpit System Design was initiated in 2008, to develop a methodology based on a cognitive model of crew behavior, to support the prediction of human errors in ways that are usable and practical for human-centered design of systems operating in complex cockpit environments (Cacciabue, Hj lmdahl, Luedtke & Riccioli, 2011)

The study identified cognitive lockup as a serious error causing mechanism for pilots. Scenarios from a human factor perspective with operational relevance were developed, wherein the combination of contextual factors would induce cognitive lockup.



The simulated cognitive model was based on Rasmussen's three behavior levels (Rasmussen J,1983) in which cognitive processing takes place at the levels of skill based, knowledge-based and behavior based. The decision-making module, also called goal management, determines which goal is executed. In the decision-making process, cognitive lockup was found as a relevant error producing mechanism (EPM). EPM has been modeled in the decision-making process, as task switch cost (TSC) representing the difference the goal priorities must have prior to switching goals.

Scenario. In the scenario, the aircraft is in cruise phase and a thunderstorm is presented very close to the destination. This attracts the attention of the pilot, as it is not clear if there is a need to divert to an alternate route or not. The pilot keeps monitoring the movement and intensity of the thunderstorm. During this monitoring phase, a failure is introduced in one of the aircraft engines. The pilot recognizes the failure but does not react and continues to monitor the thunderstorm. After a while, the urgency to handle the engine malfunction is realized and the pilot begins to solve the engine malfunction task.

The cognitive lockup prevents the pilot from immediately switching tasks from monitoring the thunderstorm to handling the engine malfunction. Figure 2 (Cacciabue, Hj lmdahl, Luedtke & Riccioli, 2011), shows the goal priorities of each goal over time during thunderstorm avoidance.

STUDY 2

Another study was presented at the proceedings of the 4th workshop human centered processes (2011) with the topic of "the effect of time pressure and task completion on the occurrence of cognitive lockup. "Mental set and shift" by Aurther T.Jersild (1927), analyses the relationship between mental set and shift. The more homogenous and uniform the mental task, the less will be the demand for adjustment. Human beings cannot perform two tasks simultaneously and must prioritize and shift between tasks. This results in an added expenditure of time and energy. The mental set comes into being through practice and a more comprehensive mental set can be formed through more or less practice. If two tasks are well practiced, the losses are less.

FACTORS INFLUENCING COGNITIVE LOCKUP

Sunk cost fallacy

Individuals commit the sunken cost fallacy when they continue a behavior or endeavor as a result of previously invested resources (time, money or effort) (Arkes & Blumer, 1985). This fallacy, which is related to status quo bias, can also be viewed as bias resulting from an ongoing commitment.

Task completion

The project completion hypothesis—has shown that individuals become more willing to allocate resources to the invested option as goal attainment nears, and goal completion becomes more important than economic concerns (Boehne & Paese, 2000). Garland and Conlon (Garland and Conlon,1998) stated: "as progress moves forward on a project, completion of the project itself takes increasing precedence over other goals that may have been salient at the time the decision was made to begin the project". When task completion is high, the probability of cognitive lockup increases. This means, in cases where people are dealing with a task, and another more urgent task is triggered, people have the tendency to stick to their current task until 90% or more of the total stages of the task has been completed (Boehne and Pease, 2000; Garland and Colon, 1998).

Time and task pressure

There are typically two types of pressure on pilots. Time pressure and task pressure. Since the aircraft is constantly moving, there is a finite amount of fuel, which relates to time. Nearing the destination the fuel remaining is sufficient to approach and land and there is additional fuel to divert, if required, and hold for 30 minutes prior to landing at the alternate destination. The fuel remaining at approach is approximately 25% of the total fuel uplifted and the fuel required for approach approximately 85% of the total fuel required for approach and landing. From the perspective of time, approximately 95% of the flight is completed and the two events amount to 70-80% of the remaining time.

Time pressure is dependent on the number of tasks that need to be performed at a given time. Time pressure is high when there is a perception that time is scarce.

> **"The pilots are trained and the policies are defined to indicate that the primary task is to fly from departure to destination and divert to the alternate aerodrome if a landing at the destination is not possible."**

According to a study on man-machine system design (Beevis, 1992), people experience time pressure when the time required to execute the task is more than 70% of the total time available to complete the task.

Study on the influence of time pressure. A study was conducted in order to investigate the influence of time pressure and task completion on cognitive lockup. The aim was to identify critical situations in cockpit environments that would allow for designing cockpit systems that would help pilots avoid critical situations and decrease the probability of cognitive lockup.

The research was carried out at the TNO Human Factors Research Institute, Utrecht (Schreuder & Mioch, 2011). The task required two types of fire to be extinguished in a computer simulation. One was the normal fire and the second was an urgent fire. Fires were of different types and they needed to be treated differently. The time to react and the time to extinguish the different types of fire were also variable. The results of the experiment indicated that although time pressure can influence decision-making, people are able to assess the priority of different tasks while dealing with a task and can switch to the more important task if necessary when facing time pressure.

The experiment, however, supported the hypothesis that task completion would have an effect on cognitive lockup. The results showed that people who have almost

completed the task tend to finish that task, even when a more urgent task is triggered. In other words, if task completion is high, the probability of cognitive lockup is also high. It was also observed that the effect of cognitive lockup was reduced in the second attempt as compared to the first one.

Risk Perception

Framing effect. Framing effect (Tversky & Kahneman, 1981) is a decision problem based on the decision maker's perception of the problem, formulation of the problem and partly by norms, habits and personal characteristics. A problem can be framed and presented with a positive

and a negative connotation, despite having the same end result. There is a tendency for the decision maker to shift from risk aversion to risk taking.

The pilots are trained and the policies are defined to indicate that the primary task is to fly from departure to destination and divert to the alternate aerodrome if a landing at the destination is not possible. The pilots flying the approach are under self-imposed task pressure to land at the destination and a diversion to the alternate is taken to have negative connotations. However, if the policy is redefined to word that the primary task of the pilot is to fly from departure to alternate aerodrome if landing at the destination is not possible, then the pilot's task completion pressure is substantially reduced.

CONCLUSION

Pilots approaching the destination have invested a lot of time in their task and it is nearing completion. Task pressure in completing the flight and the framing of the policy with the primary task of landing at the destination increases the possibility and effect of cognitive lockup. As a result, the pilot will continue with the first task, that of landing at the destination, despite being unstable on approach or when performing a long landing. Carrying out a go-around can be inferred as task switching. This task will be carried out provided there is enough time to realize the consequences of persisting with the primary task. Since there is not enough time and the task completion is within sight, the pilots will continue and land.

Training has an effect of reducing cognitive lockup by increasing practicing of task switching and that of approach/flare followed by switching to the task of a go-around and reattempting a second approach. The policy, if framed to depict a go-around and a diversion in a positive light will reduce the pressure of task completion from the pilots and they would be more prone to switching the task to go-around with ease.

Cognitive lockout is the primary reason for the reluctance to carry out a go-around. If task switching practice is increased, as compared to other tasks in training there will be a significant drop in the number of unstable approaches and long landings.

SAFETY FIRST

Creating, enabling and enhancing a safety culture in the airline industry

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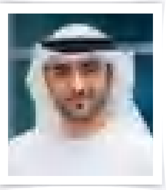


CAPTAIN MAJED AL MARZOUQI, Vice President, Safety, Security and Quality, Etihad Airways

SAFETY IS THE HIGHEST PRIORITY of Etihad Airways, the national airline of the United Arab Emirates. In the air and on the ground, every aspect of our operation is underpinned by unwavering commitment to the safety and security of our guests, our employees and the contractors, suppliers and visitors within our facilities. We continuously strive to improve the way we work, not only through implementation of best practice safety processes, but also by leveraging advances in technology.

Our approach to Safety Management Systems (SMS) aligns with the frameworks set out by the International Civil Aviation Organisation (ICAO), through which innovative solutions are constantly pursued to enhance 'The Power of SMS.'

SAFETY REPORTING AT ETIHAD AIRWAYS

A vital ingredient to the successes we have achieved at Etihad Airways is the continued maintenance and development of a positive safety culture. One of the key enablers of this is the reporting culture of the organisation.

An effective communication and safety reporting system is integrated as one of our core objectives in the overarching Airline Safety Policy. This ensures top-down leadership and continuous and active attention to reports. When coupled with the application of a just culture and non-reprisal policy in safety event investigations and the behavioral outcomes process, this engenders an atmosphere where employees feel safety reporting is not only safe for them, but also a standard operating practice - 'how we do things around here'.

Annual training of employees, which is a part of the Safety Promotion pillar of SMS, ensures awareness by all staff on the reporting requirements and the methods and channels available.

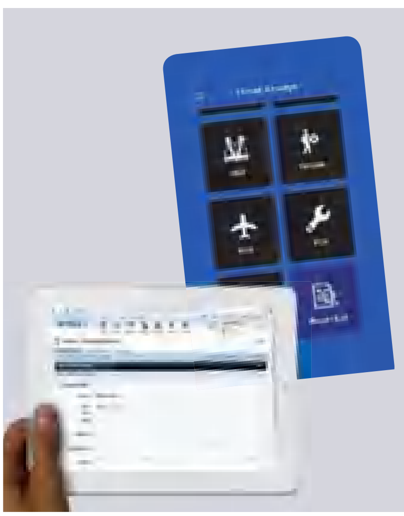
Etihad's safety leaders continuously work to ensure open and transparent reporting of safety incidents by following four core steps:

- **Simplifying the reporting system;**
- **Protecting the information of those who report, and those who are reported;**
- **Protecting those who self-report from reprisals and unjustified disciplinary action, and;**
- **Encouraging reporting, and championing those who report safety issues, or offer suggestions for improvement, based on their own knowledge of or experiences in their workplaces.**

One of the keys to the success of a positive and mature safety culture is to encourage employees to report hazards and incidents. Speaking up in order to protect the organisation is crucial not only to developing an effective safety management system but also to creating a safe environment for all.

Of course, encouraging a safety culture is one thing, but enabling it is an entirely different proposition. Employees need tools which are easy to access and easy to use, in order to achieve timely reporting, and ensure maximum detail in reports. The faster a safety issue can be reported, the more detail the report will contain. The longer a report takes to lodge, the less effective the information will be, as vital details can be overlooked and data can be lost.

Etihad has evolved from a paper-based system to electronic reporting. However, in an age where smart phones and iPads are utilised by almost everyone, safety professionals need to think creatively to enhance and enable safety reporting via personal devices, to enable immediate reporting from just about anywhere. The Safety team at Etihad has introduced Intelex, a mobile electronic platform to enhance the effectiveness of the Etihad Airways Safety Management System



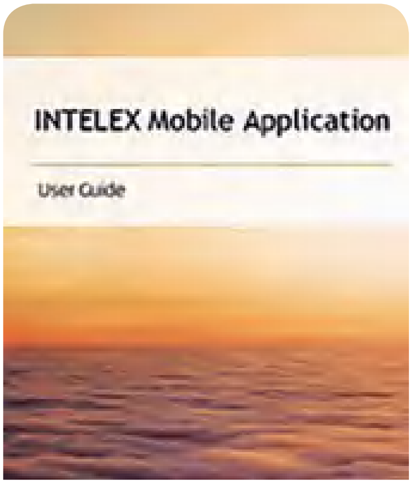
"Our success in delivering excellence has been built in part through harnessing the latest technologies to achieve a solid, safe, and high quality operation. The adoption of a mobile safety reporting application will enable us to continue, and to ensure the well-being of our customers and staff".

across the entire organisation. This solution brings fundamental improvements to the way we work, by enabling real-time reporting of safety occurrences from anywhere, at any time.

This mobile platform enables reports to be generated quickly, in a standardised format, with automatic distribution to the relevant management to further assess the risks identified and implement effective mitigation actions. This tool provides a 'one-stop shop' for safety-related reporting by all employees, not only by providing a single reporting platform throughout the Etihad Aviation Group, but by also greatly reducing the time taken for the collection of evidence related to safety events and providing more timely and comprehensive data.

The Intelex mobile app is easily downloaded on the principal operating platforms, iOS and Android, providing all employees with instant access and freedom to report hazards and safety concerns. A mobile application user guide is made available to users, as well as a help function within the app.

This app enables Etihad employees to upload Fatigue and Occupational Health and Safety Reports while issues are still 'top-of-the-mind' . Often, when time has elapsed after an event, employees can overlook key details. The immediacy



provided by Intelex facilitates more proactive reporting, and much richer information, which ultimately results in a stronger, more effective safety culture.

The electronic platform also ensures the security of the reporter's information, and enables employees to file confidential reports, with further restrictions on report accessibility.

Additionally, the mobile app also functions with an offline capability, allowing 'remote' or unconnected users to capture data at the time of an event, or soon after, and to lodge the information then and there, ready to then synchronise when they regain internet connectivity. Details can be saved for later editing or submission. The user also has the ability to upload images or populate the required fields using voice recognition. Previously-submitted reports are archived, so that the user can easily review all logged information.

The 'Enterprise Safety Management System' has increased efficiencies in safety work and improved communication of all safety-related information by all users. This further cements a positive safety culture and understanding of the ongoing risks to the operation in real-time.

Our success in delivering excellence has been built in part through harnessing the latest technologies to achieve a solid, safe, and high quality operation. The adoption of a mobile safety reporting application will enable us to continue, and to ensure the well-being of our customers and staff.

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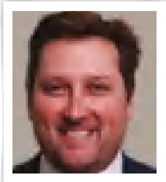


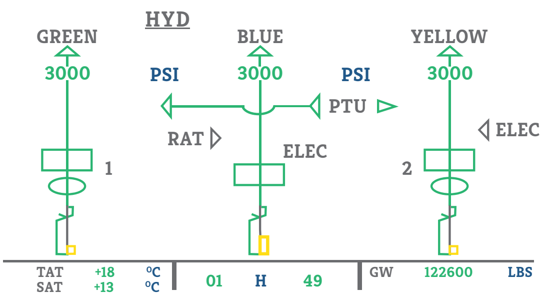
RONNIE SMITH,
Aviation Safety
Specialist – GAL ANS

HYDRAULIC FAILURE

In recent times hydraulic systems have been substantially improved and the chance of a modern airliner experiencing a total hydraulic failure is very slim.

WHAT DOES IT MEAN WHEN A PILOT REPORTS HYDRAULIC FAILURE?

A Usually two or more hydraulic systems are built into the design of an aircraft. Each system is provided with independent sources of hydraulic fluid and pressurisation. This pressure is often generated by one or more engines, so an engine failure can also involve a hydraulic problem too. Power is transmitted by the hydraulic fluid through the hydraulic lines and drives the actuators that move the control surface, brake unit or whatever is associated with that system. Some hydraulic systems are designed to allow power to be transferred between systems via a Power Transfer Unit (PTU) so that, for example, an engine failure does not result in hydraulic system failure too. However, there is rarely any provision for any exchange of fluids between systems, so a hydraulic leak will almost always result in loss of some aircraft services, besides being a potential fire hazard.



Airbus A320 Hydraulic System

WHAT DOES THIS MEAN TO ATC?

When a pilot reports hydraulic failure but does not specify what type of failure, then it is important for ATC to ask the pilot to specify what effect it will have on the aircraft's ability to recover, land, stop and taxi. Remember that the pilot is likely to be under increased workload and may be managing more than one system failure, so a long interrogation from ATC will not be welcome. Phraseology should be standard and professional when asking the pilot what effect the failure will have. If the pilot is too busy to talk then make plans for problem recovery, landing, stopping and taxiing.

Depending on the specific failure or the extent of damage to the hydraulic system(s), the following effects could result in limiting the control capabilities of the aircraft and degrading automation. It can also lead to rapture of other systems in the aircraft. This failure needs to be addressed to ATC as it has a consequence on adhering to airspace requirements especially sicne some Airspaces require Autopilot functioning and a hydraulic failure leads to immediate Autopilot disconnect.

Remember that the pilots' workload will be very high and he may be dealing with other failures that they do not have time to tell you about, so stay prepared for the unexpected!


AJWAA
The Guide to UAE Aviation
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Her Nomination to the Presidency to the International Civil Aviation Organization a new era for aviation
SETTING A NEW BENCHMARK: Abu Dhabi Airport's new \$3 billion Midfield Terminal building.
DXB SOUTHERN RUNWAY: The refurbishment of Dubai International's southern runway.
TAKING TO THE SKIES: Emirates Flight Training Academy provides advanced training facilities.
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