safety behaviours
RESOURCE GUIDE FOR PILOTS
Welcome to the Safety Behaviours: Human Factors for Pilots Resource Guide, developed by CASA to provide comprehensive human factors information to further support your learning within this field. For some, this may be your first exposure to human factors theory; for others, it will serve as a good refresher or ‘top up’ of information.

This guide has been developed to provide a stronger focus on the needs of the Australian aviation environment generally, and low capacity regular public transport and charter operations, flying training organisations and private operators in particular.

The International Civil Aviation Organization (ICAO) has highlighted human error as being the single most serious threat to aviation. Furthermore, human factors are cited as contributory factors to a vast number of serious incidents and accidents. While we cannot eliminate human error, a thorough understanding of human factors principles can lead to the development of appropriate policies, strategies and practical tools to mitigate its adverse impact on aviation safety. Human factors remains one of the key areas in which you can minimise human error and/or further protect yourself and your organisation from its consequences. In a nutshell, we make errors every day, and anything which improves what we learn from the experience contributes to achieving the goal of becoming a professional pilot.

As human factors is a diverse and developing field, the resource guide aims to target aspects of human factors which are particularly relevant to you without being too exhaustive or overly theoretical. For those just commencing this journey, we recommend you use this as a good starting point from which to review other sources of human factors theory. As you will see, each chapter contains further reading to expand your human factors understanding.

We hope you enjoy the Safety Behaviours: Human Factors for Pilots training resource.
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Chapter 1

Introduction

Human factors are important for safe and efficient aviation operations. Human factors are the social and personal skills (e.g. communication and decision making) which complement technical skills. Effective human factors are crucial for safety because of the continued threat of accidents, particularly in low capacity air transport operations; the need for improved efficiency and the importance of having fit-for-duty pilots.
Introduction

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- Human factors and the Australian low capacity air transport sector  10
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“When a flight is proceeding incredibly well, something was forgotten.”

Robert E Livingston, *Flying the Aeronca*
INDUSTRY NEED FOR HUMAN FACTORS TRAINING

Most pilots would be aware that human behaviour and performance are cited as causal factors in the majority of aircraft accidents. While the aviation industry has benefited from technology, with hardware and software becoming more reliable, human operators still continue to make errors. We cannot eliminate human error, but we can catch and minimise errors before their consequences become unacceptable. One of the best ways to do this is to train pilots so that they have the necessary human factors skills to cope with the risks and demands of flying.

Human factors - decision making and social skills - complement technical skills. For example, properly flaring the aircraft on landing is a technical skill, but maintaining situational awareness (attention to the surrounding environment) to avoid a potential runway incursion is a human factors skill (sometimes referred to as a non-technical skill).

This guide describes the basic human factors which are important for safe and efficient performance in operating aircraft, whether single pilot or multi-crew. The human factors covered in this guide are:

Table 1 Categories & elements of human factors

<table>
<thead>
<tr>
<th>Categories</th>
<th>Elements</th>
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<tr>
<td>Managing fatigue</td>
<td>Identifying symptoms of fatigue</td>
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<td>Recognising effects of fatigue</td>
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<td>Implementing fatigue-coping strategies</td>
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<tr>
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<td>Alcohol and other drugs (AOD)</td>
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<td>Identifying risk factors and symptoms of AOD use</td>
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<td>Teamwork</td>
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<td>Solving conflicts</td>
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<td>Exchanging information</td>
</tr>
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<td></td>
<td>Coordinating activities</td>
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<td>Decision making</td>
<td>Defining the problem</td>
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<td>Considering options</td>
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<td>Selecting and implementing options</td>
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<td>Reviewing the outcome</td>
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<td>Situational awareness</td>
<td>Gathering information</td>
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<td></td>
<td>Interpreting information</td>
</tr>
<tr>
<td></td>
<td>Anticipating future states</td>
</tr>
<tr>
<td>Communication</td>
<td>Sending information clearly and concisely</td>
</tr>
<tr>
<td></td>
<td>Including context and intent during information exchange</td>
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<tr>
<td></td>
<td>Receiving information especially by listening</td>
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<td>Identifying and addressing barriers to communication</td>
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Underpinning these human factors are two important strategies to manage error as shown below.

**Error management strategies**

**Table 2  Error management strategies and elements**

<table>
<thead>
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<th>Error management strategies</th>
<th>Elements</th>
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<td>Recognise and manage errors</td>
</tr>
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<td>Recognise and manage threats</td>
</tr>
<tr>
<td></td>
<td>Recognise and manage undesired aircraft states</td>
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<tr>
<td>Airmanship</td>
<td>Maintain effective lookout</td>
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<tr>
<td></td>
<td>Maintain situational awareness</td>
</tr>
<tr>
<td></td>
<td>Assess situations and make decisions</td>
</tr>
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<td></td>
<td>Set priorities and manage tasks</td>
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<tr>
<td></td>
<td>Maintain effective communications and interpersonal relationships</td>
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The relationship between human factors and accidents/incidents is shown in the following diagram.

**Figure 1  Relationship between human factors and the chance of an accident/incident**

In summary, good human factors can reduce the likelihood of error and resultant accidents/incidents. There are a number of strategies to manage error, such as applying airmanship and threat and error management skills, thus decreasing your risk.
HUMAN FACTORS AND THE AUSTRALIAN LOW CAPACITY
AIR TRANSPORT SECTOR

Australia has an excellent air safety record. Fatal accidents in passenger-carrying aircraft are very rare and
the accident rate is one of the lowest in the world. The public has every reason to be confident about their
safety when flying in Australia.

However, safety improvements can always be made. Over the last five years there have been 12 accidents
involving low capacity regular public transport (RPT) operations, one involving multiple fatalities. In May 2005,
a Fairchild Metroliner collided with the ground during an approach to Lockhart River in far north Queensland.
The accident claimed the lives of all 13 passengers and two crew, and was the most serious fatal accident
in Australia since the loss of a Vickers Viscount in 1968, which claimed 26 lives. Prior to the Lockhart River
accident, the last fatal accident involving low capacity RPT occurred in 2000. Eight people were fatally injured
when a Piper Chieftain crashed after both engines failed over water at night.

The worst civil aircraft accidents over the last 40 years in Australia, as Table 3 below indicates, all involve low
capacity RPT or charter operators.

Table 3  Ten worst civil aviation accidents in Australia since 1968

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Operator</th>
<th>Registration</th>
<th>Aircraft type</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 Dec 1968</td>
<td>Port Hedland, WA</td>
<td>Robertson-Miller Airlines (RPT)</td>
<td>VH-RMQ</td>
<td>Vickers Viscount 720</td>
<td>26 killed</td>
</tr>
<tr>
<td>23 Oct 1975</td>
<td>Cairns, QLD</td>
<td>Connair Pty Ltd (RPT)</td>
<td>VH-CLS</td>
<td>De Havilland DH-114 2E/A1</td>
<td>11 killed</td>
</tr>
<tr>
<td>21 Feb 1980</td>
<td>Sydney, NSW</td>
<td>Advance Aviation Pty Ltd</td>
<td>VH-AAV</td>
<td>Beech 200</td>
<td>13 killed</td>
</tr>
<tr>
<td>16 Dec 1988</td>
<td>Lenora, WA</td>
<td>Broughton Air Services Pty Ltd (Charter)</td>
<td>VH-BBA</td>
<td>Mitsubishi MU-2B-60</td>
<td>10 killed</td>
</tr>
<tr>
<td>13 Aug 1989</td>
<td>Alice Springs, NT</td>
<td>Balloon Safari (Farbix Pty Ltd) (Charter)</td>
<td>VH-NMS</td>
<td>Balloon Thunder &amp; Colt 240A</td>
<td>13 killed</td>
</tr>
<tr>
<td>11 May 1990</td>
<td>Atherton, QLD</td>
<td>Air North Queensland Pty Ltd (Charter)</td>
<td>VH-ANQ</td>
<td>Cessna 500 Astec Eagle</td>
<td>11 killed</td>
</tr>
<tr>
<td>2 Oct 1994</td>
<td>Williamtown, NSW</td>
<td>Seaview Air (Charter)</td>
<td>VH-SVQ</td>
<td>Rockwell Commander 690B</td>
<td>9 killed</td>
</tr>
<tr>
<td>31 May 2000</td>
<td>Whyalla, SA</td>
<td>Whyalla Airlines (RPT)</td>
<td>VH-MZK</td>
<td>Piper PA31-350</td>
<td>8 killed</td>
</tr>
<tr>
<td>7 May 2005</td>
<td>Lockhart River, QLD</td>
<td>Transair (RPT)</td>
<td>VH-TFU</td>
<td>Fairchild Metroliner SA227-DC</td>
<td>15 killed</td>
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There are many reasons why low capacity RPT operators are overrepresented in the accident fatality data
in comparison to high capacity operations. Low capacity air operators generally operate with less stringent
regulatory requirements, fewer company resources, less sophisticated aircraft, and in a more hazardous operating
environment than their mainline jet counterparts. Furthermore, unlike jet operators, low capacity operators rarely
have the resources to implement more sophisticated flight safety management systems such as flight data
recorder-based, flight operational quality assurance programs. Human factors training and instructor expertise also
tend to be lacking in comparison to larger air operators.
Controlled flight into terrain—Young

On Friday 11 June 1993, at about 1918 EST, Piper PA31-350 Navajo Chieftain aircraft, VH-NDU, while on a right base leg for a landing approach to runway 01 in low cloud and darkness, struck trees 275 feet above Young aerodrome, New South Wales, and crashed. The aircraft - Monarch Airlines flight OB301 - on a regular public transport service from Sydney to Young, was destroyed by impact forces and a post-crash fire. All seven occupants, including the two pilots, suffered fatal injuries.

The investigation found that the circumstances of the accident were consistent with controlled flight into terrain. Significant factors in the accident included:

- The cloud base in the Young circling area was below the minimum circling altitude; there was limited ground lighting and it was a dark night.
- The workload of the pilot-in-command was substantially increased by aircraft equipment deficiencies, with a possible consequent degrading of his performance as a result of skill fatigue.
- The instrument approach and landing charts did not provide the flight crew with adequate terrain information for a circling approach.
- The Monarch operations manual did not provide the flight crew with guidance or procedures for the safe avoidance of terrain at Young during a night-circling approach.
- The aircraft descended below the minimum circling altitude without adequate monitoring of obstacle clearance by the crew.
- The visual cues available to the flight crew were insufficient as a sole source of height judgement.
- There were organisational deficiencies in the management and operation of RPT services by Monarch.
- There were organisational deficiencies in the safety regulation of Monarch RPT operations by the CAA.
HOW IMPORTANT ARE HUMAN FACTORS?

Aviation has a long history of developing advanced technological innovations to improve safety and efficiency. High fidelity simulators, navigation systems such as global navigation satellite system (GNSS) and critical safety devices such as ground proximity warning system (GPWS) and the traffic collision avoidance system (TCAS), are testimony to that. However, improving the reliability of people has lagged behind technology, and still presents the single greatest challenge to further reducing aviation accident rates.

When we buy a house we consult with a real estate agent, when sick we find a doctor and when we have a legal problem we retain a lawyer for advice. However, when it comes to solving human performance issues, many people adopt a less formal approach, even though many lives may depend on the outcome. Many years of industry experience or thousands of flying hours may not help in resolving problems which only a thorough understanding of human factors and application of human factors can provide.

The following underline the need for effective human factors aviation skills:

- The ever-present and ongoing risk of aircraft accidents involving multiple fatalities
- Striving for more efficient aircraft operations in an increasingly complex system
- Flight crew’s fitness for duty

Risk of accidents

A number of major accidents, without apparent primary technical cause, highlight human performance.

One such accident occurred in 1972, when an Eastern Airlines L1011 crashed in the Florida Everglades. In this accident, duties on the flight deck were not properly allocated, and consequently, the whole flight crew became preoccupied with a landing gear indicator light bulb.

A burned out light bulb!

The crew of a Tristar aircraft flying over the Florida Everglades were not sure if their undercarriage was down. In fact the nose gear indication light had failed to illuminate.

The crew examined every possibility to find the trouble, and determined that either the nose gear was stuck and not lowering properly; or the nose gear was safely down, but the indicator system was faulty. The flight engineer crawled down into the nose, while the captain and first officer tried every combination of switches and circuit breakers. They became so obsessed with the problem that they didn’t notice that the auto-pilot had become disengaged and the aircraft was sinking lower and lower, eventually crashing into the Everglades.

With their preoccupation with the unsafe landing gear indication, they failed to monitor their altimeter readings. Ironically, the air traffic controller noticed on his radar that the aircraft was losing height, but instead of pointing this out, simply asked diplomatically, ‘How are things coming along out there?’ The crew assumed he was referring to their landing gear problem and replied seconds before impact: ‘Everything is all right’.

The cause of the problem – a 10 cent burned-out light bulb, designed to show that the undercarriage was down and locked into position.
The second accident occurred in 1977 and involved a runway collision between a Pan Am Boeing 747 and a KLM Boeing 747, at Tenerife in the Canary Islands, with a loss of 583 lives. A breakdown in normal communication procedures and misinterpretation of verbal messages were considered primary contributing factors.

**The world’s worst aviation disaster**

A bomb had exploded at the Las Palmas–Canary Islands airport earlier in the day. Traffic, including a KLM B747 and a Pan Am B747, was therefore diverted to the much smaller Los Rodeos airport, where the parking area became saturated with aircraft.

When Tenerife reopened, the KLM B747 was instructed to taxi to the end of the runway and wait for take-off clearance. The Pan Am B747 was told to follow the KLM aircraft and exit the runway using the third taxiway, so that it could line up behind KLM.

Due to poor visibility (low cloud began rolling in) the Pan Am aircraft missed its taxiway exit and continued down the runway. Meanwhile, the captain of the KLM flight was anxious to get underway because of flight duty limitations, and began his take-off roll on the same runway, despite the fact that the tower had not cleared them for take-off. The two planes collided on the runway.

Significant factors in the crash were symptoms of the ‘hurry-up syndrome’ on the part of the KLM captain, who was concerned about his crew violating maximum duty times; the poor visibility; simultaneous radio transmissions at the critical moment obscuring the fact that the Pan Am aircraft was still on the runway; and the lack of assertiveness by the KLM first officer who blindly followed his captain, despite not having take-off clearance.
Analysis of these and other accidents suggest failures in important flight crew skills such as:

- Leadership
- Team coordination
- Communication
- Assertiveness
- Attention
- Decision making
- Knowledge of personal limitations (stress and fatigue).

Australia has not been immune to aircraft accidents resulting from ineffective human factors. The Lockhart River accident mentioned previously, and detailed below, is a recent example.

**Controlled flight into terrain—Lockhart river**

On 7 May 2005, a Fairchild Aircraft SA227 DC Metro 23 aircraft, registered VH-TFU, with two pilots and 13 passengers, was being operated by Transair on an instrument flight rules (IFR) regular public transport service from Bamaga to Cairns, with an intermediate stop at Lockhart River, Queensland.

At 1143:39 Eastern Standard Time, the aircraft crashed into a heavily-timbered ridge on the north-western slope of South Pap in the Iron Range National Park, approximately 11 km north-west of the Lockhart River aerodrome. At the time of the accident, the crew was conducting an area navigation global navigation satellite system (RNAV [GNSS]) non-precision approach to runway 12. The aircraft was destroyed by the impact forces and an intense, fuel-fed, post-impact fire. There were no survivors.

According to the Australian Transport Safety Bureau (ATSB) investigation report, the accident was almost certainly the result of controlled flight into terrain, that is, an airworthy aircraft under the control of the flight crew was flown unintentionally into terrain, probably with no prior awareness by the crew of the aircraft’s proximity to the heavily-timbered ridge.
The investigation report identified a range of contributing and other human factors safety issues relating to the crew of the aircraft, including:

- The crew commenced the Lockhart River Runway 12 approach, even though the crew were aware that the co-pilot did not have the appropriate endorsement and had limited experience to conduct this type of instrument approach.
- The descent speeds, approach speeds and rate of descent were greater than those specified for the aircraft in the Transair operations manual.
- During the approach, the aircraft descended below the segment minimum safe altitude for the aircraft's position on the approach.
- The aircraft's high rate of descent, and the descent below the segment minimum safe altitude, were not detected and/or corrected by the crew before the aircraft collided with terrain.
- The crew probably experienced a very high workload during the approach.
- The crew probably lost situational awareness of the aircraft's position along the approach.
- The pilot in command had a previous history of conducting RNAV(GNSS) approaches with crew without appropriate endorsements, and operating the aircraft at speeds higher than those specified in the Transair operations manual.
- The co-pilot had no formal training and limited experience to act effectively as a crew member during the type of approach conducted into Lockhart River.

**Efficiency in aircraft operations**

The need for effective human factors is not just linked to previous accidents such as those outlined above. Efficient ongoing aircraft operations also depend on people performing well individually and in teams, to a consistently high standard.

The proper layout of displays and controls in aircraft cockpits promotes and enhances effectiveness. Well trained and supervised flight crew are likely to perform more efficiently. Compliance with standard operating procedures (SOPs) will ensure that all flight crew know what is expected.
Fitness to fly
A number of factors may influence flight crew fitness to fly; for example, the incidence of fatigue, and drug and alcohol usage.

Fatigue
Fatigue may be considered to be a condition reflecting inadequate rest. Acute fatigue is induced by long duty periods, or by a long series of demanding tasks performed in quick succession. Chronic fatigue is influenced by the cumulative effects of fatigue over the longer term. Fatigue may lead to potentially unsafe conditions and deterioration in decision making and situational awareness.

In the United States, the National Transportation Safety Board (NTSB) (1999) concluded that pilot fatigue contributed substantially to at least three recent aircraft crashes with fatalities. In Australia, although fortunately there have been no airline crashes recorded due to fatigue, the ATSB (2004) attributed a B737 ground proximity caution alert (that is, a ‘near miss incident’) near Canberra to fatigue. The investigation found that because of fatigue, the flight crew of the B737 misinterpreted the instrument approach chart and entered incorrect data into the flight management computer.

The topic of fatigue and its management is outlined in the section 2.0 on ‘Managing Fatigue’ of this resource guide.

Health and performance
Certain pathological conditions such as heart attacks, can result in incapacitation. While sudden incapacitation is thankfully rare, a reduction in capacity or partial incapacitation caused by fatigue, stress or the use of prescribed or non-prescribed drugs may go undetected, even by the person affected.

Factors known to influence fitness include diet, exercise, stress levels and the use of tobacco, alcohol or drugs. Incapacitation of a pilot due to the effects of a medical condition or a physiological impairment represents a serious potential threat to flight safety.

In the United States, three former Northwest Airlines pilots were convicted of flying a passenger jetliner while intoxicated. In 1988, a Trans-Colorado Airlines, Fairchild Metro III, operating as Continental Express, with two crew members and 15 passengers on board, crashed short of the runway at Durango, Colorado, killing the two crew members and seven passengers. The aircraft crashed 5nm short of the runway threshold while executing a VOR/DME approach in snow. The first officer, who was flying the approach, allowed the aircraft to descend below the minimum descent altitude (MDA). The autopsy on the captain revealed that he was a heavy cocaine user, and had used the drug prior to this flight. The NTSB found that the captain’s use of cocaine degraded his performance and contributed to the accident. This led the US Federal Aviation Administration (FAA) to issue new rules to identify and ground pilots involved in alcohol or drug-related motor vehicle offences, to complement their existing drug and alcohol monitoring program for flight crew.

In Australia, between 1975 and 2006 there have only been 36 drug and alcohol-related events reported to the Australian Transport Safety Bureau. However, 89 per cent of these occurrences resulted in an accident, with 67 per cent of these fatal accidents. For example, in September 2002 a Piper PA-32-300 aircraft on a charter flight to Lindeman Island, Queensland, hit the ground shortly after take off from Hamilton Island, fatally injuring the pilot and five passengers. The adverse effects on pilot performance of post-alcohol impairment, recent cannabis use and fatigue were cited as potential contributory factors.
While drug and alcohol-related safety occurrences in Australian civil aviation are very low, the accident and fatality rates are high. CASA’s introduction of a mandatory drug and alcohol testing program into Australia’s civil aviation industry will provide a more prescriptive approach to the issue of drug and alcohol use by pilots. More information on this testing program is provided in section 4.0 on Alcohol and Other Drugs (AOD).

**KEY POINTS**

- Human performance issues continue to dominate aviation accident statistics.
- The effective management of error remains one of the greatest challenges to the further reduction of accidents and improving aviation safety.
- Effective technical AND human factors are required for safe and efficient flight operations.
- The continued threat of low capacity air transport accidents, the need for improved efficiency and the importance of having fit-for-duty flight crew, highlight the crucial role of effective human factors.

*When you are ready, please turn to page 6 of the Workbook for Pilots. Read the overview and complete chapter 1.*
Chapter 2

Fatigue

Fatigue is a threat to aviation safety because it can lead to impaired performance. Perhaps one of the most insidious aspects of fatigue is an individual’s inability to recognise when their own performance is deteriorating and to act accordingly. This section identifies symptoms associated with fatigue, discusses its effects and proposes strategies for managing fatigue within aviation operations, including a focus on fatigue risk management systems (FRMS).
Fatigue

- Overview
- Causes, consequences and influencing factors
- Strategies to prevent fatigue-related errors
- Fatigue management
- Fatigue risk management systems (FRMS)
- Key points
- Resources

“Fatigue cannot be prevented by personality, intelligence, education, training, skill, motivation, size, strength or professionalism.”

Ron Heselgrave
**OVERVIEW**

Alertness and fatigue are factors which can affect individual performance and subsequently, affect crew resource management (CRM). The more fatigued you are, the less able you will be to cope with stress and workload. While efforts should be made to avoid undue fatigue in the first place, good CRM should help you recognise the signs of fatigue in yourself and others, and take appropriate measures to ensure that it is not detrimental to performance.

**What is ‘fatigue’?**

Fatigue can be defined practically as an experience of physical and/or psychological weariness. Fatigue can result in an increased level of sleepiness associated with impaired cognitive and/or physical functioning and, as a consequence, an elevated risk of error or accident. A fatigued individual is often impaired and cannot continue to perform tasks efficiently and/or effectively. Fatigue can, for example, impact upon individuals’ ability to react quickly to emergencies, communicate clearly with colleagues, determine the limits of their own safe capability and operate in a productive manner.

Fatigue is due primarily to an increased duration of wakefulness and/or reduced duration or quality of sleep, and unfortunately, has been implicated in far too many aircraft accidents. Consider the hours the crew had been awake and flying in ‘Working day & night’ below.

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**Table 4 **Fatigue

<table>
<thead>
<tr>
<th>Category</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing fatigue</td>
<td>Identifying symptoms that indicate fatigue</td>
</tr>
<tr>
<td></td>
<td>Recognising the effects of fatigue</td>
</tr>
<tr>
<td></td>
<td>Implementing strategies to manage fatigue</td>
</tr>
</tbody>
</table>

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**Working day and night**

The highly-experienced crew of a Douglas DC-8-61 freighter lost control of the aircraft on final approach at the U.S. Naval Air Station, Guantanamo Bay, Cuba. The aircraft struck level terrain about 400 metres west of the approach runway threshold and was destroyed by impact forces and a post-accident fire. The three flight crew members sustained serious injuries.

The crew had flown overnight cargo schedules for the two nights prior to the accident and had been assigned the accident trip unexpectedly.

They had signed on the night before the accident in Dallas at 2300, departing for Detroit via St Louis at 2400, and arriving at 0325. Departing Detroit at 0620, they arrived at Atlanta and finished duty around 0800. However, as the company needed them for an additional trip, they returned to duty. They departed Atlanta at 1010, arrived at NAS Norfolk at 1140, departed NAS Norfolk (IFR) at 1413 and arrived at Guantanamo Bay at 1656. By that stage the crew had been on duty for almost 18 hours.
Analysis showed that the captain, first officer and flight engineer were awake continuously for 19, 21, and 23.5 hrs respectively prior to the accident, thereby experiencing sleep loss and a disruption of their Circadian rhythms. It’s hard to fathom, but the intended flight route, including the return from Guantanamo Bay, would have resulted in the crew accumulating a total duty time of 24 hours and 12 hours of flight time.

According to the investigation, the probable cause was the impaired judgment, decision-making, and flying abilities of the captain and flight crew due to the affects of fatigue, the inadequacy of the applicable flight and duty time limitations, and the corporate circumstances leading to the extended flight/duty hours.

This accident was reportedly the first time that the US National Transportation Safety Board (NTSB) cited fatigue as the primary cause of an aircraft accident.

Safety impact—incidents and accidents

Elevated levels of fatigue, with associated deterioration in performance, have been shown to be associated with higher risk of accident in transport and in catastrophic events worldwide. In recent history, there is an abundance of aviation accidents where pilot fatigue is deemed to have impaired pilot performance, as in the studies below.

Did we brief them about needing snow shoes?
The Embraer ERJ-170 was landing on a snow-covered runway when it overran the end of the runway, contacted an instrument landing system (ILS) antenna, and struck an airport perimeter fence.

The aeroplane’s nose gear collapsed during the overrun. Of the two flight crew members, two flight attendants, and 71 passengers on board, three passengers received minor injuries. The aeroplane received substantial damage from the impact forces. Instrument meteorological conditions prevailed at the time of the accident.

The investigation found the probable cause of this accident was the flight crew’s failure to execute a missed approach when visual cues for the runway were not distinct and identifiable.
Contributing to the accident were:

- the crew’s decision to descend to the instrument landing system decision height instead of the
  localiser (glide slope out) minimum descent altitude
- the first officer’s long landing on a short contaminated runway, and the crew’s failure to use reverse
  thrust and braking to their maximum effectiveness
- the captain’s fatigue, which affected his ability to plan and monitor the approach and landing
  effectively
- the operator’s failure to administer an attendance policy permitting flight crew members to call in as
  fatigued without fear of reprisals.

Jokes, cursing and cockpit distractions
The flight crew flew three flights the day before the accident and then had the minimum eight-hour rest.
The eight hours of ‘rest’ included the time it took to get to a hotel, eat dinner and take a shuttle back to the
airport the next morning.

The crew was originally scheduled for eight flights on the day of the accident, which was legal according
to the aviation regulator (FAA).

(The FAA limits US pilots to 16 hours on duty and eight hours of operating an aircraft in a given 24-hour
period. The FAA also requires pilots to have eight hours of rest between shifts). The crew woke shortly
after 0400 to arrive at the airport by 0515, where they were advised two of the eight originally scheduled
flights were cancelled because of poor weather.

On the flight crew’s sixth and final scheduled flight of the day, after more than 14 hours on duty, the
aircraft crashed into trees, killing both members of the flight crew and eleven of the 13 passengers.
Analysis of the cockpit voice recorder revealed that just before the accident, the two crew members were
joking with each other, discussing co-workers they didn’t like and foods they did like.

The accident investigation found that the conversational distractions, coupled with the fact that the pair
was trying to land their sixth flight of the day after such a long duty time, were contributing factors in the
accident. Investigators stated that the pilot and co-pilot ignored guidance about when and at what speed to descend, joking and cursing at one another while the aircraft’s warning system alerted them of the rapidly approaching ground below.

In Australia, although fortunately there have been no airline accidents recorded due to fatigue, the Australian Transportation Safety Bureau attributed a Boeing 737 ground proximity caution alert (that is, a ‘near miss incident’) near Canberra to fatigue as summarised below.

### Caution: terrain

The Boeing 737 was being operated on an overnight service from Perth to Canberra when it proceeded beyond the limits of the Church Creek holding pattern, 10.9 nm south of Canberra. In doing so the crew manoeuvred the aircraft closer to terrain than intended. As a consequence the aircraft received a ‘Caution: Terrain’ message from the aircraft’s enhanced ground proximity warning system.

The crew had commenced a right turn back to the north towards Canberra shortly before the ‘Caution Terrain’ message. They then flew the aircraft to a higher altitude.

The investigation found that the flight crew of the aircraft were affected by fatigue: they misinterpreted the instrument approach chart and entered incorrect data into the flight management computer (FMC). It was found that the flight crew’s fatigue was partly attributable to an over-hot cockpit, the result of an air-conditioning fault, on the Perth to Canberra leg. Normal air traffic assistance was not available in Canberra for 40 minutes after the scheduled 0530 opening time. As a result of this incident, the aircraft operator amended procedures to require a higher altitude for aircraft holding to the south of Canberra, and the chart publisher has amended charts to reduce the likelihood of misinterpretation.

The investigation noted that the occurrence was not simply a case of incorrect data entry, but was influenced by a number of events occurring prior to, and during the flight affecting the crew, the aircraft and the air traffic control system.

Evidence suggests that the flight crew’s operational performance was affected at a critical stage of the flight by fatigue, the late advice of the status of air traffic services and the crew’s misinterpretation of the CCK locator holding pattern data on the runway 35 ILS approach chart.

The crew’s ineffective contingency planning for a descent to Canberra without air traffic control support, and the erroneous data entry in the aircraft’s FMC suggest that the crew was not functioning at an appropriate level of alertness. It is likely that both the pilot in command and the co-pilot were experiencing fatigue due to the cumulative effects of ineffective sleep in the period preceding the Perth to Canberra night sector and the ongoing period of wakefulness during the flight.

Additionally, as they approached Canberra, the crew was working at a low point in their Circadian rhythms. It is therefore likely that they were experiencing a decreased level of alertness. The application of the minimum equipment list on the flight deck air-conditioning system allowed continued flight operation despite abnormally hot conditions - about 10° C above normal. While this may have had less impact on crew performance during a short daylight flight, it was of greater significance during a night flight of more than three hours.
These conditions probably combined to reduce the level of crew alertness, performance and attention. The crew’s failure to recognise the inaccurate entry in the FMC is consistent with the effects of fatigue, and it is likely that those effects were exacerbated by the excessive flight deck temperatures.

CAUSES, CONSEQUENCES & INFLUENCING FACTORS

Causes of fatigue

The general causes of fatigue can include inadequate recovery sleep between shifts, demanding tasks or conditions, long commutes, and individual factors such as sleep disorders.

The operational demands placed on pilots also have an impact, including transmeridian travel, night work, shift work, irregular work schedules and exposure to stress-inducing factors such as noise, vibration, reduced oxygen, high or low temperature, low humidity, physical restraint, navigation problems, bad weather, technical problems, and difficulties with passengers. The variety of factors which can influence fatigue includes both work-related and non-work-related issues.

Work-related fatigue factors:
- Hours employees are required to work (and the impact of these hours on sleep opportunity)
- Timing and duration of breaks provided within shifts
- Task/s employees are required to perform
- Work environment & conditions

Non work-related fatigue factors:
- Long commutes to and from work
- Sleep disorders affecting quantity and/or quality of recovery sleep
- Individual factors relating to family and social responsibilities

Consequences of fatigue

The consequences of fatigue are wide and varied. Some are fairly easy to observe and/or measure, while others are more difficult. In general, however, there is a sliding scale of impairment progressing from ‘fully rested’ to ‘highly fatigued’. An early indicator of fatigue is mood - with a reduction in positive feelings and a corresponding increase in negative feelings. Further along the scale, the desire to communicate reduces, as does the quality/clarity of content. At the next level, the speed of performance begins to be degraded, and if fatigue is significant enough, then accuracy of performance will also be impaired.

Research has shown that the effects of fatigue are similar to moderate alcohol consumption. The result is significantly delayed response and reaction times, impaired reasoning, reduced vigilance and impaired hand-eye coordination. Research has shown that after 17 hours of wakefulness, fatigue-related impairment is equivalent to a breath alcohol concentration (BAC) of 0.05 per cent. After 24 hours of wakefulness, this increases to a BAC of 0.10 per cent - well over the legally prescribed limit for operating a motor vehicle. For a pilot who only has four hours sleep a night, research has shown that just one beer can have the impact of a six-pack.
General consequences of fatigue can include:

- Lapses in attention/concentration
- Poor assessment of risks, and incomplete or inaccurate assessment of potential consequences
- Inefficiency in terms of production, on-time performance, resource use (e.g. fuel), and/or motivation
- Impaired or delayed decision making
- A higher likelihood of focusing on the most apparent data or stimulus, and ignoring or being unaware of other important system information as in the case below.

### Possible fatigue, degraded situational awareness

A chartered Gulfstream III aircraft struck a light pole about three miles southwest of the destination and crashed in poor weather while on an ILS approach. The aircraft was being repositioned from Dallas Love Field to Houston where it was scheduled to pick up former President, George H. W. Bush, and several other passengers. At the time of the accident, two pilots and a flight attendant were aboard the aircraft, and all three perished.

The investigation found the probable cause of this accident was the flight crew’s failure to monitor and cross-check the flight instruments adequately during the approach. Contributing to the accident was the flight crew’s failure to select the instrument landing system frequency in a timely manner and to adhere to approved company approach procedures, including the stabilised approach criteria.

The investigation report also mentioned fatigue. According to the captain’s wife, on the night before the accident, the captain received about four hours less sleep than normal. A company employee stated that when the captain arrived for work on the morning of the accident, he looked as though he had just woken up. The first officer’s wife stated that the first officer did not have regular sleeping hours and that she was not sure how much he slept the night before the accident. Although the early reporting time for the accident flight might have resulted in flight crew fatigue, the actual amount and quality of sleep received by the captain and the first officer could not be determined. Given the facts uncovered about crew sleep, the investigators found fatigue may have played a role in the flight crew’s degraded situational awareness.
Behavioural symptoms of fatigue

The table below indicates the typical behavioural symptoms of fatigue. If an employee has experienced three or more of the specified symptoms in a 15-minute period they are likely to be fatigued, and should be considered at an elevated level of fatigue-related risk.

Table 5 Symptoms of fatigue

<table>
<thead>
<tr>
<th>Physical symptoms</th>
<th>Mental symptoms</th>
<th>Emotional symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yawning</td>
<td>Difficulty concentrating on the current work task</td>
<td>More quiet or withdrawn than normal</td>
</tr>
<tr>
<td>Heavy eyelids</td>
<td>Lapses in attention</td>
<td>Lethargic or lacking in energy</td>
</tr>
<tr>
<td>Eye-rubbing</td>
<td>Difficulty remembering what you are meant to be doing</td>
<td>Lacking in motivation to do the task well</td>
</tr>
<tr>
<td>Head drooping</td>
<td>Failure to communicate important information to a colleague</td>
<td>Irritable or bad tempered behaviour with colleagues, family or friends</td>
</tr>
<tr>
<td>Inappropriate or unintentional sleep onset</td>
<td>Failure to anticipate events or actions</td>
<td></td>
</tr>
<tr>
<td>Poor co-ordination</td>
<td>Unintentionally doing the wrong thing (errors of commission)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unintentionally failing to do the right thing (errors of omission)</td>
<td></td>
</tr>
</tbody>
</table>

Effects of fatigue and sleep loss on flight crew

- Timing errors in response sequences, less smooth control, enhanced stimuli required, for example, energy drinks.
- Overlooked/misplaced sequential task elements, preoccupations with single tasks or elements, reduced audio-visual scan, less aware of poor performance.
- Inaccurate recall of operational events, forgetting of peripheral tasks, reversion to old habits.
- Less likely to converse, less likely to perform low demand tasks, more distracted by discomfort, more irritable, displaying a ‘do-not-care attitude’.
- Fatigue makes a pilot less vigilant and more willing to accept below-par performance. A pilot can begin to show signs of poor judgement and a multitude of factors can be degraded, including:
  - Error management
  - Memory
  - Ability to cooperate
  - Vision and perception
  - Motivation and attitudes
  - Communication
  - Decision making
  - Performance monitoring
  - Muscular strength and coordination

When you are performing physical tasks - such as lifting baggage or digging trenches – signs of fatigue will appear more slowly than if you are undertaking mentally demanding tasks.

However, if you are performing tasks with both physical and mental demands, the likelihood of fatigue may increase, as seen in the case below.
When all the holes line up

A Cessna 172 was assisting a ground party of outback station hands to muster sheep, when the aircraft crashed. The pilot sustained fatal injuries and the aircraft was destroyed.

Damage to the aircraft was consistent with it hitting the ground in a near-vertical attitude at a low forward speed. A significant quantity of fuel was later recovered from the aircraft wreckage. There was no evidence that a mechanical defect had contributed to the accident.

Analysis

On the day of the accident, the pilot had been flying at low level for most of the day, with minimal rest periods. On the day of the accident, he had flown at least eight hours and 30 minutes. He had only recently qualified for his private pilot licence and a significant portion of his total flying hours had been accumulated in the nine days before the accident. During this period, he had exceeded the flight and duty times normally permitted for a commercial operation.

A human factors report noted that the pilot had worked long hours in a job in which he was inexperienced, and that he probably found this type of flying both physically and mentally demanding. Fatigue can diminish human performance, particularly with tasks requiring sustained attention and rapid reaction times. It may impair a pilot’s ability to judge distance and speed, and it increases reaction times. It may also lead to poor decision making. Heat, noise and vibration may exacerbate these effects.

The report concluded that at the time of the accident the pilot was suffering from the effects of fatigue, possibly impairing his ability to operate the aircraft safely. The pilot was not qualified to conduct mustering or low-flying operations. Without such qualifications, the pilot was legally required to operate no lower than 500ft above ground level. At this height, the aircraft may have been of some use in spotting sheep, but probably would have been ineffective in mustering.

The pilot had received minimal training to identify the visual illusions associated with low-level flight. It was considered therefore unlikely he was aware of appropriate techniques to manoeuvre safely at low level. Several visual illusions affect pilots of low-flying aircraft. An untrained pilot would be particularly susceptible to such illusions, some of which may prevent correct estimation of airspeed, or making appropriate control inputs during a critical phase of flight.

The property owners had little aviation experience to help them manage the hazards of this type of operation. Although one of the owners knew that pilots needed special training for mustering, the accident pilot was employed while still unqualified. While the immediate circumstances of the aircraft crash could not be established, the investigation identified possible contributing factors including: pilot fatigue, a lack of low-flying training and no appropriate supervision of a relatively inexperienced pilot.

At the ‘highly-fatigued’ end of the scale, individuals can experience micro-sleeps, head nodding, or even involuntary sleep. For someone performing a routine low-risk task, this is not critical. However, for a pilot, it’s different. When you consider that an aircraft travelling at 250 kts on a glide path, can cover over 400 feet in one second - the duration of a micro-sleep - imagine the distance it would cover if both pilots fell asleep. This has happened, as seen in the incident below.
2 – Fatigue

### Variables that can influence fatigue

#### Table 6  Factors influencing fatigue

<table>
<thead>
<tr>
<th>Duration of shifts</th>
<th>Mental activity</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of day shift occurs</td>
<td>Age</td>
<td>Social life</td>
</tr>
<tr>
<td>Health</td>
<td>Experience</td>
<td>Psychological well being</td>
</tr>
<tr>
<td>Diet</td>
<td>Circadian rhythms</td>
<td>Work ethic, work rate</td>
</tr>
<tr>
<td>Physical activity</td>
<td>Work</td>
<td>Water intake</td>
</tr>
<tr>
<td>Drugs</td>
<td>Caffeine</td>
<td>Alcohol</td>
</tr>
<tr>
<td>Time since last opportunity for restorative sleep</td>
<td>Other stimulants</td>
<td>Hypnotics</td>
</tr>
</tbody>
</table>

### STRATEGIES TO PREVENT FATIGUE-RELATED ERRORS

There are a number of specific strategies to prevent fatigue-related errors. Examples of these strategies include:

- Napping
- Task reassignment
- Peer monitoring
- Double-check systems
- Task rotation
- Additional breaks
- Strategic use of caffeine

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**Asleep in the cockpit**

It’s one thing for passengers on a short flight to grab 40 winks, but it’s quite another for both the captain and his co-pilot to take a power nap at 21,000 ft. Two airline pilots flew past Hilo (the Hawaiian airport where they were supposed to land) because both fell asleep in the cockpit. They overshot the airport by 15 miles.

The Bombardier CRJ-200, with 40 passengers on board, was left on auto-pilot as the crew dozed and the aircraft drifted off course over the Pacific. The captain and his co-pilot have been grounded and are under investigation for allegedly snoozing through 11 calls from air traffic controllers desperate to reach them.

The first call from air traffic control came through about 15 minutes into the flight, asking for confirmation that the pilots were preparing for a landing. Over the next seven minutes, the controller tried repeatedly to make contact with no response. When the captain finally responded, 32 minutes into the flight, the panicked controller told him: ‘Guys, I’ve been trying to contact you for the last 90 to 100 miles. I understand you’ve passed Hilo. Is there some kind of emergency situation going on?’

The captain responded: ‘Uh, no emergency situation.’ By that time, the aircraft should have landed after a 30-minute inter-island Hawaiian trip, but was still at cruising speed and altitude.
**Napping**
In general, the longer the nap, the greater the recovery value. Naps should permit at least 20 minutes sleep, and be no longer than two hours, for maximum benefit. Shorter naps do not produce appreciable or lasting improvements in alertness. Naps longer than two hours are of diminishing usefulness compared to providing another individual with an opportunity to have a nap.

Additionally, longer naps are also associated with a longer period of sleepiness immediately following waking, an effect known as sleep inertia. Before returning to work after a nap, an individual should be given sufficient time in order to overcome the effects of sleep inertia. Typically, this will be not less than 10 minutes during the day, and up to 20 minutes in the early hours of the morning.

**Supervisory and co-worker monitoring**
Where flight crew are at an elevated risk of a fatigue-related error, increased monitoring for fatigue-related behaviours and/or impaired task performance can be an effective self, peer or supervisory strategy. Sometimes this can be a sensitive issue and it is important that the criteria for increased monitoring are agreed in advance to minimise misunderstanding of the intent.

Increased monitoring can be achieved in a number of ways. It can be as simple as more frequent verbal contact, or it can involve more formal policies or procedures mandating verified additional supervisory checks on safety-critical work by the fatigued-impaired individual, co-workers or a supervisor/line manager. The preference is for support through supervisor and colleague monitoring using double-checks, monitoring of operational performance and general supervision of performance.

**Task rotation**
Task rotation has significant potential as a control measure for fatigue, as in many cases, workload can be made more engaging by varying the tasks undertaken across a duty period. Flight crews engaging in monotonous tasks with little variety are particularly susceptible to the effects of fatigue.

It is important to understand there are limits to the benefits of task rotation. In general, the number of different tasks undertaken in a duty period should not exceed three or four, otherwise errors due to unfamiliarity or lack of currency may occur. Where task rotation is used to manage fatigue-related risk, the number and types of tasks allocated are to be determined consultatively, and should only be undertaken with agreement of the supervisor.

**Task reallocation**
When fatigue-related symptoms are recognised, or the use of a self-assessment tool indicates impairment from the effects of fatigue is likely, some specific activities should not be scheduled or carried out by flight crew. These would include any high-risk activity.

Acceptable activities include simple procedural tasks, word and data processing, quality checks and basic communication. However, this control only reduces exposure to high impact hazards; it does not mitigate fatigue.
**Strategic use of caffeine**

Caffeine can provide a short term improvement in alertness. The effects will vary in intensity and duration, depending on how often and how much caffeine the body is used to. Not surprisingly, the more frequent and higher the habitual dose, the less it will affect alertness. Therefore, it should only be used in a contingency when increased alertness is required.

Caffeine is also known to affect sleep quality and duration. Caffeine has the capacity to ‘shift’ fatigue and alertness to more appropriate times, but the fatigue has only been postponed, not eliminated. Consequently, there are significant disadvantages to prolonged habitual caffeine use.

**FATIGUE MANAGEMENT**

The need for fatigue management is more widely recognised - most extended-hours and 24-hour industries now have a defined need for improved fatigue management. It could be argued that fatigue has become more prominent as a risk as other more ‘traditional’ risks - such as ineffective procedures, poor engineering or maintenance - have been more successfully addressed. As awareness about fatigue increases, so has pressure from regulators, unions, and safety professionals on organisations to manage fatigue proactively.

Initially, fatigue management was seen as a way to address specific areas such as: hours of work, training and education, policy and procedures, and in time, risk management. But the experience of implementing fatigue management systems across various industries and countries shows a more integrated approach is needed.

**Fatigue risk**

In operations, there are three basic elements which need to align for fatigue to contribute to a hazardous event. These elements (red boxes) are illustrated in the following figure - the absence of any one element implies that fatigue is unlikely to contribute to a fatigue-related event.

*Figure 2 Fatigue risk triangle (based on InterDynamics Pty Ltd)*

For example, if an individual is working longer hours with inadequate sleep, but is doing something where the likelihood and consequences of errors is negligible, then there is said to be a lower fatigue risk. But, if an individual is flying AND working long, demanding hours with inadequate sleep, then the fatigue risk is likely to be higher.
Pilot/crew rest and flying duties

Scheduling of adequate pilot/crew rest needs to consider several important factors, such as: time since awake, time on task, type of tasks, extensions of normal duty periods and cumulative duty times.

The ‘time since awake’ is the starting point for fatigue to build. This can be prolonged prior to flying due to a variety of issues such as:

- the effects of jet lag
- early waking due to disturbances in the sleep environment
- the extra time needed to get up, check out of a hotel, and travel to the airport for flight check-in
- Delays in starting pre-flight procedures, including mechanical problems or weather delays.

‘Time on task’ is the time required to pre-flight and fly: from check-in to knock-off plus fifteen minutes on the last flight of the day. ‘Type of tasks’ again depends on issues such as: crew position, type of aircraft and the nature of the flight. Extensions of normal duty periods can occur from unscheduled events such as: delays for en route weather, rerouting due to traffic, or diversions.

Research suggests that duty periods greater than twelve hours are associated with a higher risk of errors. To determine maximum limits for extended duty periods, you need to consider: the number of legs in the day’s flight plan; whether jet lag is a factor in the crew duty day; and the time since awake. ‘Cumulative duty times’ are most fatiguing when there are consecutive flying days with minimal or near minimal crew rest periods. This can result in sleep debt requiring additional time to overcome.

FATIGUE RISK MANAGEMENT SYSTEMS (FRMS)

Fatigue risk management systems are being adopted by a range of organisations to control the risks of fatigue-related accidents and incidents. The Civil Aviation Safety Authority now regulates flight and duty times under Civil Aviation Order 48 (CAO 48). However, the limitations imposed by CAO 48 were developed well before the science of sleep and fatigue was established. CASA is moving towards a risk management approach to the control of fatigue, advocating fatigue risk management systems, as an option to a prescriptive approach.

A fatigue risk management system (FRMS) is designed to provide a flexible operating environment highlighting potential higher fatigue risks. Operators are required to anticipate and address fatigue risk and amend their system in light of company experience or operational changes. An FRMS should be implemented as a component of a safety management system (SMS), where one exists.

Aim of a fatigue risk management system

Ideally, an FRMS introduces an organisational culture change to mitigate fatigue-related risk, resulting in enhanced flight safety, efficiency, productivity and operational flexibility, while satisfying the company’s duty of care to its employees and the public. An FRMS can also bring improved health and wellbeing benefits for employees.

Commonly FRMS include training and education, hours of work guidelines, policy, etc. Arguably, an effective FRMS needs to be more than this.
Overview of an FRMS

An FRMS is a set of management practices and procedures for predicting, managing and monitoring fatigue-related risk. An FRMS should be tailored to a specific organisation, taking into account its operations, size and complexity.

Figure 3 below summarises the structure of an FRMS. An effective FRMS should take a ‘systems-based’ approach to minimising fatigue-related incidents, including all the items listed.

Figure 3  Structure of a fatigue risk management system

The fatigue risk controls – the processes and procedures for identifying and managing fatigue-related risk – are at the core of an FRMS. Communication & consultation are essential to coordinating the FRMS. The policy and procedures document defines the framework and details individual responsibilities for the FRMS. Education and training ensures individual employees become competent in fatigue risk management. Evaluation and review measures FRMS effectiveness and provide recommendations for improvement. Record keeping provides evidence of fatigue risk management practices and is also an important element of the evaluation and review process. Audit practices assess operational compliance with the FRMS policy and procedures document.

Systems approach

As shown in Figure 4, an effective FRMS should take a ‘systems approach’ to minimising fatigue-related incidents.
At **level one**, organisations should provide sufficient sleep opportunity to all employees, and employees are responsible for using the sleep opportunity provided. This can be achieved through validated prescriptive duty time limitations, or fatigue modelling.

At **level two**, employees are responsible for obtaining sufficient sleep, and for reporting instances where that has not been possible.

At **level three**, organisations should train employees to recognise fatigue-related behavioural symptoms in themselves and others, and provide appropriate management strategies. Symptom monitoring should occur regardless of sleep opportunity and actual sleep obtained.

These levels describe a framework to reduce the likelihood an individual will be exposed to fatigue-related risk. Fatigue-related risk cannot be eliminated, but implementing mitigation strategies should reduce the likelihood of fatigue-related errors and incidents.

The final two levels in the diagram concern reporting, and analysing errors and incidents that may be fatigue-related.

**Figure 4  Fatigue risk management error trajectory**

---

**CASA's philosophy**

The Civil Aviation Safety Authority’s stance on fatigue management in Australia is about managing the risk of fatigue within a defined environment or work setting, and not simply about managing the work or flight and duty times of operational personnel. Each organisation and individual has a role to play in contributing to managing and mitigating the potentially hazardous effects of fatigue.

CASA’s focus is on scientific, evidence-based, fatigue risk management. As a result of ongoing participation in such research, CASA proposes to issue guidelines for fatigue risk management during 2009.

No-one is immune to fatigue. Establishing widespread preventative measures to combat fatigue is often very difficult to achieve. Both individuals and organisations sometimes ignore the problem until an incident or accident occurs. Even then, implementing lasting change is not guaranteed. Lifestyle changes are not easy
for individuals to make, particularly if that person is not in complete control of the situation. Commercial pilots, for example, have to contend with shift work and the disruption of their *Circadian rhythm.*

For pilots generally, busy lifestyles, commuting distances and family responsibilities may lead to fatigue. Pilots must make every effort to be fully aware of, and modify, personal lifestyle factors that may lead to fatigue.

**KEY POINTS**

This section has addressed the following key points:
- Fatigue is a threat to aviation safety because it can impair alertness and performance.
- Fatigue has been implicated in many aviation accidents.
- Many factors can contribute to fatigue. It is important for pilots to be able to monitor and identify the symptoms of fatigue not only in themselves, but in others.
- Individuals and organisations should adopt a risk-based approach to managing fatigue.

**RESOURCES**

**Further reading**


When you are ready, please turn to page 19 of the *Workbook for Pilots* and complete the exercises.
References


Chapter 3

Stress

In a safety critical environment such as aviation, stress can have both acute and long-lasting effects. Stress has been identified as a contributing factor in accidents, so the ability to recognise and manage your own stress and that of others is important. This section identifies some of the common causes of stress, discusses how to recognise symptoms and effects, and suggests coping strategies.
Stress

- Overview 38
- Workload: overload and underload 38
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- Stress and flying 41
- Causes and symptoms of stress 42
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“You’ve never been lost until you’ve been lost at Mach 3.”

Paul F. Crickmore
Table 7  Stress

<table>
<thead>
<tr>
<th>Category</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Identifying symptoms of stress</td>
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<td></td>
<td>Recognising effects of stress</td>
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<tr>
<td></td>
<td>Implementing coping strategies</td>
</tr>
</tbody>
</table>

OVERVIEW

Stress, a state of highly unpleasant emotional arousal associated variously with overload, fear, anxiety, anger and hostility - can threaten both individual performance and teamwork. It can quickly undermine the emotional climate in which a flight crew is operating.

Stress often arises as a result of a perceived gap between the demands of a situation and an individual’s ability to cope with these demands. As stress involves both perception and evaluation, it directly affects the cognitive and interpersonal skills which form the basis of good crew resource management (CRM).

Stress is a response to circumstances, leading to changes in a pilot’s mental and physical functioning. Stress forces the pilot to adapt to these changes. Stress is an inevitable and necessary part of life; up to a point, it adds motivation to life and heightens a pilot’s response to meet challenges. Performance of a task will generally improve with the onset of stress, but will peak and then begin to degrade rapidly as stress levels exceed a pilot’s ability to adapt and handle the situation.

WORKLOAD: OVERLOAD AND UNDERLOAD

Arousal and alertness are both necessary to enable individuals to achieve optimum performance in CRM-related skills, but too much or too little arousal will adversely affect a crew’s ability to function effectively as a team. Crew members therefore should not only be aware of the symptoms of stress in themselves and others, but also understand the effects stress can have on CRM, and to take counter measures where possible.

Factors determining workload

Operating an aircraft usually follows a fairly standard pattern and order of tasks. Some of these the flight crew control, while others are beyond their control. It is more difficult to assess how that work translates into workload.

Our mental capacity to deal with information is limited, as is our physical capacity - eyesight, strength, dexterity and so on. Therefore, workload reflects how far the demands of the work we have to do eats into our mental and physical capacities.

We all experience workload differently, and this experience is affected by:

- What’s being done:
  - physical demands (e.g. strength required.)
  - mental demands (e.g. complexity of decisions to be made)
- Where and when it’s being done
  - standard of performance required (i.e. degree of accuracy)
  - time available to accomplish the task (and thus the speed at which the task must be carried out)
- requirement to carry out the task at the same time as doing something else
- environmental factors existing at the time (e.g. extremes of temperature, etc.)
- The individuals concerned, and their
  - skills (both physical and mental)
  - experience (particularly familiarity with the task in question)
  - current health and fitness levels
  - emotional state (e.g. stress level, mood, etc.).

As the workload of the flight crew may vary, they may experience periods of overload and underload. This is a particular feature of some flights and sectors, but overloads are often unpredictable.

**Work overload**

Overload occurs at very high levels of workload, when the individual’s or crew’s workload exceeds the ability to cope well. As performance deteriorates when arousal becomes too high, we are forced to shed tasks and focus on key information. Error rates may also increase. Overload can occur for a wide range of reasons. It may happen suddenly (e.g. if you’re asked to remember something more, when you’re already trying to remember a lot of data), or gradually.

Try to plan tasks so that the flight crew are not left with several things to be done at once, possibly during the final stages of the approach. Task management between flight crew members can reduce the likelihood of one pilot being overloaded. In overload situations, be clear as to who is carrying out the vital task of actually flying the aircraft.

The case study below describes a situation where the flight crew were faced with a high workload due to a landing gear problem.

---

**Running on empty**

Flight 3378 departed Khania, Crete, Greece, at 10:59 for a flight to Hanover. The crew encountered problems raising the right hand main landing gear fully; however, they decided to continue the flight with the gear down and divert to München.

During the flight, the calculated spare fuel (EFOB) at Munich decreased on the FMS. The crew now decided to divert to Vienna-Schwechat Airport instead. Approaching Vienna it appeared that there was not enough fuel on board. At about 4000 ft and about 12 nm short of the runway, both engines quit. The crew were able to restart one engine briefly, managing to reach the airport. The aircraft landed in the grass some 500 m from the runway 34 threshold. The left main gear broke off and the no. 1 engine and wing sustained substantial damage as the aircraft slid for 600 m before coming to rest. The investigation found that the continuation of the flight with a landing gear problem until the engines failed due to fuel shortage caused the accident. A major contributing factor listed in the report was the flight crew’s failure to comply with the company’s rules on fuel reserves, caused by several human factors, the main ones being extreme workload and stress (loss of situational awareness).
**Work underload**

Underload occurs at low levels of workload (when the pilot is under stimulated). Underload can result from a task a pilot finds boring, or indeed a lack of tasks. The nature of routine flights means that workload tends to come at the start and finish of a flight, with long periods of low workload in the cruise. Hence, unless stimulating ‘housekeeping’ tasks can be found, underload can be difficult to avoid at times.

**INSIDE AND OUTSIDE THE COCKPIT**

Often stress in the cockpit is only considered in terms of cognitive stresses, such as a high mental workload, caused by piloting modern transport aircraft in congested airspace. This helps to perpetuate the myth that pilots can compartmentalise their professional and private lives, keeping the two separate. Any changes in personal circumstances such as divorce, marital separation, difficult family affairs or financial difficulties can bring stress and can form part of any pilot’s emotional ‘carry-on baggage’.

Flight crew are particularly susceptible to these stressors: such as, long periods away from home, and the feelings of job insecurity caused by regular medical and proficiency checks. In addition, there are constant commercial pressures, real or imagined, such as the need to stick to deadlines, be economically conscious, and always project the right ‘image’ to passengers and other operational staff. This cocktail of issues, when not dealt with properly can lead to job dissatisfaction, reduced work effectiveness, behavioural changes, health damage, and in some cases, depression.

To complicate matters further, admitting to suffering from these stresses is often viewed by peers and society at large as an admission of weakness or failure. Therefore, early telltale symptoms such as depression or sleep disruption are often denied by the individual, who can resort to aggressiveness, or drug or alcohol abuse, as an unhealthy means of coping with stress.

Such behaviour generally further reduces performance and has severe career implications. Therefore, it is important that both individual flight crew and company management are aware of this potential problem, and the effects it can have on operational performance.

**Domestic stress**

Pre-occupation with a source of domestic stress can play on one’s mind during the working day, distracting from the working task. Inability to concentrate fully may affect task performance and the ability to pay due attention to safety. Domestic stress typically results from major life changes at home: such as marriage, the birth of a child, a son or daughter leaving home, the bereavement of a close family member or friend, marital problems, or divorce.

**Work-related stress**

Aviation personnel can experience stress because of their job, or because of the general organisational environment. Carrying out particularly challenging or difficult tasks can cause stress. This stress can be increased by a lack of standard operating procedures (SOPs) in the organisation, or time pressures.

The latter type of stress can be reduced by careful workload management, and good training, for example. Within the organisation, the social and managerial aspects of work can be stressful. Pilots whose jobs
are under threat due to a company re-organisation, for instance, are likely to have an increased level of background stress which, when combined with task or domestic stresses, may not be conducive to safe operations.

**STRESS AND FLYING**

Stress creates a special kind of problem for flight crew since its effects are often subtle and difficult to assess. Although any kind of emergency situation generates stress, crew members may bring physical and mental stress to the job. These demands on a pilot can range from encountering unexpected windshear on landing, to a lost wallet.

Studies have shown that emotional factors, mental upsets and psychological maladjustments are repeatedly present in aircraft accidents. Our ability to think clearly and act decisively is greatly influenced by our feelings and emotions. Everyone will panic more readily if they are suffering from fatigue, illness, worry or anger. Good judgment is seriously impaired under stress.

**Fitness to fly**

Healthy pilots should perform at their optimum level and make decisions to the best of their ability. Numerous physical and physiological conditions in pilots' personal and professional lives, as well as the nature of flight itself, can hamper this ability. Even though pilots hold a medical certificate stating that they meet the health requirements for a particular type of flight operation, the decision whether the pilot is fit to fly is strictly the pilots'.

Fitness to fly is not just a physical condition, but has a psychological side as well. This is the ability of pilots to perceive, think and act to the best of their ability without the hindering effects of anger, worry and/or anxiety.

Stress management skills not only involve your ability to perceive and accommodate stress in others, but above all, to anticipate, recognise and cope with your own stress. This includes psychological work stresses related to scheduling and rostering; anxiety over training courses and checks; career and achievement stresses; interpersonal problems with both cabin crew and other flight crew. Then there are domestic problems (family health, children's education, etc.), and so-called 'life event' stresses: the death of a spouse, divorce, or marriage, all of which represent major life changes.

**Stress in the cockpit**

Many factors contribute to stress in the cockpit. These generally fall into three categories: physical, physiological or psychological.

- Physical stressors, such as: extreme temperature and humidity, noise, vibration, lack of oxygen
- Physiological stressors, such as: fatigue, poor physical condition, hunger, disease
- Psychological stressors: emotional factors such as a death or illness in the family, business worries, poor interpersonal relationships with family or boss, financial worries.

Pilots must be able to recognise when stress levels are getting too high. If you are suffering from domestic stress, if you are undergoing divorce or separation, if you have suffered bereavement, if an argument with your spouse or your boss is still rankling, if worries are building up to an unbearable load, if you have been despondent and moody, the cockpit of your aircraft is probably no place for you.
Stress levels do build up in the cockpit, generated by the multitude of decisions to make and tasks to perform. This stress is not always negative, as the sympathetic nervous system responds, providing the resources to cope with any new and sudden demands.

However, stress may easily become unmanageable, and pilots need to learn how to reduce or prevent those stress factors they can control.

Maintaining good physical fitness and bodily function; engaging in a program of regular physical exercise; getting enough quality sleep to prevent fatigue; eating a well balanced diet; learning and practising relaxation techniques, all help to control physiological stresses. A conscious effort to avoid stressful situations and encounters helps to minimise the psychological stressors.

**Relationship of stress with accidents**

Aviation accidents often occur when flying task requirements exceed a pilot's capabilities. There is an old saying in aviation

> ‘A superior pilot uses superior judgement to avoid stressful situations which might call for use of superior skills’

The margin of safety is the difference between pilot capabilities and task requirements.

An approach under ideal conditions may provide a sufficient margin of safety. However, if a pilot is cold, stressed, or fatigued, this may reduce the safety margins. Stress, real or perceived, can lead pilots to make less-than-ideal judgements, which translates to poor decisions.

**Decisions under time pressure with high risk**

Performance under time pressure will be affected primarily by an individual’s training and experience. Considerable research has found that more experienced pilots make the right decision under stress more often than inexperienced pilots. Their experience enables individuals to locate vital cues and act on them.

Knowing how to respond in an emergency and the capacity to act in a timely manner obviously increases the likelihood of a correct response. Stress research has found that people under stress tend to make premature hypotheses, based only on the information originally available at the onset of the situation, or is subsequently easy to obtain. There is a finite information process capacity available in novel situations.

**CAUSES AND SYMPTOMS OF STRESS**

Stress can result from a one-off stimulus (such as a challenging problem or a punch on the nose), or an ongoing factor (such as an extremely hot hangar, chronic illness or ongoing lower back pain for example). The one-off stressors tend to lead to acute stress (typically intense but of short duration) and the ongoing to chronic stress (frequent recurrence or of long duration) respectively.
Characteristics of stress

Stress is often described as being insidious
In other words, it has a gradual and cumulative effect, developing so slowly that stress can be well established before becoming apparent. Pilots may think that they are handling everything quite well, when in fact there are subtle signs that they have gone beyond their ability to respond appropriately.

Stress is cumulative
A generalised stress reaction can develop as a result of accumulated stress. There is a limit to a pilot's adaptive nature - the stress tolerance level - based on a pilot's ability to cope with the situation. If the number or intensity of the stress factors becomes too great, you are susceptible to an environmental overload, and at this point, performance begins to decline and judgement deteriorates.

Stressors
Different stressors affect different people to varying extents. Stressors may be:
- Physical - such as heat, cold, noise, vibration, presence of something damaging to health (e.g. carbon monoxide), the onset of fatigue
- Psychological - such as emotional upset (e.g. due to bereavements, domestic problems, etc.), worries about real or imagined problems (e.g. due to financial problems, ill health, etc.)
- Reactive - such as events occurring in everyday life (e.g. working under time pressure, encountering unexpected situations, etc.).

Common stress factors applicable to pilots:
- Medicals
- Check-rides
- Conflict
- Illness
- Pay
- Noise and vibration
- Time schedules
- Passengers
- Dehydration
- Temperature and humidity
- Diet
- Poor visibility
- Altitude changes
- Confined space
- Fatigue
- Poor visibility

Signs of stress

Table 8  Symptoms of stress

<table>
<thead>
<tr>
<th>Area</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiological</td>
<td>Cardiovascular, gastrointestinal, respiratory, sleep disturbance, migraines, muscular tension, low-grade infections, sweating, dryness of the mouth, nausea, headaches, gastric ulcers, shaking</td>
</tr>
<tr>
<td>Psychological</td>
<td>Anxiety, uneven temper, loss of interest, poor self-esteem, feelings of loss of control, irritability, depression, moodiness, aggression</td>
</tr>
<tr>
<td>Cognitive</td>
<td>Difficulties in concentrating, omissions, errors, slowness, poor judgement, poor memory, reduced vigilance and attention</td>
</tr>
<tr>
<td>Behavioural</td>
<td>Loss of motivation, tendency to skip items and look for short cuts, easily distracted, slowness or hyperactivity, restlessness, taking longer to perform tasks, nervous laughter, changes to appetite, excessive drinking</td>
</tr>
</tbody>
</table>
Consequences for pilots
Stress can degrade pilot performance and directly compromise safety. Too much stress or too little (boredom) leads an individual to become distressed or complacent, and it could lead to:

- Eroded judgement
- Compromise or acceptance of lower performance levels
- Inattention
- Loss of vigilance and alertness
- Preoccupation with a single task; fixation on one instrument or procedure
- Forgetting or omitting procedural steps
- Greater tendency toward spatial disorientation and misperceptions
- Misreading charts or checklists
- Misjudgement of distance or altitude
- Loss of time perception
- Loss of situational awareness

Managing Stress

In high-pressure situations, stress can be relieved by establishing priorities as a single pilot or if possible, by delegating tasks to other members of the crew or other resources (e.g. passengers). However, this technique can be successfully implemented only if an organisational culture exists which empowers subordinates by training them in the appropriate skills to enable them to take on additional responsibility when needed.

In a low-pressure situation, where fatigue, boredom and over-familiarity with the task are the greatest hazards, careful attention to environmental conditions such as heat, humidity noise, vibration and lighting can help to maintain alertness. Individual crew members can help to ensure that they are best able to contribute to the team effort when the need arises by keeping fit and maintaining a healthy lifestyle, in so far as the demands of the job allow.

Coping strategies

Once we become aware of stress, we generally respond to it by using one of two strategies: defence or coping. Defence strategies involve alleviation of the symptoms (taking medication, alcohol, etc.) or reducing the anxiety (e.g. denying to yourself that there is a problem, or blaming someone else).
Coping strategies involve dealing with the source of the stress rather than merely the symptoms (e.g. delegating workload, prioritising tasks, sorting out the problem). When ‘coping’, the individual either adjusts to the perceived demands of the situation, or changes the situation itself.

Unfortunately, sometimes the problem is outside the control of the individual (such as during an emergency), but there are well-published techniques for coping with stress. Good stress management techniques include:

- Relaxation techniques
- Careful regulation of sleep and diet
- Regular physical exercise
- Counselling—ranging from talking to a supportive friend or colleague to seeking professional advice.

**Life stress management**

There are many techniques available to help reduce the stress in your life or help you cope with it better. Some of the following may be effective:

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Practical examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Become knowledgeable about stress</td>
<td>Further reading and/or complete a course in stress management and/or a personality profile</td>
</tr>
<tr>
<td>Make a realistic assessment of yourself</td>
<td>Use a self check quiz—see workbook</td>
</tr>
<tr>
<td>Take a systematic approach to problem solving</td>
<td>Use of decision making aids—see workbook sections (situational awareness, decision making and airmanship)</td>
</tr>
<tr>
<td>Develop a lifestyle that will buffer against the effects of stress</td>
<td>Identify potential sources of stress to reduce their effects</td>
</tr>
<tr>
<td>Practise behavioural management techniques</td>
<td>Recognise your own personal symptoms of stress</td>
</tr>
<tr>
<td>Establish and maintain a strong support network</td>
<td>Use a mentor, peers and/or family to provide you with feedback and to help you to better manage stress</td>
</tr>
</tbody>
</table>

**Cockpit stress management**

Good cockpit stress management begins with good life stress management. Many of the stress-coping techniques practised for life stress management are not usually practical in flight. Rather, you must condition yourself to relax and think rationally when stress appears.

Managing cockpit stress:

- Avoid situations that distract you from flying the aircraft.
- Reduce your workload to reduce stress levels. This will create a proper environment in which to make good decisions.
- If an emergency does occur, be calm. Think for a moment, weigh the alternatives, then act.
- Maintain proficiency in your aircraft; proficiency builds confidence. Familiarise yourself thoroughly with your aircraft, its systems, and emergency procedures.
Know and respect your own personal limits.
Do not let little mistakes distract you. Wait until after you land, then ‘debrief’ and analyse past actions.
If flying is adding to your stress, either stop flying or seek professional help to manage your stress within acceptable limits.

FLIGHT FITNESS TEST
A ‘Go/No-Go’ decision is made before each flight. Pilots should not only pre-flight check the aircraft, but also themselves on each and every flight.

Before every flight, you should ask, ‘Could I pass my medical examination right now?’ If you cannot answer with an absolute ‘Yes,’ then the reality is, you should not fly.

Several studies over the past few years have examined whether some particular stress factors are more likely than others to precipitate an aircraft accident. Robert Alkov, an aviation psychologist, studied flight-related mishaps in the US Navy during the early 1980s. Alkov investigated the psychological background of over 500 US Navy flight crew members involved in aircraft incidents or accidents.

The study showed that various situational factors, such as recently getting engaged, or being involved in disputes with loved ones, peers or authority, significantly pre-disposed aircrew to involvement in accidents where human error was a contributory factor. While his findings indicated that there are substantial differences in the ability of pilots to cope with stress, the study concluded that many of the errors committed by flight crew were symptoms of inadequate stress-coping behaviour.

Alkov based his study on work conducted by two psychiatrists, Dr Thomas Holmes and Dr Richard Rae, who created the SRRS (Social Readjustment Rating Scale) - a list of 43 events that can cause stress. These were ranked in order of the impact they may have on a person’s life with a severity level (and stress points) assigned to each event. Holmes and Rae suggested that any stressful events could be linked with higher chances of illness and indeed their research found that many diseases in their patients were linked with changes in life events.

If you hope to succeed at reducing stress associated with crisis management in the air or with your job, it is essential to begin by making a personal assessment of stress in all areas of your life. You may face major stressors such as a loss of income, serious illness, death of a family member, change in residence, or birth of a baby, plus a multitude of comparatively minor positive and negative stress factors. These major and minor factors have a cumulative effect which constitutes your total stress-adaption capability. These can vary from year to year.

KEY POINTS
This section has addressed the following key points:

- People working within safety critical environments can be affected by both acute and chronic stress.
- Stress can be associated both with work overload and work underload.
- A failure to cope with stressors can result in errors, which may lead to accidents.
- The ability to recognise and manage stress in yourself and others is an important human factors skill.
- There are methods to manage and cope with stress that all people should be aware of.
RESOURCES

Further reading


References


Chapter 4

Alcohol and other drugs (AOD)

The use of alcohol and other drugs (AOD) can have a detrimental impact on aviation safety. The pilot’s critical cognitive and psychomotor functions necessary for the safe operation of an aircraft can be affected. This section discusses the effects of alcohol and other drugs, risk factors and symptoms of AOD use. Information is also included on CASA’s AOD Program which includes a random testing regime and drug and alcohol management plans (DAMPs).
Alcohol and other drugs (AOD)

- Overview
- AOD consumption and the workplace
- AOD in aviation
- Occurrences involving AOD use in Australia
- AOD testing of safety-sensitive personnel in Australia
- CASA alcohol and other drugs program
- The CASA AOD initiative—program design
- Testing procedure for alcohol and other drugs
- Key points
- Resources

“Never fly in the same cockpit with someone braver than you.”

Richard Herman Jr, in Firebreak
Table 10  Alcohol and other drugs

<table>
<thead>
<tr>
<th>Category</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol and Other Drugs (AOD)</td>
<td>Recognising the effects of AOD use</td>
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<tr>
<td></td>
<td>Identifying risk factors and symptoms of AOD use</td>
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<tr>
<td></td>
<td>Implementing strategies to maintain fitness for duty</td>
</tr>
<tr>
<td></td>
<td>Awareness of AOD testing</td>
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</tbody>
</table>

OVERVIEW


Introduction

The most common drugs used by Australians are alcohol, coffee, nicotine and various medications. Illegal drugs such as cannabis (marijuana), ecstasy, heroin and methamphetamines (speed) are less commonly used.

What is a drug?

A drug is any substance - solid, liquid or gas - that brings about physical and/or psychological changes. The drugs of most concern in the community are those affecting the central nervous system. These drugs - known as ‘psychoactive drugs’ - act on the brain to change the way a person thinks, feels or behaves.

How are drugs classified?

Drugs are commonly classified according to their legal status or their effects on the central nervous system.

Legal drugs:

Laws and regulations control the availability, quality and price of ‘legal’ drugs. For example, tobacco may not be sold to persons under the age of 18.

Illegal drugs:

Because they are illegal, there are no price or quality controls on illicit drugs. PMA (paramethoxyamphetamine), a toxic form of amphetamine, has been sold as ecstasy. A user of illegal drugs also cannot be sure of a drug’s strength or purity. Different batches of an illegally manufactured drug may have different mixtures of the drug and additives such as poisons, caffeine or even talcum powder.

Central nervous system

Three main types of drug affect the central nervous system: depressants, stimulants and hallucinogens.

Depressants slow down the functions of the central nervous system and do not necessarily make a person feel depressed. Depressants include:

- Alcohol
- Cannabis
- Barbiturates, including Seconal, Tuinal and Amytal
- Benzodiazepines (tranquilisers), such as Rohypnol, Valium, Serepax, Mogadon, Normison and Eupynos
GHB (Gamma-hydroxybutrate), or ‘fantasy’
Opiates and opioids, including heroin, morphine, codeine, methadone and pethidine
Some solvents and inhalants found in household products.

Depressants in small quantities can cause the user to feel more relaxed and less inhibited. However, depressants in larger quantities can cause unconsciousness, vomiting and even death. Depressants affect a person’s concentration and coordination by slowing down their ability to respond to unexpected situations.

Stimulants act on the central nervous system to speed up the messages to and from the brain.
Stimulants can make the user feel more awake, alert or confident. Other effects include increased heart rate, body temperature and blood pressure, reduced appetite, dilated pupils, talkativeness, agitation and sleep disturbance.

Mild stimulants include:
- Ephedrine: used in medicines for bronchitis, hay fever and asthma
- Caffeine: in coffee, tea and cola drinks
- Nicotine: in tobacco.

Strong stimulants include:
- Methamphetamines, including illegal methamphetamines
- Cocaine
- MDMA/ecstasy
- Slimming tablets such as Duromine, Tenuate Dospan and Ponderax.

Large quantities of stimulants can ‘over-stimulate’ the user, causing anxiety, panic, seizures, headaches, stomach cramps, aggression and paranoia. Prolonged use of strong stimulants can mask some of the effects of depressant drugs such as alcohol, making it difficult for a person to judge their effects.

Hallucinogens affect perception. People using hallucinogens may believe they see or hear imaginary things, or what they see may be distorted in some way. The effects of hallucinogens vary a great deal, so it is impossible to predict how they will affect a particular person at a particular time. Hallucinogens include:
- Datura
- Ketamine
- LSD
- ‘Magic mushrooms’
- Mescaline

Cannabis is an hallucinogen as well as a depressant. Ecstasy can also have hallucinogenic qualities. Some effects of hallucinogens include dilation of pupils, loss of appetite, increased activity, talking or laughing, emotional and psychological euphoria and well-being, jaw clenching, sweating, panic, paranoia, loss of contact with reality, irrational or bizarre behaviour, stomach cramps and nausea.
How do drugs affect a person?
The effects of a drug depend on:
- How much of the drug is taken and how often
- How the drug is taken
- A person’s physical characteristics, such as height, weight and sex
- The person’s mood and their environment
- Tolerance to the drug
- Other drugs used (poly drug use).

Alcohol

What is alcohol?
The term ‘alcohol’ describes a series of organic chemical compounds. One type, ethyl alcohol or ethanol, is found in drinks intended for human consumption. Alcohol, a depressant, primarily affects the central nervous system. The stages of alcohol intoxication are summarised in Table 11. The degree to which the central nervous system function is impaired, is directly proportional to the concentration of alcohol in the blood.

Breath alcohol concentration depends on the amount of alcohol consumed and the rate at which the user’s body metabolises alcohol. Because the body metabolises alcohol at a fairly constant rate (somewhat more quickly at higher and lower alcohol concentrations), ingesting alcohol at a rate higher than the rate of elimination results in a cumulative effect and an increasing breath alcohol concentration.
### Table 11  Stages of alcohol intoxication

<table>
<thead>
<tr>
<th>BAC (g/100 ml of blood or g/210 l of breath)</th>
<th>Stage</th>
<th>Clinical symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 - 0.05</td>
<td>Subclinical</td>
<td>Behaviour nearly normal by ordinary observation</td>
</tr>
</tbody>
</table>
| 0.03 - 0.12                                | Euphoria | • Mild euphoria, sociability, talkativeness  
• Increased self-confidence; decreased inhibitions  
• Diminution of attention, judgement and control  
• Beginning of sensory-motor impairment  
• Loss of efficiency in finer performance tests |
| 0.09 - 0.25                                | Excitement | • Emotional instability; loss of critical judgement  
• Impairment of perception, memory and comprehension  
• Decreased sensory response; increased reaction time  
• Reduced visual acuity; peripheral vision and glare recovery  
• Lack of sensory-motor coordination; impaired balance  
• Drowsiness |
| 0.18 - 0.30                                | Confusion | • Disorientation, mental confusion; dizziness  
• Exaggerated emotional states  
• Disturbances of vision and of perception of colour, form, motion and dimensions  
• Increased pain threshold  
• Decreased muscular coordination; staggering gait; slurred speech  
• Apathy, lethargy |
| 0.25 - 0.40                                | Stupor | • General inertia; approaching loss of motor functions  
• Markedly decreased response to stimuli  
• Marked decrease in muscular coordination; inability to stand or walk  
• Vomiting; incontinence  
• Impaired consciousness; sleep or stupor |
| 0.35 - 0.50                                | Coma | • Complete unconsciousness  
• Depressed or abolished reflexes  
• Subnormal body temperature  
• Incontinence  
• Impairment of circulation and respiration  
• Possible death |
| 0.45 +                                    | Death | • Death from respiratory arrest |

### How long does it take for alcohol to be eliminated from the body?

The rate at which alcohol is eliminated from the body differs for men and women, and depends on the number of drinks consumed, and the time over which drinking occurs (Figure 1). The calculations refer to standard drinks - a standard drink being any drink containing 10 grams of alcohol. One standard drink always contains the same amount of alcohol regardless of container size or alcohol type (beer, wine, or spirit).
Examples of typical drinks, expressed as standard drinks are:

- One can or stubby (375 ml) low-strength beer = 0.8 standard drink
- One can or stubby (375 ml) mid-strength beer = 1 standard drink
- One can or stubby (375 ml) full-strength beer = 1.5 standard drinks
- One average glass (180 ml) of wine = 1.8 standard drinks
- One nip (30 ml) of spirits = 1 standard drink
- One can (375 ml) of pre-mixed spirits = 1.5–2.5 standard drinks.

**Figure 5** Hours required to return breath alcohol concentration (BAC) to zero

![Graph showing BAC over time for different scenarios](image)

(Source: Centre for Accident Research and Road Safety, Queensland University of Technology).

The observations in Figure 5 are quite enlightening. Regulation 256 of the Civil Aviation Regulations 1988 (CAR) prohibits the consumption of alcohol by aircraft crew and air traffic controllers while on duty and for eight hours before duty, and precludes them from carrying out duties while affected by alcohol. However, as can be seen from Figure 5, it may take longer than eight hours for the BAC to return to a permitted level (in Australia - a concentration of less than 0.02 grams of alcohol in 100 ml of blood or a concentration of less than 0.02 grams of alcohol in 210 litres of breath).

**Alcohol content**

Table 12 shows that some drinks are more potent than others.
### Table 12  Alcohol content of some typical drinks

<table>
<thead>
<tr>
<th>Drink</th>
<th>Alcohol content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manhattan</td>
<td>1.15 fl oz. (34 ml)</td>
</tr>
<tr>
<td>Dry Martini</td>
<td>1.00 fl oz. (30 ml)</td>
</tr>
<tr>
<td>Malt liquor - 12 oz. (355 ml)</td>
<td>0.71 fl oz. (21 ml)</td>
</tr>
<tr>
<td>Airline/hotel miniature</td>
<td>0.70 fl oz. (21 ml)</td>
</tr>
<tr>
<td>Whiskey Sour/Highball</td>
<td>0.60 fl oz. (18 ml)</td>
</tr>
<tr>
<td>Table wine - 5 oz. (148 ml)</td>
<td>0.55 fl oz. (16 ml)</td>
</tr>
<tr>
<td>Beer - 12 oz. (355 ml)</td>
<td>0.54 fl oz. (16 ml)</td>
</tr>
<tr>
<td>Reduced alcohol beer</td>
<td>0.28 fl oz. (8 ml)</td>
</tr>
</tbody>
</table>

Mixed drinks are based on typical drink recipes using 80 proof liquor. The amount of alcohol in actual mixed drinks may vary.

Table 13 shows the alcohol content of selected beverages.

### Table 13  Alcohol content (in percent) of selected beverages

<table>
<thead>
<tr>
<th>Beverage</th>
<th>Alcohol content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beers (lager)</td>
<td>3.2 - 4.0</td>
</tr>
<tr>
<td>Ales</td>
<td>4.5</td>
</tr>
<tr>
<td>Port</td>
<td>6.0</td>
</tr>
<tr>
<td>Stout</td>
<td>6.0 - 8.0</td>
</tr>
<tr>
<td>Malt liquor</td>
<td>3.2 - 7.0</td>
</tr>
<tr>
<td>Sake</td>
<td>14.0 - 16.0</td>
</tr>
<tr>
<td>Table wines</td>
<td>7.1 - 14.0</td>
</tr>
<tr>
<td>Sparkling wines</td>
<td>8.0 - 14.0</td>
</tr>
<tr>
<td>Fortified wines</td>
<td>14.0 - 24.0</td>
</tr>
<tr>
<td>Aromatised wines</td>
<td>15.5 - 20.0</td>
</tr>
<tr>
<td>Brandies</td>
<td>40.0 - 43.0</td>
</tr>
<tr>
<td>Whiskies</td>
<td>40.0 - 75.0</td>
</tr>
<tr>
<td>Vodkas</td>
<td>40.0 - 50.0</td>
</tr>
<tr>
<td>Gin</td>
<td>40.0 - 48.5</td>
</tr>
<tr>
<td>Rum</td>
<td>40.0 - 95.0</td>
</tr>
<tr>
<td>Aquavit</td>
<td>35.0 - 45.0</td>
</tr>
<tr>
<td>Okolehao</td>
<td>40.0</td>
</tr>
<tr>
<td>Tequila</td>
<td>45.0 - 50.5</td>
</tr>
</tbody>
</table>

The alcohol concentration in drinks may slightly affect the peak alcohol concentration in the blood due to different absorption rates for different alcohol concentrations. Alcohol is most rapidly absorbed when the alcohol concentration of the drink is between 10 and 30 per cent.
After effects
In addition to the eight-hour-rule and BAC, pilots must also be aware of the less-publicised after effects of alcohol – for example fatigue, nausea, disorientation and headache. While the consequences of excessive alcohol intake on performance are well known, most people are less aware that performance can be impaired long after the blood alcohol concentration returns to zero.

Alcohol and safety
Alcohol is a depressant drug, even though it may feel stimulating at first. Within minutes of drinking alcohol, some alcohol is absorbed into the bloodstream. The rate of absorption is affected by different factors, for instance eating slows alcohol absorption. Even a small amount of alcohol affects decision-making skills. The following case studies demonstrate the consequences of alcohol consumption.

Case study: Bad weather, dark night, a few drinks … tragic decision
The president and an instructor of a local aero club died when their microlight aircraft crashed. The two aviators took off from the airfield just after 0300 UTC in an Air Sea 601. A third man who stayed at the airfield raised the alarm at about 0430 when the aircraft failed to return.

The three men had been drinking at a party before deciding to take the flight in difficult weather conditions that included heavy showers, lightning and patches of fog.
Can’t talk, can’t walk … but did fly
A DC-8 had been cleared for departure on runway 24L. The crew attempted to taxi to the runway in thick fog, but ended up on runway 24R. The crew then taxied to runway 24L with directions from the control tower. Just after lift off, the DC-8 stalled and crashed 300m past the runway.

The investigation found the probable cause of the accident was: ‘A stall that resulted from the pilot’s control inputs, aggravated by airframe icing while the pilot was under the influence of alcohol. Contributing to the cause of this accident was the failure of the other flight-crew members to prevent the captain from attempting the flight.’

Opportunity missed
The captain’s initial blood alcohol level was 298 mg per cent. A blood alcohol level of 100 mg per cent was considered to be legally intoxicating for drivers in the State of Alaska.

What makes this accident all the more tragic was that there were opportunities to detect and prevent the captain from flying the aircraft.

The flight crew was wakened about 0330, left the hotel by taxi about 0430, and arrived at the dispatch office about 0500. The taxi driver stated that he became concerned by the captain’s actions in the taxi and called his dispatcher to report his impressions. He stated that the captain’s movements were uncoordinated, jerky and unstable, his face was flushed, his eyes were glazed; and his conversation was garbled and incoherent. He had trouble getting out of the cab and had to steady himself on the car door. When this was reported to the airline, the observation was dismissed with the comment that nobody noticed anything amiss at the airline dispatch office.

Alcohol reduces reaction time. Thus driving, using machinery, or undertaking activities such as swimming, even after a small amount of alcohol, is dangerous. Females have less water in their bodies than males to dilute the alcohol. This is one of the reasons women feel the effects of alcohol more quickly than men.

The use of alcohol with other drugs - whether illicit, prescribed or over the counter - can be dangerous and the results unpredictable. A pharmacist or doctor is in the best position to offer sound and knowledgeable advice on the interaction between different drugs and how this interaction might impact on your health and capacity to undertake different tasks.

Long- and short-term effects of alcohol
The consumption of alcohol has health, social and economic costs and benefits, for both individuals and the population as a whole. People who drink small quantities have better health outcomes than those who do not drink, although abstainers achieve very much better health outcomes than heavy drinkers. There are many valid, and often compelling, health and social reasons why people choose not to drink.

The harmful effects of high levels of consumption far outweigh its benefits. The higher the consumption, the greater the costs both to individual health and society.
Short-term effects:
- Feeling of relaxation
- Reduced concentration
- Slowed reflexes
- Fewer inhibitions and increased confidence
- Reduced coordination
- Slurred speech
- More intense moods (e.g., feeling sad, happy, angry)
- Confusion
- Blurred vision
- Poor muscle control
- Nausea and vomiting
- Drowsiness
- Coma
- Death.

Long-term effects:
- Malnutrition
- Depression and anxiety
- Cancer of the mouth, throat, oesophagus, lips and liver
- Brain injury, loss of memory, confusion, hallucinations
- High blood pressure, irregular pulse, enlarged heart
- Weakness and loss of muscle tissue
- Sweating, flushing and bruising of the skin
- Inflamed stomach lining, ulcers
- Increased risk of lung infections
- Severe swelling of the liver, hepatitis and cirrhosis
- Inflamed pancreas
- Tingling and loss of sensation in hands and feet
- Impotence, shrinking of testicles and damaged/reduced sperm
- Increased risk of gynaecological problems.

**AOD CONSUMPTION AND THE WORKPLACE**

Alcohol consumption patterns found in the community are likely to be similar in the workplace. As the majority of Australians who use alcohol or illicit drugs are employed, it should come as no surprise that patterns of harmful use of alcohol and illicit drugs are evident in the Australian workforce. Harmful alcohol and illicit drug use is found at all levels in an organisation.

Workers employed in some industries and occupations - for example tradespersons, farm managers, labourers, hospitality industry workers and agricultural industry workers - report high levels of alcohol or drug consumption. Some drivers in the transport industry report using methamphetamines to ‘stay awake’. Nurses
and others in health-related occupations are more likely to misuse pharmaceuticals than employees in other occupations.

**Risk factors**

The differences in alcohol and illicit drug consumption patterns between industries and occupations indicate that workplace environmental and cultural factors may influence consumption patterns. Research indicates the following factors may contribute to employees' alcohol or other drug use:

The physical environment of the workplace:
- Hot or dusty conditions
- Hazardous or dangerous work
- Inadequate training
- Poor-quality equipment
- Lack of appropriate resources.

Availability:
- Availability of alcohol and other drugs at the worksite
- Social and peer pressure to drink on site
- Demands of the job (e.g. socialising with clients)
- Lack of clear alcohol and other drug policies.

Stress, resulting from:
- Poor or volatile industrial relations climate
- Lack of control over the planning or pace of work
- Heavy responsibility
- Unrealistic performance targets and deadlines
- Over work/under work
- Fear of retrenchment
- Workplace bullying/harassment.

Characteristics of the job:
- Extended or excessive hours
- Shiftwork
- Low visibility/working away from the workplace
- Boring, repetitive, or monotonous work
- Lack of job security
- Low job satisfaction
- Poor promotion opportunities
- Level of income.

Management style:
- Absence of clear goals
- Lack of supervision
- Lack of accountability
- Poor feedback on performance
- Lack of or inconsistent performance standards.

**Impact of AOD on the workplace**

Alcohol and other drug use can have a substantial negative impact on the workplace. For example, studies show that lost production from harmful alcohol and other drug use costs Australian industry more than $4.5 billion each year. Research in 2003 indicated that up to 15 per cent of all Australian workplace accidents and at least five per cent of all Australian workplace deaths may be associated with alcohol use.
Alcohol and other drug use has a variety of negative outcomes that are costly for both employers and employees, including:

**Accident costs:**
- Accidents resulting in injury or death
- Lost employee work time
- Damage to tools and equipment (repair costs)
- Increased insurance costs and/or WorkCover levy
- Possible bad publicity
- Reduced productivity - lower quantity and quality of work
- Loss of business
- Loss of skills when an employee is terminated/injured/ill
- Co-workers covering for affected employees
- Costs associated with prosecution.

**Absenteeism costs:**
- Lost production
- Disruption of operations
- Covering for absent employee.

**Staff turnover costs:**
- Costs of dismissal or premature retirement
- Replacement of employees
- Training of new employees
- Loss of skills and experience
- Loss of investment in employees.

**Cost to the individual employee:**
- Possible injury to self and others
- Demotion/discipline/dismissal
- Problems with family, friends and workmates
- Loss of self-esteem
- Loss of wages
- Cost of medical expenses.

**Costs to other employees:**
- Unsafe work environment with risk of accidents
- Covering for poor work performance
- Disputes
- Reduced morale
- Embarrassment if forced to ‘dob in a mate’.

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**AOD IN AVIATION**

In a safety critical environment such as flying, optimal performance is required for safe operations. Safe flying performance requires a high level of cognitive function and psychomotor skill. Any substance that impairs these functions and skills presents a threat to flight safety. Consumption of alcohol and drugs by pilots is therefore a major potential risk to flight safety.

**Human performance effects of alcohol**
- Poor human performance is known while the person is under the influence of alcohol or after the return of BAC to zero.
- Pilots under the influence of alcohol - regardless of individual flying experience - have impaired ability to fly an ILS approach or to fly IFR, or even to perform routine VFR flight tasks.
- The number of serious errors committed by pilots dramatically increases at or above concentrations of 0.04 per cent blood alcohol. Studies have shown reduced performance by pilots with blood alcohol concentrations as low as 0.025 per cent.
- Even after complete elimination of all of the alcohol in the body, undesirable side effects – most notably a hangover - can last for 48-72 hours.
- The majority of adverse effects produced by alcohol relate to the brain, eyes, and inner ear - three crucial organs for pilots.
Brain effects include impaired reaction time, reasoning, judgment, and memory loss. Alcohol decreases the ability of the brain to use oxygen. This adverse effect can be magnified by simultaneous exposure to altitude (decreased partial pressure of oxygen).

Visual symptoms include eye muscle imbalance, which leads to double vision and focus difficulties.

Inner ear effects include dizziness and decreased hearing perception.

These negative effects are significantly magnified when other variables are added - sleep deprivation, fatigue, medication use, altitude hypoxia, flying at night, or in bad weather.

The following information is taken directly from an ATSB research report into alcohol and human performance. Consider the adverse human performance effects of alcohol on flying and just how much of an impact these effects either alone, or in combination, could have on the safe operation of your aircraft.

Alcohol has widespread general effects on human behaviour and performance. In simple terms, alcohol impairs human performance. It has detrimental effects on cognitive functions and psychomotor abilities. Risk-taking behaviour may result, and a full appreciation of the consequences of a planned action may not be possible. Adverse effects can also persist the day after alcohol ingestion, with reductions in alertness, concentration and vestibuloocular function, and increases in anxiety all being reported.

Almost all forms of cognitive function have been shown to be affected adversely by alcohol. Alcohol affects information processing, memory, verbal skills, reaction times, attention, vigilance, perception and reasoning tasks. All of these cognitive functions are required for tasks such as driving and flying.

Alcohol has a particularly serious effect on information processing and memory, particularly working or short-term memory. Alcohol has been shown to impair registration, recall, and organisation of information, leading to increased reaction times and/or a greater number of errors. Alcohol interferes with the integration of incoming information, and this has been suggested as the mechanism underlying alcoholic amnesia.

Alcohol also significantly impairs attention, especially in terms of tasks requiring sustained, selective or divided attention. Alcohol at a BAC of 0.015 per cent has been shown to cause impairment of performance at tasks requiring division of attention, such as monitoring two channels of information simultaneously.

Psychomotor performance is also adversely affected by alcohol, in a dose-dependent way. Even low levels of alcohol have been shown to cause impaired psychomotor performance, particularly on tracking tasks. It is well-known that skill-based psychomotor tasks such as driving are impaired by low doses of alcohol.

In light of these findings, it is little surprise that alcohol has been shown to have its greatest performance-impairing effect on demanding and complex cognitive tasks … a consistent finding in the research literature is that subjects are usually unable to accurately determine the extent of their impairment due to alcohol.

In addition, performance has also been found to suffer most when an unexpected or unanticipated event occurs. This reflects the global cognitive impairment caused by alcohol, in that processing of new information, problem solving and abstract thought are all adversely affected.

This ATSB report has further specific information on the impact of alcohol use pilots should be aware of:

- Spatial disorientation (a pilot’s inability to correctly interpret aircraft attitude, altitude or airspeed in relation to the Earth or other points of reference)
- Coriolis phenomenon (also known as cross-coupled stimulation) - a severe tumbling sensation brought on by moving the head out of the plane of rotation, simultaneously stimulating one set of semi-circular canals and deactivating another set
- Reduction of speed and latency of eye movements
- Altitude and hypoxia
- Fatigue
- Tolerance to +Gz acceleration.

**Post-alcohol impairment**

Performance of any demanding task may be impaired after alcohol. Alcohol increases the risk of spatial disorientation, hypoxia and poor +Gz tolerance. While a considerable amount of emphasis is placed on ensuring pilots do not fly while under the influence of alcohol, there is now an increasing realisation that the after-effects of alcohol consumption have a potential impact on safety long after the BAC of a pilot has returned to zero.

The Australian Defence Force (ADF) recently changed their eight-hour ‘bottle to throttle’ rule - as we know it in civil aviation - to 12 hour abstinence from alcohol/drug use. ADF accident investigations showed that the final ‘active failure’ in some accidents resulted from a moment of indecision or a lack of alertness. While post-accident toxicology tests revealed the BAC of the crew members in these accidents was zero, the subtle, lingering impairment of performance due to alcohol consumption could not be ruled out as a contributing factor.

In addition to the extension of time between consuming alcohol and flying, some areas within the ADF have adopted guidelines based more on the amount of alcohol consumed than the time since the last drink. For instance, one Royal Australian Airforce (RAAF) Force Element Group (FEG) prevent flying duties for:

- 8 hours after 4 standard drinks
- 18 hours after 7 standard drinks
- 30 hours after 11 standard drinks
- 48 hours for 20 or more standard drinks.

**General recommendations**

- As a minimum, adhere to all the regulatory guidelines and provisions (CAR 256):
  - Eight hours from ‘bottle to throttle’
  - Do not fly while under the influence of alcohol
  - Do not fly while using any drug that may adversely affect safety.
- A more conservative approach is to wait 24 hours from the last use of alcohol before flying. This is especially important after excessive consumption or if you plan to fly IFR. Note that cold showers, drinking black coffee, or breathing 100 per cent oxygen cannot speed up the elimination of alcohol from the body.
Consider the effects of a hangover. Eight hours from ‘bottle to throttle’ does not mean you are in the best physical condition to fly, or that your breath alcohol concentration is below the legal limits.

- Recognise the hazards of combining alcohol consumption and flying.
- Use good judgement. Your life and the lives of your passengers are at risk if you drink and fly.

**Remember - You are in control.**

*The use of alcohol and other drugs is a significant self-imposed stress factor that should be eliminated from the cockpit. The ability to do so is strictly within the pilot’s control.*

### OCCURRENCES INVOLVING AOD USE IN AUSTRALIA

What is the situation in Australia with AOD use? Recent examples of Australian incidents/accidents involving AOD use include:

- A pilot in South Australia was placed on a methadone program without disclosing his occupation to his doctor or advising his chief pilot.
- An incident at Tyabb where a pilot taxied an aircraft into a fence while carrying five passengers. The pilot was found to have a BAC of 0.25.
- A fatal crash at Hamilton Island which killed all six people on board. Post-mortem toxicological testing of the pilot revealed a significant BAC and the presence of metabolites of other potentially impairing substances.

The Australian Transport Safety Bureau (ATSB) conducted a study in 2006 *‘Accidents and Incidents Involving Alcohol and Drugs in Australian Civil Aviation: 1 January 1975 to 31 March 2006’*. A search of the ATSB’s accident and incident database was conducted for all occurrences in which drugs or alcohol were recorded between 1 January 1975 and 31 March 2006. The database search identified 36 drug and alcohol-related events (31 accidents and five incidents). The majority of these occurrences related to alcohol use (22 occurrences). The drugs identified included:

- Prescription drugs
- Over-the-counter medications
- Illegal drugs (including heroin and cannabis).

While drug and alcohol events accounted for only 0.02 per cent of all the occurrences listed on the Australian Transport Safety Bureau’s database, drug and alcohol related accidents accounted for 0.4 per cent of all accidents. Furthermore, 89 per cent of drug and alcohol occurrences resulted in an accident, with a high proportion (86.5 per cent) of these 32 occurrences resulting in fatalities. Fatal accidents accounted for 67 per cent of all drug and alcohol occurrences. The results of the study show that the prevalence of drug and alcohol-related accidents and incidents in Australian civil aviation is very low, but that the related accident and fatality rates are high. Some of the information from the report appears below.

#### Type of operation

Table 14 displays the type of air operations being conducted for each event. The majority of these events occurred in private flying operations (61 per cent). No drug and alcohol occurrences occurred in the airline operations category.
Table 14  Drug and alcohol-related events by operation type

<table>
<thead>
<tr>
<th>Operation type</th>
<th>Number</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>4</td>
<td>11%</td>
</tr>
<tr>
<td>Business</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Charter</td>
<td>3</td>
<td>8%</td>
</tr>
<tr>
<td>Flying training</td>
<td>2</td>
<td>6%</td>
</tr>
<tr>
<td>Other aerial work</td>
<td>3</td>
<td>8%</td>
</tr>
<tr>
<td>Private</td>
<td>22</td>
<td>61%</td>
</tr>
<tr>
<td>Sport aviation</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Injury outcome

In the majority of cases, the highest injury outcome was a fatality. Several of the occurrences involved pilots operating aircraft with one or more passengers. While there were 24 fatal occurrences, a total of 46 fatalities were recorded.

Table 15  Drug and alcohol related events by injury outcome

<table>
<thead>
<tr>
<th>Injury level</th>
<th>Number</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>24</td>
<td>66.7%</td>
</tr>
<tr>
<td>Serious</td>
<td>1</td>
<td>2.8%</td>
</tr>
<tr>
<td>Minor</td>
<td>2</td>
<td>5.5%</td>
</tr>
<tr>
<td>Nil</td>
<td>9</td>
<td>25.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Class of licence

Table 7 shows the breakdown of occurrence by the type of flight crew licence held by the pilot. Fourteen pilots held commercial licences and 14 held private pilot licences. In four cases the pilot held no licence at all.

Table 16  Drug and alcohol related events by class of licence held

<table>
<thead>
<tr>
<th>Licence held</th>
<th>Number</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>14</td>
<td>38.9%</td>
</tr>
<tr>
<td>Private</td>
<td>14</td>
<td>38.9%</td>
</tr>
<tr>
<td>Student</td>
<td>2</td>
<td>5.6%</td>
</tr>
<tr>
<td>None</td>
<td>4</td>
<td>11.0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>5.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Identified drugs by class
Both legal and illegal drugs were identified in these occurrences (Table 17).

Table 17  Drugs by class

<table>
<thead>
<tr>
<th>Drug class</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural chemicals</td>
<td>Not specified</td>
</tr>
<tr>
<td>Analgesics</td>
<td>Dextropropoxyphene, Paracetamol</td>
</tr>
<tr>
<td>Antihistamines</td>
<td>Doxylamine</td>
</tr>
<tr>
<td>Cardiovascular drugs</td>
<td>Verapamil, Atenol, Analopril</td>
</tr>
<tr>
<td>Decongestants</td>
<td>Pseudoephedrine</td>
</tr>
<tr>
<td>Opiates</td>
<td>Morphone, Heroin</td>
</tr>
<tr>
<td>Psychostimulants</td>
<td>Amphetamine</td>
</tr>
<tr>
<td>Recreational drugs</td>
<td>Cannabis</td>
</tr>
<tr>
<td>Sedatives</td>
<td>Diazepam</td>
</tr>
<tr>
<td>Steroids</td>
<td>Nandrolone, Stanozolol</td>
</tr>
</tbody>
</table>

AOD TESTING OF SAFETY-SENSITIVE PERSONNEL IN AUSTRALIA

On 18 March 2004, the Australian Transport Safety Bureau (ATSB) publicly released its accident report on a fatal accident that occurred at Hamilton Island in September 2002.

The report concluded that the possible adverse effects on pilot performance of fatigue, recent cannabis use and post-alcohol impairment could not be discounted. The following case study summarises this accident.

Possible impact of alcohol and other drugs
At about 1708 eastern standard time (EST) on 26 September 2002, the pilot of a Piper PA-32-300 (Cherokee Six) aircraft (registered VH-MAR) taxied for departure from runway 14 at Hamilton Island, Queensland. The charter was to Lindeman Island, a distance of about 15 km to the southeast. The pilot and five passengers were on board the aircraft.

Witnesses to the east of runway 14 at Hamilton Island reported that shortly after the aircraft became airborne, the engine began coughing and misfiring, before cutting out and then starting again. Shortly after, as the aircraft commenced a right turn, the engine was heard to splutter and misfire. Witnesses reported that, when part way around the turn, the engine again cut out, and the aircraft descended and hit the ground.

The aircraft came to rest upright, aligned in an east-north-easterly direction, approximately 300 m to the west of the runway centreline and approximately 100 m south of the departure end of the runway. A severe post-impact fire consumed the majority of the aircraft's fuselage. The six occupants of the aircraft were fatally injured.
The pilot was qualified, appropriately endorsed and authorised for the operation. The pilot's condition and demeanour on the day of the occurrence were reported to be normal. There was no evidence of fuel contamination, insufficient fuel carried, structural failure or adverse meteorological conditions, being factors in the occurrence.

The engine installed in the aircraft was different from that specified in the aircraft type certificate data sheet. Notwithstanding, the Civil Aviation Safety Authority (CASA) and the engine manufacturer reported that the installed engine should have been capable of producing the power output expected from the engine certified for installation in the Cherokee Six.

Furthermore, the engine had been in service in the aircraft for 126.2 flight hours with no reported power abnormalities, suggesting that, provided there were no defects, the engine should have been capable of producing the required power throughout its operating range.

The extensive damage caused by the impact forces and post-impact fire prevented functional testing of a significant number of aircraft and engine components. On the available evidence, nothing was found to suggest what may have degraded the engine performance to the extent reported by the witnesses to the occurrence.

Post-mortem toxicological examination of the pilot's blood revealed a blood alcohol concentration (BAC) of 0.081 per cent, the presence of an inactive metabolite of cannabis, and an analgesic preparation consistent with a therapeutic dosage. The possibility that the pilot's BAC reading resulted at least in part from post-mortem alcohol production could not be discounted.

There was insufficient evidence to definitively link the pilot's prior intake of alcohol and/or cannabis with the occurrence. However, the adverse effects on pilot performance of post-alcohol impairment, recent cannabis use and fatigue could not be discounted as contributory factors to the accident. In particular, the possibility that the pilot experienced some degree of spatial disorientation during the turn as a combined result of the manoeuvre, associated head movements and alcohol-induced balance dysfunction could not be discounted.

Significance of this investigation report

The investigation report was quite significant in that the ATSB raised the issue of establishing the safety benefits of the introduction of a drug and alcohol testing program in the Australian aviation industry for safety sensitive personnel.

As part of their research into this initiative, CASA found that major accidents involving drug and alcohol usage have driven proposals internationally to implement testing programs together with related safety measures, e.g. rehabilitation, return-to-work initiatives, and peer support programs. The United States has been at the forefront, prompted by drug-related accidents (collision of Amtrak and Conrail trains in January 1987, a commuter plane crash in January 1988) and alcohol-related events (pilot of a major US air carrier flying while intoxicated in March 1990, the Exxon Valdez oil spill in 1989).

The US Federal Aviation Administration (FAA) began a Drug Abatement Program in 1988 to assist their industry to develop and implement substance testing programs. Over 30,000 positive tests were reported between 1990 and 2003 under the US testing regime. High profile incidents involving substance use have occurred in Australia and New Zealand, most notably the accident that killed nine people on the Franz Josef
Glacier in 1993. However, Australia did not have legislated testing procedures in place for aviation safety-sensitive personnel, including flight crew.

There is evidence that:

- Substance abuse occurs in aviation, across national borders and job descriptions
- People have died in substantial numbers where evidence of inappropriate substance use was confirmed
- In all types of aviation operations - from microlights to Boeing 747s – people have been placed at risk (see the following case study and attached reading for examples).

### Cocaine use

A Fairchild Metro III, operating as Continental Express flight 2286 from Stapleton International Airport (Denver, Colorado), with two flight-crew members and 15 passengers on board, crashed on approach to Durango Airport (Colorado). The two flight-crew members and seven passengers were killed in the accident.

The investigation found the probable cause of the accident was the first officer’s flying and the captain’s ineffective monitoring of an unstabilised approach which resulted in a descent below the published descent profile. The degradation of the captain’s performance from his use of cocaine before the flight contributed to the accident.

In summary, aviation personnel are no different from the rest of the community in substance abuse. It is necessary to consider appropriate safety responses - specifically testing - employed internationally in aviation and locally in other vocations and industries to achieve better safety.

### CASA ALCOHOL AND OTHER DRUGS PROGRAM

#### Background

The decision to introduce the Aviation Alcohol and Other Drugs Program was based on a joint report prepared in 2005 by the Department of Transport and Regional Services (DOTARS) and the Civil Aviation Safety Authority (CASA), at the direction of the Australian Transport Safety Bureau (ATSB), into the safety benefits of introducing drug and alcohol testing for safety sensitive aviation workers.

The report comprehensively examined the safety benefits of introducing a drug and alcohol testing program for the Australian aviation industry. The agreed terms of reference listed six primary non-exclusive issues that should be addressed in considering the broad safety case for drug and alcohol testing. These issues were:

- The need to define safety-sensitive personnel
- Who would administer the testing process (CASA or industry)
- Whether testing should be part of a company’s safety management system
- Whether testing would be on a random or a regular basis
- Alternative and/or supplementary programs to be used for alcohol and drug management – for example mentoring, differentiating between a regime for management of alcohol and other drugs use
- The costs involved with establishing programs (including education campaigns) and the ongoing testing regimes.
The report made 17 recommendations, the first of which was that alcohol and other drugs testing should be introduced for safety-sensitive personnel in the Australian aviation industry. The full report can be found at: http://www.infrastructure.gov.au/aviation/safety/pdf/Final_Report_Drug_Alcohol_Testing.pdf.

**Safety benefit**

The ATSB has previously noted that key areas of cognitive functioning and psychomotor skill in human performance are generally impaired following the use of substances such as alcohol and illicit drugs. The use of such substances can therefore compromise the ability of people to safely undertake their tasks, with clear negative implications for other aviation personnel and passengers depending on the integrity of their work.

The joint CASA and DOTARS report found:

‘...that alcohol and other drugs testing offers a number of safety benefits. Most importantly, it offers a mechanism to measure, manage, prevent and recover from the use of these substances. A testing regime provides an opportunity to quantify an issue that to date relies on anecdotal evidence in an Australian context. It also provides a tool, together with self-referral, for dealing with usage by individuals, and applying a range of responses including exclusion from safety-sensitive roles and remedial action focusing on return to duty through Employee Assistance Programs (EAPs) ... Without a testing program, substance abuse continues to exist and is more likely to be undiscovered, unrecognised and unreported.

As a result, the report proposed introduction by regulation of a minimum standard for drug and alcohol testing in the aviation sector, managed as appropriate by industry and law enforcement agencies and reported to the regulator.

The overall program is designed to assist those associated with the civil aviation industry to better understand the significance of alcohol and other drug (AOD) use in their environment, and to ensure that those people are aware of the serious risks posed by possible impairment caused by AOD use in that particular environment.

**Legislation and regulation**

Amendments to the Civil Aviation Act 1988 were made in August 2007 to ensure that CASA was able to implement the program. The Act amendments provide a head of power for the development of regulations to implement a broad ranging, random testing regime covering all safety-sensitive personnel. In accordance with Civil Aviation Safety Regulation Part 99, personnel who perform, or are available to perform, safety-sensitive aviation activities are subject to random alcohol and other drug testing.

The aim of the program is preventative, not punitive. However, the regulations are supported by a suitable enforcement regime to deal with persons whose test results return confirmed positive readings over the acceptable levels for alcohol or other drugs. In dealing with positive test results, CASA will have a wide range of options including administrative sanctions.
THE CASA AOD INITIATIVE–PROGRAM DESIGN

Drug and Alcohol Management Plans (DAMPs)

The program has two key components. The first is an aviation industry component consisting of a Drug and Alcohol Management Plan (DAMP), implemented by the holders of Air Operator Certificates and Certificate of Approval holders, but subject to audit, oversight and monitoring by CASA. This component covers approximately 67,000 employees in aviation safety-sensitive roles.

The program is supported by a comprehensive industry-wide education and awareness campaign and training in the development of DAMPs for organisations required to implement a DAMP. DAMP organisations are required to conduct pre-placement, reasonable suspicion, return to work and post-incident/accident testing for personnel undertaking safety-sensitive aviation activities.

Random testing regime

The second component of the program is a scaleable random testing regime undertaken by a CASA testing provider. Personnel subject to testing are all safety-sensitive personnel. These include; flight crew, cabin crew, flight instructors, aircraft dispatcher and load controllers, aircraft maintenance and repair staff, aviation security, air traffic controllers, baggage handling, ground refuelling persons and other personnel with airside access.

This regime covers all personnel undertaking safety-sensitive aviation activities, including individuals not covered under the commercial scheme. This group includes private pilots, contractors and all those undertaking safety-sensitive aviation activities with a total coverage of approximately 120,000 personnel. For private pilots, this testing is analogous to roadside random drug and alcohol testing undertaken by police and for the DAMP organisations, the random CASA testing is to assist with measuring the success of those programs.

Aim and objectives

The aim of the initiative is to minimise problematic alcohol and other drugs use in the Australian aviation sector. The objectives of the initiative are to:

- Positively influence attitudes, beliefs, knowledge and behaviour in relation to alcohol and other drug use through the delivery of accurate, credible and up-to-date information and strategies that are evidence-based
- Deliver a multi-level education and training program that is provided at regular intervals, and that will ensure an adequate level of knowledge about alcohol and other drugs
- Co-ordinate and administer a regime of alcohol and other drug testing throughout the safety-sensitive aviation workplace
- Provide specialist advice to the aviation sector on strategies to minimise the risks to the individual and the community, associated with problematic alcohol and other drug use
- Play a role in ensuring that industry policies relating to alcohol and other drug use are consistent with facilitating an environment in which problematic use of alcohol and other drugs is minimised.
Scope
The initiative applies throughout the aviation sector in all areas of Australia. The CASA-coordinated random AOD testing component of the program covers personnel undertaking, or available to undertake, safety-sensitive aviation activities.

The education component of the program is accessible to all personnel and organisations within the Australian aviation sector.

TESTING PROCEDURE FOR ALCOHOL AND OTHER DRUGS

What substances will be tested?
- Delta-9-tetrahydrocannabinol (THC), the active component of cannabis
- Methylamphetamine, also known as speed, ice and crystal meth
- Methylenedioxymethyleneamphetamine (MDMA), also known as ecstasy
- Benzoylcgonine, the major metabolite of cocaine
- Opiates, found in heroin, morphine and codeine
- Alcohol.

What are the permitted levels?
- **Testable drugs**: the permitted level is a concentration of the testable drug in 100 ml of blood, less than the confirmatory target concentration for that drug specified in table 5.1 of the Australian Standard 4760-2006.
- **Alcohol**: the permitted level is a concentration of less than 0.02 gm of alcohol in 100 ml of blood (or a concentration of less than 0.02 gm of alcohol in 210 litres of breath).

On who, when and where will testing be conducted?
- Any person present in an area that safety-sensitive aviation activities are undertaken can be asked to undergo a test in accordance with the regulations
- Testing will be conducted 365 days, 24/7
- Testing will be where any safety-sensitive aviation activities occur and will not be limited to metropolitan and major regional centres.

How will the testing be carried out?
An independent authorised collector can ask for an oral fluid sample for drug testing and/or a breath sample for alcohol testing.

Drug testing
- All testing will be conducted with privacy as a primary consideration
- For the purposes of drug testing, the donor is asked to provide a measured sample of oral fluid on the device provided
- The screening for the presence of any of the target drugs takes approximately five minutes
If the test is negative the donor is able to continue with their duties
If the test is positive the donor is required to be observed while the sample is split and the specimens sealed for security; both these samples are sent to a laboratory for confirmatory analysis
The donor is then asked to stand down until a CASA Medical Review Officer authorises their return to duties
When the results are confirmed, the donor is contacted by a CASA MRO to verify the nature of the positive result.

Alcohol testing
All testing is conducted with privacy as a primary consideration
The donor is asked to provide a measured breath sample
A positive or negative result is known at the time of the testing
If the test is negative, the donor is able to continue with their duties
If the test is positive, the donor is required to wait with the authorised collector for 20 minutes before providing a second confirmatory sample
If the confirmatory test is negative, a negative test result is recorded and the donor can continue with their duties
If the positive result is verified, the donor is asked to stand down until authorised to return to their duties.

AOD testing—reasons why the aviation industry needs it
A quick search of internet articles in relation to pilots and other safety critical aviation personnel apparently affected by alcohol or other drugs, revealed many examples. A small sample of these results is included below:
The pilot of a privately-operated Beech Bonanza A23 and three passengers apparently spent the afternoon drinking alcohol at a hotel. Afterwards, they departed in the aircraft and attempted a low-level fly-past over the town. The aircraft struck a cow during the manoeuvre, and subsequently crashed. All four occupants received fatal injuries.
A Cessna 172 pilot was detained by the police after landing. The pilot was found to have a blood alcohol concentration of 0.285 per cent.
A helicopter pilot scheduled to fly a NASCAR team owner to a meeting, was drunk when the helicopter plunged into swampy woodlands near the Daytona 500 Speedway in 2002, killing a Las Vegas woman. The helicopter pilot's blood-alcohol content was 0.11 percent.
A microlight pilot killed on an instruction flight with a pupil was nearly seven times over the prescribed blood-alcohol limit for pilots. The 54-year-old died after the Airborne Edge aircraft struck a tree.
Although the aircraft had already pushed back from the gate and began taxiing towards the active runway, the ground controller told the crew they needed to return to the gate immediately. Both pilots were arrested and charged with operating an aircraft under the influence of alcohol. A security screener alerted police who subsequently apprehended and arrested the crew before the aircraft took to the sky.
An airline pilot was fired after he flew a DC-10 aircraft carrying 59 passengers. An airline employee smelled alcohol on the employee's breath after the plane landed. A breathalyser test showed that the pilot's blood-alcohol concentration was 0.056, exceeding the limit for that jurisdiction (0.04).
Three intoxicated pilots were arrested after flying a Boeing 727 carrying 58 passengers. Federal authorities were tipped off by an inspector who had learned the three had been drinking heavily at a bar the night before their flight.

A DC-8 crashed shortly after take-off. The aircraft was flown by a 53 year-old pilot with 23,000 hours flying experience; his co-pilot was a 31 year-old with 1,600 hours experience. The captain was found to be more than three times over the legal alcohol limit for driving a car.

A bus driver alerted police when he detected alcohol on the captain’s breath while ferrying him and other cabin crew from the staff car park to the terminal building. A subsequent blood test revealed the captain had 49mg of alcohol per 100 millilitres of blood (the limit under the legislation applicable to him was 20mg). In an interview with the police, the captain admitted that during the previous afternoon he had drunk ‘six or so glasses of wine with a meal, and one beer’. The Boeing 757, with 225 passengers on board, was delayed for six hours while a replacement pilot was found.

Minutes before a Boeing 737 with 123 passengers was to take-off, airport police removed the co-pilot from the aircraft. He was subsequently arrested by the FBI on suspicion of being intoxicated. A screener reported to supervisors that the man’s breath smelled of alcohol when he went through a security screening line. The flight departed 15 minutes late, after the co-pilot was replaced.

The captain of an Embraer 145 with 28 booked passengers tested positive for alcohol before a scheduled flight and was fired. In addition, a flight attendant resigned, and a co-pilot suspended. The captain had a blood-alcohol reading of 0.06 percent and 0.05 percent in two tests administered after screeners at the airport smelled alcohol on his breath (the limit in this jurisdiction was 0.04 percent). The three were stopped as they were about to board the jet.

The pilot of a scheduled airline flight was grounded after a security screener smelled alcohol on his breath. He was placed on paid leave pending an investigation, but later resigned.

Two pilots were removed from their plane after security crews suspected they had been drinking before a flight. The pair pleaded innocent to charges of operating an aircraft and a motor vehicle under the influence of alcohol. The airline has since fired them.

The captain of a Boeing 737 was refused permission to take off from an airport because he was drunk. The pilot, due to fly with 125 passengers on board, was walking along the gangway to his plane when security officers noticed that he seemed unsteady on his feet. Military police at the airport asked him to take a breath test, and although he objected strongly to begin with, he did comply eventually. The level of alcohol in his blood was found to be more than four times the legal limit.

An unlicensed US pilot who reportedly managed to steal an aircraft and fly it a considerable distance landing at a closed airport whilst drunk, received a one-year prison sentence. The 21-year-old after release from prison still faces airport security charges in Connecticut.

A flight engineer was dismissed by an airline after being charged with buying crack. Results from a test several months earlier showed evidence of cocaine use, but the flight engineer kept flying for the airline. Apparently no one noticed the results of the test because of the ‘hectic pace’ of clerical work related to a strike by pilots and mechanics.

The pilot of a charter aircraft that had recently crashed killing nine people, had traces of cocaine and alcohol in his body. An autopsy performed on the body of the pilot, revealed cocaine in his urine and traces of alcohol in his stomach. Investigations also revealed the pilot was sentenced to probation for crack cocaine possession 12 days before the accident.
A police helicopter pilot lauded for his high-flying heroics in an air-sea rescue and post-9/11 anti-terror sweeps was suspended after testing positive for cocaine. The officer, a 15-year veteran in the aviation unit, was suspended without pay after a hair-sample drug test came back positive. The level of cocaine in the sample was ‘not minuscule’ according to the officer’s lawyer.

The pilot of a small plane who died in an accident along with two passengers was impaired by marijuana and had likely used the drug within three hours of the crash. The pilot was found to have ‘volatile concentrations’ of the drug in his system when his Cessna 182 hit power lines. The investigation found the probable cause of the accident was the ‘pilot’s failure to maintain clearance from the transmission wire’ with contributing factors being ‘the pilot’s impairment from his recent marijuana use’.

**CASA’S AOD PROGRAM—COMMON QUESTIONS**

**Alcohol and other drug use in aviation**

CASA continues to work closely with the aviation industry to develop alcohol and other drugs management plans (DAMPs) for all Air Operator Certificates (AOC) and Certificate of Approval (COA) holders and operators of certified and registered airports. The initiative - designed to make aviation even safer - affects all safety-sensitive personnel, that is, anyone who is airside and not a passenger.

The program has two components. The first is the industry managed DAMPs and the second is CASA managed random testing. Both are supported by comprehensive industry wide education and awareness campaigns.

**Who will be tested?**

All persons who are performing, or are available to perform, safety-sensitive aviation activities (including flight crew, cabin crew, flight instructors, aircraft dispatchers, aircraft maintenance, aviation security, air traffic controllers, baggage handlers, ground refuellers and other personnel with airside access) are subject to testing as part of the program.

**Who conducts testing?**

Organisations required to have a Drug and Alcohol Management Plan (DAMP) in place are required to perform pre-placement, reasonable suspicion, post accident and serious incident and return to work testing of their safety-sensitive personnel. DAMP employers may also choose to conduct random testing of their employees. A random testing regime is conducted by an independent provider, contracted by CASA, on a sample of all safety-sensitive personnel including those covered by a DAMP organisation testing.

**Will CASA provide assistance to organisations required to have a DAMP in place?**

CASA provides comprehensive guidance material and training which enables operators to tailor a DAMP to suit their operational environment. The guidance material includes information for supervisors dealing with Alcohol and Other Drug (AOD) issues and their impact on staff, the effects of different substances (including prescription and over-the-counter substances), referral options, and what to expect from treatment services.
Will there be any warning of CASA testing taking place?
Only CASA and the testing provider know in advance of the tester’s arrival at a particular location.

How are testing samples collected and what happens to them?
CASA random testing samples will be collected in accordance with the relevant CASA regulations. DAMP testing samples will be collected in accordance with the relevant Australian Standards. For the purposes of CASA random testing, breath samples are tested for alcohol and oral fluid samples are tested for other drugs.

If a breath sample indicates the presence of alcohol (at or above 0.02%), the individual providing the sample is required to provide a second sample for confirmatory testing 20 minutes after the initial test. This confirmatory process is conducted on-site.

If an oral fluid sample test returns a positive indication for other drugs, the sample will be sent to an accredited laboratory, under strict chain of custody arrangements, for further confirmatory analysis.

What is the maximum BAC limit for an employee in a safety-sensitive role?
Less than 0.02% BAC, but the eight-hour rule for pilots still applies.

What happens if I test positive to alcohol or other drugs?
If the test occurred when you were performing, or available to perform, a safety-sensitive activity the most important course of action for you (or your supervisor if operating under a DAMP) is to remove yourself from the hazardous situation immediately. It is an offence to continue the activity until you are cleared to return. Further action will depend on the circumstances and will be addressed on a case by case basis.

When does the testing commence?
Testing has already begun.

I am taking medication from a pharmacist/doctor - will that show up on a drug test? Do I need to tell my employer?
Some over-the-counter (OTC) or prescribed medications may be detected on a drug test. This may be because:

- The medication contains the drug that is being tested (e.g. codeine in the case of an opioids screen)
- A cross reactivity (false-positive) caused by a substance other than the targeted drug.
- There is no obligation to tell your employer if you are on medication, however, you are advised to do so. If you are taking medication with codeine or other prescription medications, it is important to inform your healthcare professional you are a pilot and find out if there are other medications that can be used with the same effect.
- The rate of false-positives in oral fluid testing is low. Appropriate confirmatory testing is conducted in the laboratory.
Where to find more information about AOD

If you would like to obtain more information about CASA’s alcohol and other drug program please visit www.casa.gov.au/aod

If you would like to obtain more information about alcohol and other drugs, the following organisations are recommended for the accuracy and currency of information they provide:

- **The Australian Drug Foundation**
  The Australian Drug Foundation is a major Australian non-government organisation, established in 1959. ADF prevention is based on harm minimisation, with a range of prevention strategies, from abstinence, to managing of severe and chronic drug misuse.
  Phone: 03 9278 8100  Web: www.adf.org.au

- **Turning Point Alcohol and Drug Centre**
  Turning Point Alcohol and Drug Centre was established in 1994, and is regarded as a leading provider of services in the AOD sector. Turning Point also has a strong research agenda. Turning Point is formally affiliated with St Vincent’s Hospital Melbourne and the University of Melbourne, is part of the International Network of Drug Treatment and Rehabilitation Resource Centres for the United Nations Office of Drugs and Crime (UNODC) and is a member of the International Harm Reduction Association. The Centre is also a Registered Training Organisation and an accredited higher education provider.
  Phone: 03 8413 8413  Web: www.turningpoint.org.au

- **National Drug and Alcohol Research Centre**
  The National Drug and Alcohol Research Centre (NDARC), at the University of NSW, opened in 1987. It is funded by the Australian Government as part of the National Drug Strategy. NDARC’s mission is to conduct high quality research and related activities to increase the effectiveness of Australian and international treatment and other intervention responses to alcohol and other drug related harm.
  Phone: 02 9385 0333  Web: www.ndarc.med.unsw.edu.au

- **Alcohol and Drug Information Service**
  In addition to the agencies mentioned above, each state and territory provides AOD assessment, referral or advisory/counselling services. Resources include printed information for people experiencing AOD-related harm, and their friends, families and carers. Many centres operate 24 hours, and offer a free-call number for people living in regional areas. State details are given in the following table.
Table 18  Referral, advisory and counselling services

<table>
<thead>
<tr>
<th>State/Territory</th>
<th>Information service</th>
</tr>
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<tbody>
<tr>
<td>Australian Capital Territory</td>
<td>24 Hour Alcohol and Drug Telephone Line 02 6207 9977</td>
</tr>
<tr>
<td>South Australia</td>
<td>Alcohol and Drug Information Service 1300 13 13 40</td>
</tr>
<tr>
<td>New South Wales</td>
<td>Alcohol and Drug Information Service 02 9361 8000 (Sydney residents) or 1800 422 599</td>
</tr>
<tr>
<td>Tasmania</td>
<td>Alcohol and Drug Information Service24 Hour 1800 811 994</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>Alcohol and Drug Information Service 1800 131 350, 1800 629 683 or 08 8981 8030 (Darwin residents)</td>
</tr>
<tr>
<td>Western Australia</td>
<td>Alcohol and Drug Information Service 08 9442 5000 (Perth residents) or 1800 198 024</td>
</tr>
<tr>
<td></td>
<td>Parent Drug Information Service 08 9442 5050 or 1800 653 203</td>
</tr>
<tr>
<td>Queensland</td>
<td>Alcohol and Drug Information Service 07 3236 2414 or 1800 177 833</td>
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<tr>
<td>Victoria</td>
<td>Alcohol and Drug Information Service 13 15 70</td>
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<tr>
<td></td>
<td>DirectLine 1800 888 236</td>
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<tr>
<td></td>
<td>DrugInfo 1300 85 85 84</td>
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<tr>
<td></td>
<td>Family Drug Helpline 1300 660 068</td>
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<tr>
<td></td>
<td>Youth Substance Abuse Service (YSAS Line) 03 9418 1020 or 1800 014 446 (rural)</td>
</tr>
</tbody>
</table>

Contacts

CASA has established a virtual resource centre on AOD in the Australian aviation sector, providing comprehensive policy and program advice, resources for education and training purposes, self-assessment tools, links to useful documents and services, and a range of other materials. The website can be found at www.casa.gov.au/aod The Program Manager for the CASA AOD initiative has responsibility for the overall coordination of the various aspects of the program and can be contacted at:aod@casa.gov.au

KEY POINTS

This section addressed the following key points:

- The effects of AOD are numerous - even mild alcohol ingestion or impairment can degrade relevant skills and abilities which can increase the risk of errors and subsequent incidents / accidents.
- A breath alcohol concentration of zero is not sufficient to ensure safe operations. Post-alcohol impairment needs to be acknowledged and managed as well as actually having a low or zero BAC.
- All pilots should ensure safety is put before pressure to fly, and if in doubt, or feeling affected by AOD ingestion, take control and do not put yourselves or others at risk.
- CASA's AOD Program aims to reduce the significant impact of alcohol and other drug use on flight safety.

When you are ready, please turn to page 33 of the Workbook for Pilots and complete the exercises.
RESOURCES

Further reading

References
Chapter 5

Communication

Communication is a critical aspect of flight safety ensuring coordination between flight crews, air traffic control, dispatchers, maintainers etc. Numerous accidents have demonstrated the catastrophic consequences when critical communication links are compromised. This section discusses communication as a safety critical element in an organisation’s safety management system and mentions the different types of communication, barriers to effective communication, types of communication errors and principles to improve communication.
Communication

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- Communication methods 82
- Barriers to effective communication 85
- Managing communication 89
- Single-pilot applications 90
- Avoiding confusion and errors 90
- Improving communication 91
- Key points 92
- Resources 92

“The only time an aircraft has too much fuel on board is when it is on fire.”

Sir Charles Kingsford Smith
Table 19  Communication

<table>
<thead>
<tr>
<th>Category</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Sending information clearly and concisely</td>
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<td></td>
<td>Including context and intent during information exchange</td>
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<tr>
<td></td>
<td>Receiving information especially by listening</td>
</tr>
<tr>
<td></td>
<td>Identifying and addressing barriers to communication</td>
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</table>

**COMMUNICATION**

Communication is a major part of good teamwork and is critical to both safety and operational efficiency. Communication relates to many different activities and takes so many different forms, that in itself it is not an easy concept to define. However, most researchers and human factors practitioners agree that communication is characterised by two issues

- The transfer of information from one party to another
- The transfer of meaning.

The distinction between ‘information’ and ‘meaning’ is significant. The transfer of *information* alone does not ensure effective communication. For communication to be effective and useful, there should be *shared meaning*: parties should share the same significance and purpose. Accordingly, communication is the process of sharing information within a shared interpretative framework which allows that information to be meaningful and useful.

**Relevance to safety**

Effective communication has a critical role in ensuring safe and efficient aviation operations. When pilots, air traffic controllers, dispatchers and other frontline staff talk to each other using the right protocols, the risk of accidents and incidents reduces significantly. However, there are many examples where confusion between traffic controllers, dispatchers and other frontline staff talk to each other using the right protocols, the risk of accidents and incidents reduces significantly. However, there are many examples where confusion between the sender and receiver of information has resulted in tragic aircraft accidents, as illustrated by the case study below.

**Was that left or right?**

On 26 September 1996, Garuda Airlines Flight #152 flew into a mountain just prior to landing at Medan, Indonesia. An error from air traffic control (ATC) resulted in the aircraft being routed directly into mountainous terrain, which due to forest fires at the time, was obscured by smoke and haze. None of the 234 passengers and crew survived the impact.

This extract of conversation illustrates the confusion between the between the ATC tower and flight crew:

- ATC: GIA 152, turn *right* heading 046 report established localiser.
- GIA 152: Turn *right* heading 046 GIA 152 check established.
- ATC: Turning *right* sir.
- GIA 152: Roger 152.
Basic communication framework

In trying to understand exactly what communication is and how best to manage it, particularly safety-critical communication, it is useful to consider a basic framework displaying the concepts and steps involved.

Figure 6 displays the basic communication process in relation to task-related communication.

Figure 6  A task-related basic communication process

As illustrated in Figure 6:

- The message is formulated and issued by a sender (1),
- Via a medium (2),
- To be received and processed by a receiver (3),
- The receiver can then react in one of two ways: the receiver can respond (4A) and therefore become the sender as per (1) or; the receiver may not respond (4B).

While this is a simplistic framework, it provides a graphical depiction for use in a task-related context, recognising that in performing tasks, information transfer is the main aim of communication. The framework enables consideration and identification of where safety-related communication failures tend to occur, as well as how communication failures at different points in the process can be prevented. For example, the communication could be related to the medium being used (e.g. two-way radio) or it could be a problem with the actual formulation of the message.

Essential prerequisite for good CRM

Effective communication between crew members is an essential prerequisite for good crew resource management. Research has shown that in addition to its most widely perceived function of transferring information, the communication process in an aircraft fulfills several other important functions. It not only helps
the crew to develop a shared mental model of the problems which need to be resolved in the course of the flight, thereby enhancing situational awareness, but it also allows problem solving to be shared amongst crew members by enabling individual crew members to contribute appropriately and effectively to the decision-making process. Most importantly, it establishes the interpersonal climate between crew members and is therefore a key element in setting the tone for the management of the flight.

The communication process invariably takes place in a social and organisational context, and it is therefore profoundly influenced by company culture. Its effectiveness also depends on the experience levels of the pilot or crew, and their perception of their roles and position in the chain of command. The effectiveness of the communication process also depends on the nature of the task and operational context in which the flight is taking place e.g. phase of flight, and whether it is being conducted under normal, abnormal or emergency conditions.

In addition, it is affected by the mode of speech employed and the linguistic context in which the transaction takes place. In this context, individual styles, body language, grammatical styles and speech patterns all have their part to play. Because of these complexities, crew members need to be aware of and sensitive to the non-verbal elements that can affect communication. They also need to understand and avoid where possible, things preventing or hindering effective communication.

COMMUNICATION MODELS

Communication can be described as one-way or two-way. One-way communication involves information or a message being sent via a medium to one or more receivers who then interpret the information. Examples of one-way communication could include:

- Emails
- Letters
- Instructions
- Voicemail, etc.

Two-way communication involves information or a message being sent via a medium to one or more receivers who have the opportunity to respond, thereby becoming the sender. This forms a closed feedback loop. Examples of two-way communication include exchanges in which information flows back and forward between the sender and receiver, such as:

- Conversations
- Telephone calls
- Radio transmissions, etc.

COMMUNICATION METHODS

Information may be transferred by speech, written word, symbols, displays or gestures.

Both formal and informal communication methods are adopted for different types of information. There are several different processes for communicating different sorts of information. Formal methods and documents such as user manuals, safety cases, hazard logs etc. are used routinely. However, other types of communication of a less formal nature may include:
- Face-to-face briefings
- Informal documents (such as newsletters, bulletins, electronic mail)
- Audio-visual packages
- Training.

**Conveying information**
The means by which information is conveyed can vary greatly and include
- Induction and other training programs
- Company policy and procedures manuals
- Employee rule booklets
- Employee handouts/pay check enclosures
- Health and safety policy and procedure manuals/meetings
- Standard job procedures manuals
- The health and safety committee or representative
- References in job descriptions
- Notice board announcements and reminders.

**Written communication**
Written communication can be in hard copy (paper) or soft copy (electronic) format and includes, but is not limited to:
- Flight manuals
- Forms
- Radio-transmitted text messages.

**Verbal communication**
Verbal (oral) communication consists of direct or transmitted speech between two or more individuals and is more likely to be misinterpreted than written information. Verbal communication can include, but is not limited to, communication via:
- Landline
- Mobile phone
- Radio
- Face-to-face communication.

While passing on information verbally is sometimes required to convey information quickly and resolve misunderstandings rapidly, it is always good practice to follow up safety-critical communication in writing.
**Non-verbal communication**

Non-verbal communication consists of wordless messages, where meaning may be conveyed by gestures, posture, appearance, voice tone, eye-contact. Eye contact for example, indicates attention, interest, involvement; gestures such as winking, or rolling one’s eyes communicate powerful messages.

- Body language – important for teamwork communication
- Appearance.

**Phraseology**

Verbal communication has significant safety implications. In order to minimise potential ambiguities and other variances in aviation, there are established rules or protocols regarding which words, phrases or other elements will be used for communicating.

For example, International Civil Aviation Organization (ICAO) phraseology now requires that the word ‘departure’ is used instead of ‘take-off’ (except for the single case of the take-off itself) and that clearances, heading, runway etc. are read-back. This was introduced to enhance safety following many cases where messages were misinterpreted.

However, read-back alone does not guarantee that the message has been accurately received or processed. The four most common errors associated with miscommunication in the air are:

- Similar aircraft call signs resulting in confusion in transmission or reception
- Only one pilot on board working and monitoring the ATC frequency
- Numerical errors, such as confusing ‘one zero thousand’ with ‘one one thousand’
- Expectancy (hearing what one expects to hear).

This last point regarding expectancy was dramatically illustrated in the world’s worst aviation disaster at Tenerife in 1977 (mentioned in the introductory chapter). Following this accident, ICAO undertook a systematic review, which resulted in changes to the standard phraseology in use at the time of the accident. One of the critical changes was to restrict the use of the words ‘clear/clearance’ and ‘take-off’ to avoid such accidents. ‘Clear/clearance’ are no longer used for start-up, push-back and taxiing. The word ‘take-off’ was replaced by ‘depart/departure’ as mentioned previously.

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**Cleared for take-off?**

The report of the Civil Aviation Authority Netherlands on the 1977 Tenerife accident made some relevant and insightful comments in concluding that:

- The crew of the KLM aircraft took off in the absolute conviction that they were clear for take-off,
- The communication procedures and terminology employed were not perfect, but were those in normal daily use in civil aviation at the time; and
- The accident resulted from a breakdown in normal communication and from misinterpretations of verbal messages. Such breakdowns were known to have occurred a number of times on other occasions (some of which resembled the Tenerife accident).

The most critical error at Tenerife centred on the word ‘cleared’. However, as illustrated from cockpit voice
recordings, other verbal confusion also occurred:

- PAA: Third to the left, OK
- PAA Capt: Third he said
- PAA: Three
- TOWER: ...ird one to your left
- PAA Capt: I think he said first
- PAA First Officer: I’ll ask him again
- PAA First Officer: Must be three. I’ll ask him again.

In the meantime the KLM aircraft, which was waiting at the beginning of the runway, had reported ‘...now ready for take-off... we’re waiting for our ATC clearance’. The ATC Controller replied ‘... cleared to the Papa beacon ... right turn after take-off, proceed’.

Note both the words ‘cleared’ and ‘take-off’ were used by ATC. The KLM crew interpreted the word ‘cleared’ as applicable to the airways clearance and the take-off clearance, as both had been requested (expectancy). However, ATC intended it to apply only to the airways clearance.

As a result of this misinterpretation, and the poor visibility due to fog, the KLM crew proceeded with their take-off roll and struck the Pan Am aircraft which had not turned off the active runway at either the first or the third taxiway.

**BARRIERS TO EFFECTIVE COMMUNICATION**

Barriers in communication can occur at any point in the communication process:

- In the sender’s message: e.g. using jargon or non-standard phraseology which some individuals may not be familiar with
- In the outside environment: e.g. when background noise interferes with the transmission of the message;
- In receivers themselves: e.g. the receiver does not want to hear a message, or has such a high workload that a message is not completely received.
Types of communication errors

Communication errors which have an adverse effect on safety include:

Table 20 Communication errors

<table>
<thead>
<tr>
<th>Types of errors</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
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<td>Senders’ errors</td>
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<tr>
<td>Omitting communication</td>
<td>Clipping call signs</td>
</tr>
<tr>
<td>Passing on incomplete/ambiguous information</td>
<td>Not adequately defining an abnormal situation to ATC</td>
</tr>
<tr>
<td>Passing on incorrect information</td>
<td>Call-sign confusion</td>
</tr>
<tr>
<td>Senders’/receivers’ errors</td>
<td></td>
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<tr>
<td>Failing to reach a clear and mutual understanding</td>
<td>Confusion about assigned runway</td>
</tr>
<tr>
<td>Failing to follow recognised sequence for communication</td>
<td>Using non-standard phraseology or jargon</td>
</tr>
<tr>
<td>Failure to use correct units of speech</td>
<td>Excessive use of abbreviations/acronyms</td>
</tr>
<tr>
<td>Poor elocution/failing to speak clearly</td>
<td>Rushing or mumbled speech</td>
</tr>
<tr>
<td>Failing to read back messages</td>
<td>Failure to read back mandatory pieces of information to ATC requiring further communication to resolve</td>
</tr>
<tr>
<td>Receivers’ errors</td>
<td></td>
</tr>
<tr>
<td>Not responding correctly to communication</td>
<td>An aggressive response to ATC</td>
</tr>
<tr>
<td>Mis-recording information communication</td>
<td>Writing down an incorrect QNH</td>
</tr>
<tr>
<td>Not listening (partial or total message)</td>
<td>Tuning out due to high workload</td>
</tr>
</tbody>
</table>

Safety-critical communication

Effective communication is essential for safe operations. Information may be transferred by speech, written word, symbols, displays or gestures. The quality and effectiveness of communication is determined by the degree to which the intended message is understood by the receiver.

In most industries, safety-critical communication can occur in the following situations:

- Shift/crew handovers
- Communications during emergencies
- Any form of remote communication
- Communication of hazards and risks to contractors
- Use of radios
- Plant/equipment labelling and identification
- Communication of changes to procedures.

Organisations should make arrangements to pass on the following sorts of safety-related information to people who need it to reduce risk:

- Hazards, risks and arrangements to control them
- Limitations on the products and systems and any implications for users and maintainers
- Lessons learned relating to safety, and
Safety-related information about products.

Any changes to this type of information should be passed on promptly to those who may be affected by it. Organisations should have arrangements in place to capture and record safety-related information; to decide who should receive it; and to make sure that they do receive it.

A serious aircraft incident in Tasmania in 2005 demonstrated deficiencies in safety-critical communication which affected an emergency evacuation of a Boeing 717-200. The ATSB found that while the emergency passenger evacuation was conducted rapidly and in a pro-active manner in the interests of passenger safety, there were problems with communication involving the pilots, ground crew and cabin crew, creating potential risk.

Emergency evacuation

On 17 May 2005, a Boeing 717-200, registered VH-VQI, was scheduled to operate a regular public transport flight from Hobart to Sydney, departing at 0600 Eastern Standard Time.

During the starting of the right engine, the aircraft dispatcher informed the flight crew that there was smoke and sparks shooting from the right engine and advised, ‘we’ll have to get everyone off’.

The pilot in command called for an emergency evacuation without initiating the passenger evacuation checklist. As a result, the wing flaps were not set to the extended position and the tail section of the aircraft was without emergency lighting while passengers were exiting the aircraft in darkness.

All three of the floor level exits were opened by cabin crew. The forward-door, right 1 escape slide fell to the ground uninflated when the door was opened. A number of ground personnel ran to the front of the aircraft and helped 22 passengers off the forward-door left 1 slide and directed them towards the terminal. Four passengers exited by the door 2 slide at the rear of the aircraft and ran into the middle of the apron. The overwing exits were not opened.

The aircraft’s dispatcher had not received any training in emergency communications with flight crew, nor in aircraft evacuations at the terminal.

The flight crew were engaged in conversations not confined to the engine start process, or other operational matters during both engine start sequences, until the problem with the right engine was first mentioned by the dispatcher.

The reported smoke and sparks were a result of the right-engine air turbine starter failing during the engine start sequence.

Of the 26 passengers, 11 sustained minor injuries.

As a result of this incident, the operator has undertaken several safety actions to enhance passenger safety. These include: improved aircraft maintenance procedures relating to markings on door slide brackets; defined phraseology to be used in emergency communications between aircraft dispatchers and pilots; door closure procedures for engine starts; improved policy on cockpit discussion restrictions after door closure; and improved cabin crew procedures and training.
Unreliable communication
Unreliable communication can result from a variety of problems including:

- Missing information
- Unnecessary information
- Inaccurate information
- Poor or variable quality of information
- Misunderstandings
- Failing to carry forward information over successive shifts/crew changes.

Effective/ineffective communications
Both social and psychological factors frequently combine in different ways to render communication either effective or ineffective in safety-critical operations.

Quality issues
The quality of information that is transferred from one party to another can be affected by:

- Failures during transmission (e.g. unclear or ambiguous messages)
- Difficulties caused by the medium of transmission (e.g. background noise or distortion)
- Failures during reception (e.g. another message expected, or message misinterpreted or disregarded)
- Conflict between the rational and emotional levels of communication (e.g. arguments)
- Physical problems relating to hearing or speaking (e.g. impaired hearing).

Influences on poor communication
Operational experience and safety occurrences have highlighted several factors that influence poor communication during operations including:

- Physical conditions
- High workload
- Fatigue
- Interruptions
- Stress
- Distractions
- Conflicts and pressures
- Culture
- Gender
- Personality
- Attitudes
- Language proficiency.
Workload and interruptions

Communication in itself can also have an impact on workload and interruptions. Human cognitive resources are strictly limited and are shared between current reasoning processes and actions. Therefore, the efficiency of communication is sensitive to variations in the workload and to interruptions. An increased workload tends to shorten communications and reduce the number of exchanges, with a corresponding increase in communication errors. A person absorbed in a difficult or unfamiliar task is less likely to understand what someone is saying to them. It is always best to wait until the task is complete or stabilised before interrupting them.

Communication requires and consumes mental resources. Unfortunately, as humans our mental resources are limited and it is impossible to go on with a task while at the same time communicating. Therefore, when communications interrupt an ongoing task, a person is less likely to shift their attention to the context of the communication, which can temporarily affect their mental representation and situational awareness.

Under conditions of excessive workload, one of the first signs of degraded situational awareness is a loss of ‘hearing’. If you and/or another pilot is continually asking ATC to repeat their clearance (more often than normal), this may be an early sign of degraded performance.

MANAGING COMMUNICATION

There are certain communication principles common across all industries, and which should be adopted by the entire workforce:

- Communicating effectively with all members of the workforce, both up and down the chain of responsibility, to help ensure that risk management activities are sufficiently comprehensive and understood.
- Endeavouring to raise awareness of potential hazards and risk issues amongst the workforce.
- Ensuring that all those involved with a project are aware of any risks to which they may be exposed, of any relevant limitations inherent in the design or operating procedures, and of any implications for their conduct.
- Discussing the reasons for incidents and near misses with the workforce, so that lessons can be learned.

A number of simple steps can assist in improving safety-critical communication:

- Carefully specify what key information needs to be communicated
- Eliminate unnecessary information
- Use aids (such as logs, computer displays) to help accurate communication
- Repeat the key information using different mediums, e.g. use both written and verbal communication
- Allow sufficient time for communication, particularly at shift/crew handovers
- Encourage two-way communication with both the giver and recipient of the information taking responsibility for accurate communication
- Encourage the asking of confirmation, clarification and repetition
- Encourage face-to-face communication wherever feasible
- Try to develop all employees’ communication skills
- Set standards for effective and safe communication.
SINGLE-PILOT APPLICATIONS

Good communication involves tailoring your message to best fit the audience. In aviation, this is about using standard phraseology and being receptive to what others have to say. Many communication problems develop from a lack of clear or common understanding about respective roles.

If you are a general aviation pilot who normally flies alone, and are planning on taking a fellow pilot with you on a long trip, be sure there is an understanding of your respective roles. To ensure understanding, consider conducting a departure and an approach brief, just as airline pilots do. This may seem like overkill but it is important for the second pilot to be in the loop.

AVOIDING CONFUSION AND ERRORS

The following procedures are good practice in maintaining clear communication and avoiding confusion and errors.

Use correct radio procedures.
- Ensure your radio procedures comply with regulatory and company requirements. Write longer messages (e.g. a clearance), down and read back what you have recorded.

Read back clearances.
- Read back any clearance containing altitude, heading or speed assignments completely. Always read back any hold-short or position-and-hold instructions.
- For longer clearances (e.g. entry into controlled airspace for an instrument approach), you can reduce errors and improve recall, by writing down the information prior to readback. This can provide an extra check to confirm the information written down is the same as that provided by ATC.

When in doubt, verify.
- Always seek verification of any clearances you do not understand; or if two crew members do not agree on the clearance, verify the information rather than guess.

Use full call signs.
- Misunderstandings can occur when full call signs are not used. All communications should be acknowledged with a call sign, not a double click of the mike button or stating ‘Roger’.

Be alert for similar call signs.
- Ensure that the controller and other aircraft involved are aware of similar call signs in use.

Use thoughtful radio technique.
- Listening for a full two seconds before keying a microphone will reduce simultaneous transmissions on the same frequency.

Hearback.
- Pilots should never assume that ATC is listening to their readbacks or that errors will be corrected.

Keep communication simple.
- Clearances, instructions or requests should never contain more than two or three critical items unless preceded by a ‘ready to copy?’
Apply CRM to communication.

- When a particularly distracting problem arises, or the workload becomes unusually heavy in multi-pilot environments, one of the pilots should be made responsible for communication while the other remains in control of the flying.
- Single pilots with high workloads must remove unnecessary distractions and prioritise.

**IMPROVING COMMUNICATION**

**Faults and remedies**

The figure that follows displays some possible communication faults and suggested remedies in terms of creating, sending and receiving messages.

<table>
<thead>
<tr>
<th>Communication stage</th>
<th>Possible communication fault</th>
<th>Remedies</th>
</tr>
</thead>
</table>
| Create the message  | • Message is incorrect  
  – incomplete or missing information  
  – contains the wrong information  
  – is badly worded or presented (e.g. is ambiguous)  
  – Too much information given | • A second person checks the message  
  • Make sure message sender is competent (give training if necessary)  
  • Have rules for presentation and content of messages |
| Send                | • Fail to send message or send too late, message gets lost  
  • Use the wrong communication channel (email instead of conversation)  
  • Send to wrong person | • Make sure sender and receiver understand timelines  
  • Have procedures specifying how information (especially safety-critical) should be presented  
  • Ensure person receiving the message needs the information  
  • Feedback—follow-up on message sent |
| Receive             | • Fail to receive message  
  • Receive message too late  
  • Receive message in a unsuitable state  
  • Partially receive message (obfuscated by noise, damaged or only partial retrieval)  
  • Receiver fails to understand message | • Feedback—sender to ensure that information is received and understood, receiver to send acknowledgement  
  • System in place for resending or reformatting messages |

**Practical rules to improve communication**

- Use standard terms or language. This will ensure that other people share the same image of the situation.
- Speak clearly, concisely and unambiguously. Do not hesitate to have the message repeated if you are unsure.
Do not interrupt other people to give them information that could wait, if their workload is heavy.

Try reframing information you have received. This involves summarising the central theme of a message or piece of information. When you use reframing, you restate what you think the other person is saying, using different words but not changing the meaning of what the person is saying. Reframing can also calm a person if they are agitated or highly emotional as it indicates to them that you are listening and have understood their message.

Practise active listening. It is claimed that about 75 per cent of verbal communication is ignored, misunderstood or quickly forgotten. This is partly due to the fact that we are often occupied with our own thoughts and don’t adequately listen to others.

**KEY POINTS**

This section has addressed the following key points:

- Communication is a dynamic process by which people engage and interpret messages within a given situation or context.
- Unfortunately, history shows that communication error and failures are a contributing factor in many transport accidents.
- Communication is a critical factor for both technical aviation operations as well as in human factors/non-technical skills (eg. leadership, decision-making, teamwork etc.)
- Standard protocols and phraseology should be utilised at all times.
- The most effective method of communication may differ, given the operation at the time. Pilots should be conscious of the most effective means of communicating and the principles mentioned to improve operational safety and efficiency.

When you are ready, please turn to page 41 of the *Workbook for Pilots*, and complete the exercises.

**RESOURCES**

**Further reading**


References


Chapter 6

Teamwork

Effective teamwork is important in many industries. However, teamwork is especially important in higher-risk industries such as aviation, where it can be crucial in avoiding communication breakdown, errors and conflict. This section will discuss elements of teamwork, including supporting team members, conflict resolution, exchanging information and coordinating activities.
Flexible is much too rigid; in aviation you have to be fluid.

Verne Jobst
Successful teamwork occurs when the output of the team is greater than the sum of the efforts of the individual crew members acting in isolation. In a successful team, each individual is empowered and encouraged to contribute in the most effective way to the overall task of the team. This process of interaction is known as ‘synergism’.

Synergism is unlikely to occur however, unless all individual members of the team fully understand their role within the group and how this role may vary with the decisions being made and the actions being taken. Pre-requisites for the creation of synergy and high team performance depend on effective communications within the group, a high degree of situational awareness and a comprehensive understanding of the decision-making process of the group.

For operational reasons, flight teams frequently have many new crew members on each flight. It is important that the culture of the organisation encourages and fosters a climate in which good teamwork can flourish. A healthy organisational culture actively promoting crew resource management (CRM) also fosters good teamwork, since CRM and teamwork are integral to effective flight management techniques.

When it goes wrong

Sound teamwork in aviation operations reduces and mitigates error, at the same time promoting safety and efficiency. Teamwork failures have contributed to many aviation accidents. The CRM and other human factors training programs have been developed in response to these findings.

The case study below illustrates how the flight crew members did not perform as a team, but rather as individuals. The group failed to focus on a critical aspect of the flight.

**Low fuel-state**

On 28 December 1978, during an approach to Portland International Airport (Oregon), a United Airlines DC-8 crashed in a populated area of suburban Portland. The accident resulted in the loss of the lives of eight passengers, the flight engineer and a flight attendant.

The captain had delayed landing the aircraft for about an hour, while the flight crew coped with a landing gear malfunction warning. The investigation determined that the accident probably occurred because the captain failed to monitor the fuel-state of the aircraft properly and didn’t respond to advice from crew members about the low fuel. This failure resulted in fuel exhaustion to all four engines.
The captain, and to a lesser extent the crew, had developed a ‘set’ in which all their attention was concentrated on the possible landing-gear malfunction and directing cabin crew to prepare for an emergency landing. They failed to consider other important factors such as the low fuel-state. Both the first officer and the flight engineer commented on the low fuel, but their comments were too half-hearted to make an impact on the captain.

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**Crew resource management (CRM)**

As a result of this and other accidents in the United States, the National Aeronautical and Space Administration (NASA) and the National Transportation Safety Board (NTSB) issued recommendations to the Federal Aviation Authority (FAA) and the airline industry to adopt methods encouraging teamwork.

Teamwork was explained in the context that while captains are in command, they rely on other crew members for vital safety-of-flight tasks, sharing duties, information and help.

United Airlines was one of the first airlines in the USA to adopt this concept in the form of crew resource management (CRM). A United Airlines DC-10 flight crew involved in a subsequent accident in 1989 credited CRM training with providing them with the skills to cope successfully with an extreme situation for which no pilot in the world had been trained. The case study below summarises this incident.

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**The effectiveness of teamwork**

While cruising at FL370 on a flight from Denver to Chicago, the number 2 (centre) engine of United Flight 232 suffered an uncontained failure. The captain asked for the engine shutdown and checklist to be started.

As the flight engineer began the checklist, he noticed that all three hydraulic systems were losing pressure and quantity. The flight crew were unaware that shrapnel from the engine had damaged all three main hydraulic lines in the tail, rendering it virtually uncontrollable.

The first officer disconnected the autopilot and attempted to level the aircraft, but found that he could not control the aircraft. Meanwhile, the aircraft had begun to descend. The captain attempted to fly the aircraft via his controls, but with the same result. He eased the power on the port engine and the excess thrust on the starboard side began to roll the aircraft to a wings-level attitude.

The crew realised that they were unable to move any of the aircraft’s control surfaces and had only the engine power of the left and right engines to control the aircraft. With engine thrust only, the flight crew and a deadheading captain lined up a runway at Sioux City’s Gateway Airport, but could not accurately control the airspeed and sink rate.

The aircraft descended at over 1,600ft per minute, at around 225 knots. In an incredible feat of airmanship, the crew managed to touch down near the beginning of the runway just off the centreline. Unfortunately, the starboard wingtip touched down just prior to the landing gear, pulling the aircraft sideways. The excess airspeed and high sink rate caused the aircraft to break up on impact, igniting into a huge fireball. While more than 100 people perished in the accident, 185 people survived the accident, including all four crew members in the cockpit.
Subsequent simulator tests showed that other DC-10 crews were unable to repeat the effort of the crew of United Flight 232. Investigators concluded that it was almost impossible to land the damaged aircraft on a runway. The crew of the ill-fated aircraft was highly praised for their team work in landing the aircraft just off the runway centreline saving many lives.

After the accident, the captain spoke about the accident at many conferences as well as writing papers advocating the importance of teamwork and flight crew co-ordination. Some pertinent points from Captain Haynes’ writings are quoted below.

*I am firmly convinced that CRM played a very important part in our being able to land at Sioux City with any chance of survival. I also believe that its principles apply no matter how many crew members are in the cockpit.*

Those who fly single-pilot aircraft sometimes ask, ‘How does CRM affect me if I fly by myself?’ Well, CRM does not imply just the use of other resources available in the cockpit - it is an ‘everybody resource’. To these pilots I say that there are all sorts of resources available to them (air traffic control, flight attendants etc.).

All pilots have a lot of help available to them; all you have to do is ask for it, and use it when you get it. The bottom line for pilots is that you have resources available to you. Use them as team members - you are not alone up there. If you do have a co-pilot, listen to them. They are sure to have some advice for you.

There were 103 years of flying experience in that cockpit when we faced our end and they came through to help - but not one minute of those 103 years had been spent operating an aircraft the way we were trying to fly it.

*If we had not worked together, with everybody coming up with ideas and discussing what we should do next and how we were going to do it, I do not think we would have made it to Sioux City. Captain Al Haynes.*

### ELEMENTS OF TEAMWORK

Teamwork consists of a number of elements as discussed below.

**Supporting others**

Effective teamwork includes providing support to other team members by:

- Sharing work load when appropriate
- Accepting responsibility for your role
- Maintaining good working relationships
- Establishing openness.

**Solving conflicts**

Conflict between team members may arise when roles and responsibilities are not clarified. It is good practice to discuss and define the task clearly and who will assume particular duties. For example, the roles and expectations of the pilot flying (PF) vs pilot not flying (PNF) should be fully discussed.
Another potential area of conflict is interpersonal conflict, which is usually managed by remaining objective and un-emotional, with an assertive manner. At times, this can be challenging.

Research and accident investigations have demonstrated that team members who perceive themselves as lower in status are less likely to be assertive or to challenge others, as illustrated by the following case study.

Doing nothing to intervene

The pilot, a senior manager in the airline and known to be somewhat hot-tempered, commanded a twin-prop commuter aircraft. His first officer, a junior in the company, was still on probation. At the end of an already long day, the captain was asked by company operations to pilot another flight. He reluctantly undertook it, but was clearly annoyed.

During the approach at the end of this leg, the first officer went through the approach checks but received no response from the captain. Rather than questioning or challenging the captain, the first officer remained quiet to let the captain concentrate on the landing. The aircraft flew into the ground short of the runway without the first officer intervening.

The investigation revealed that the captain failed to respond to checks, not because he was in a bad mood, but because he had died during the approach.

Exchanging information

Exchanging information enables a shared understanding (or mental model) of a situation to be established. The concept of shared mental models has been proposed as a means to explain coordinated performance in teams. Through teamwork, crews develop shared understanding of the nature of problems, solution strategies, cue significance (e.g. the implications of emergency language such as ‘pan, pan, pan’ and ‘mayday’) and participants’ roles and responsibilities. Having a shared understanding means all participants are solving the same problem and creates a context where everybody can contribute.

Communication is vital so that individuals can develop and coordinate activities to achieve goals. Therefore, communication is the mediator of team processes. The flight-deck command structure is a crucial factor which can affect information sharing. The captain remains largely responsible for the flight and makes any major strategic and tactical decisions regardless of whether or not they are the pilot flying.

While one person may have ultimate responsibility for decision-making and the overall safety of the flight, team members provide critical redundancy. In addition to performing their own tasks, team members support each other by monitoring the situation and the performance of others. This ‘cross-monitoring’ allows ‘primary errors’ (procedural, technical or decision errors) to be detected and rectified before they cause problems.

According to research, reduced errors occur when flight crew members verbalise pertinent information and challenge the actions and decisions of others. Reviews of accidents and incidents indicate that it is the captain who usually commits the primary error, and the first officer who then fails to catch or correct it. These errors are significant, as they often represent the last opportunity to break the chain of events leading to an accident. Failure to challenge another crew member’s questionable decision or action may occur by choice, or because of pressure not to say anything.
On the flight deck, the captain has responsibility for the flight and is effectively the senior member or leader of the team. The relationship or command structure between the captain and first officer is referred to as the ‘trans-cockpit authority gradient’. Figure 7 illustrates the different gradient relationships that may occur between a captain (C) and the co-pilot (CP).

**Figure 7  The trans-cockpit authority gradient**

Essentially, the angle of the slope describes the power relationship between the two individuals:

- If the cockpit gradient is flat the captain is adopting a weak leadership role with a consequent lack of authority.
- A steep gradient may result in the co-pilot feeling unable to question any of the captain's actions or decisions.

In any multi-crew operation, crew coordination is vital to safe and effective flights. While the captain has overall responsibility for the safety and success of the operation, this fact does not absolve other crew members from their responsibility to do all that is reasonable to improve safety and effective operation.

Flying in a multi-crew environment is unquestionably a team effort. No single member is any less, or any more valuable than any other. During periods of high workload or high stress, it may be very difficult to ensure critical information is assimilated and acted upon appropriately. It is the responsibility of the crew – collectively and individually – to ensure that critical information is passed, understood, and acted upon in a manner that fits the situation. The following case studies illustrate how this can go wrong.

**Going along with the captain**

A Douglas DC-3C freighter was on a charter flight in Canada. At the previous station stop, fuel calculations by the captain and the first officer differed. The first officer (who had much less flying experience than the captain), accepted the captain’s fuel calculations, and did not assert himself regarding the aircraft’s potentially low fuel.

While turning final for runway 31 at Fort Simpson, the flight crew advised the Flight Service Station that they were attempting a forced landing on a road. The aircraft crashed into trees about half a nautical mile short of the runway and was substantially damaged. The first officer was seriously injured and the captain received minor injuries. The investigation found that the flight started with less than the minimum required fuel, resulting in loss of engine power because of fuel exhaustion. Lack of flight crew co-ordination was found to be a contributing factor.
In multi-crewed aircraft, teamwork is essential to the detection of errors such as fuel management. Effective cockpit communications are vital to good teamwork. Neither the captain nor the first officer had received formal training from this company in CRM, although the captain had taken a CRM course with a previous employer.

Ah, that’s not right

After take-off from Washington National Airport, Air Florida Flight 90, a Boeing 737, crashed into the 14th Street Bridge and plunged into the Potomac River.

On the previous leg, the crew had flown the aircraft from warm Miami to freezing Washington. Their limited experience in jet transport winter operations was reflected in a number of poor decisions.

When conducting their start checklist, the first officer called out ‘anti-ice’ (the system which protects the engines from the effects of ice and slush); to which the captain, incredibly, answered ‘Off’. As they were taxiing out to the runway they decided to tuck themselves close behind a New York Air DC-9, thinking that the heat from the DC’s engines would thaw out deposits of snow and ice on their aircraft. However, the heat from the DC-9’s engines was effectively melting the snow, enabling it to refreeze as infinitely more threatening ice.

As the B737 began its take-off roll, the first officer expressed concerns three times:

First Officer: Ah, that’s not right.
Captain: Yes, it is, there’s 80 [referring to speed].
First Officer: Nah, I don’t think it’s right. Ah, maybe it is.
Captain: Hundred and twenty.
First Officer: I don’t know.

The first officer was referring to the grossly inflated readings on the engine instruments as a result of the ice build-up in a sensor. Since the speed indicators were too high, the captain applied too little power as the aircraft ascended.

No positive action was taken to address the first officer’s concerns by the captain and the first officer did not press the point.

As Flight 90 began its take-off down the runway, the captain on another aircraft waiting to take-off, commented to his crew, ‘look at all that junk on that aircraft’. The B737 staggered off the ground and shortly after hit the bridge, tearing up massive lumps of concrete. The plane then fell into the icy waters of the river. Only five of the 79 people on board survived, and many people inside their vehicles on the bridge were killed. The flight crew coordination failed at a critical moment – and an opportunity to prevent the accident failed because the first officer wasn’t sufficiently assertive in conveying his concerns.
Coordinating activities
Rather than working as highly-skilled individuals, working as a team reduces possible errors, breakdowns in communication and conflicts. With coordinated activities, workload can be shared or delegated to ensure any one team member is not overloaded. In addition, team members can monitor the performance of other team members and provide support as required. Lack of coordination was infamously displayed in the Sioux City accident, a previous case study in this section.

Unfortunately, there are other examples where pilots have not operated effectively as a team. Another example of this can be found in the accompanying workbook, on page 51. The cockpit voice recording from this accident indicated that the level of CRM was low and the crew performed poorly as a unit. In this sense, the ‘safety net’ which good CRM provides, was absent.

CHARACTERISTICS OF TEAMS
Certain characteristics define good teamwork:
- Individual task proficiency (members should be competent at their own task, but also possess good team skills)
- Understanding the role and duties of other team members
- Good communication
- Motivation to perform as a team
- Shared goals about the task being undertaken
- Understanding decision making strategies and individual differences within these.

CONDITIONS FOR TEAMWORK
Conditions enabling teams to function effectively are:
- Effective and balanced leadership
- Clear, two-way communication
- Clear role allocation
- Shared understanding about goals
- Clear operating procedures
- Balanced participation
- Effective feedback.

SINGLE-PILOT APPLICATIONS
A good team manager recognises individuals have different strengths and limitations. Effective team managers are measured by how well they harness individuals to work together in a coordinated effort. This competency applies not only to multi-crew operations, but also for single pilots even though the team may be outside the aircraft.

The term ‘single pilot’ suggests that the individual flying the plane does so in isolation. It is often overlooked that many sources of assistance are available to a single pilot—even passengers. For example, if a pilot selects gear-down in the circuit area and discovers that three green lights are not showing, the pilot can make
a radio call to a team of people willing to share their expertise.

The pilot may call on the local tower or other pilots on the ground to do a fly-by. If these resources are not available, the pilot may seek advice from the local LAME. If the pilot needs to land with gear up, the pilot should ensure that local emergency services are put on stand-by. Remember, you are almost never alone!

**KEY POINTS**

This section addressed the following key points:

Good communication and crew coordination are as important as technical proficiency for flight safety.

Benefits of team coordination include:

- Increased efficiency by the organised use of all existing and available resources
- Improved in-flight management
- Increased safety by building in redundancy to monitor, detect and correct individual errors.

Fewer crew errors occur with good information sharing:

- High number of crew observations about flight status
- Statement of intent to perform actions
- Acknowledgement of messages from others
- Verbal agreement.

*When you are ready, please turn to page 47 of the Workbook for Pilots and complete the exercises.*

**RESOURCES**

**Further reading**


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Chapter 7

Leadership

This section examines ‘leadership’ and what makes a good leader. Case studies are presented demonstrating the critical role leadership plays in aviation, and how one Australian airline defines core command skills. Followership and assertiveness for junior crew members are also discussed, as well as methods for practical assertiveness. Finally, the focus in the last part of this section is on one of the most critical attributes of any leader in a safety-critical environment such as aviation: the willingness to report safety incidents.
Leadership consists not in degrees of technique, but in traits of character; it requires moral, rather than athletic or intellectual effort, and it imposes on both leader and follower alike the burdens of self-restraint.

Lewis H. Lapham
OVERVIEW

Leadership is not an easy concept to define, and is even harder to put into practice successfully.

A team leader is defined as:

The person who is appointed, elected, or informally chosen to direct and co-ordinate the work of others in a group

(Fiedler, 1995: p7).

On the other hand, leadership is defined as the art of getting others to do (and want to do) something that the leader believes should be (must be) done, involving interpersonal influence, goal-setting and communication (Furnham, 2005).

Consider the following model.

Table 23 Leadership

<table>
<thead>
<tr>
<th>Category</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>Using authority</td>
</tr>
<tr>
<td></td>
<td>Maintaining standards</td>
</tr>
<tr>
<td></td>
<td>Planning and Prioritising</td>
</tr>
<tr>
<td></td>
<td>Managing workload and resources</td>
</tr>
</tbody>
</table>

Figure 8 Leadership/followership model (FAA, 1998)
According to the model, effective and efficient flight operations occur in a number of influencing environments:

- Regulatory (CASA)
- Physical (weather and terrain)
- Corporate (the airline or organisation); and
- Market (financial and aviation industry forces).

Within the cockpit there must be a leader (captain) and a follower (subordinate crew members). Each crew member brings to the cockpit knowledge, skills and attributes, which need to be communicated regularly for the team to function effectively. How that interaction is established is the big question mark!

Team leadership is about directing and coordinating the activities of team members; encouraging them to work together; assessing performance; assigning tasks; developing team knowledge, skills and abilities; motivating; planning and organising; and establishing a positive team atmosphere (Salas et al., 2004). The thoughts and behaviour of others in the team are influenced by the team leader’s ideas and actions.

According to Flin, O’Conner & Crichton (2008) safety research has shown that the most effective leaders of multi-disciplinary teams, whose team members must coordinate action in risky, uncertain, dynamic situations, are those who communicate a motivating rationale for change and minimise concerns about status differences. This encourages their team members to speak up and engage in more proactive coordination. In other words, good leaders in the cockpit will not be concerned about the number of gold bars they are wearing.

Good leadership involves being flexible and adapting your leadership style to the situation at hand. Consider the following model from Kenneth Blanchard’s Model of Situational Leadership. (Blanchard et al, 1985).

**Figure 9 Situational styles of leadership**

<table>
<thead>
<tr>
<th>Participating</th>
<th>Selling (Coaching)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supportive, facilitative</td>
<td>Guidance and direction</td>
</tr>
<tr>
<td>Frameworks and examples</td>
<td>Explanation and encouragement</td>
</tr>
<tr>
<td>Share responsibility</td>
<td>Involve team in problem solving and goal setting</td>
</tr>
<tr>
<td>Ask team to problem solve and action plan</td>
<td>Listen for concerns/ideas</td>
</tr>
<tr>
<td>Listen and encourage</td>
<td>Make final decisions</td>
</tr>
<tr>
<td>Praise and reassure</td>
<td>Explain why...</td>
</tr>
<tr>
<td></td>
<td>Share knowledge and expertise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Delegating</th>
<th>Telling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giving freedom, trusting</td>
<td>Strong directive</td>
</tr>
<tr>
<td>Support and monitoring</td>
<td>What, where, when and how</td>
</tr>
<tr>
<td>Team take lead in goal setting, action planning and decision making.</td>
<td>Define job, identify goals</td>
</tr>
<tr>
<td>Encourage self-evaluation</td>
<td>Lead action planning</td>
</tr>
<tr>
<td>Challenge</td>
<td>Provide instruction</td>
</tr>
<tr>
<td></td>
<td>Team’s level of competence, experience, motivation and commitment</td>
</tr>
</tbody>
</table>

The above model implies that leadership styles must be flexible to fluctuating demands. When time is critical, a more directive (telling) style is required. When there is the luxury of time to consider a problem, a supportive (participating) style is the best.
What are the skills needed for effective leadership?

How do you spot a good leader in the cockpit? When there is strong leadership in a team you would expect to see the following:

- Captains taking responsibility for performance and giving their team the time and support to maintain their duties under effective control
- A visible commitment to safety and the care of others
- Captains, leading by example inside and outside the cockpit
- Captains demonstrating that they care about their own safety and that of others, and won’t tolerate unsafe behaviour
- Promises delivered.

When a team is not functioning well, and leadership is ineffective, we might expect to see some of the following:

- Captains saying one thing and doing another
- Captains having one set of rules for themselves and another set for subordinate crew members
- Safe behaviour having to be remembered rather than being instinctive
- Captains exhibiting inappropriate behaviour when under pressure
- Captains blaming subordinate crew members for poor performance.

Effective leadership helps in the safe completion of tasks within a motivated, full-functioning team, through coordination and persuasiveness. Even self-managed teams have someone who influences the team, although this may change depending on the situation. The British Civil Aviation Authority (CAA) has defined the leader on an aircraft as ‘a person whose ideas and actions influence the thought and the behaviour of others. Through the use of example and persuasion, and an understanding of the goals and desires of the group, the leader becomes a means of change and influence’ (CAA, 2006: Appendix 7, p. 3).

Generally speaking leadership is about demonstrating the following qualities.

Use of authority and assertiveness

This refers to the ability to create a proper challenge and response atmosphere, by balancing assertiveness and team member participation, and being prepared to take decisive action if the situation requires it. Leaders must also know when to apply their authority to achieve safe completion of a task.

Providing and maintaining standards

This relates to compliance with essential standards, e.g. standard operating procedures (SOPs and others) for task completion, as well as supervision and intervention that may be required due to deviations from standards by other team members.

Planning and prioritising

This describes how leaders apply appropriate methods of planning and prioritising for tasks and delegate roles to achieve best performance. The communication of plans and intentions is important.

Managing workload and resources

Leaders must manage not only their own workload and resources, but also that of the team. This involves understanding the basic contributors to workload and developing the skills of organising task-sharing to avoid workload peaks and dips. Causes of high workload include unrealistic deadlines and being under-resourced.
According to Flin (1996) the most effective leaders:

- Diagnose the situation (the task/problem, the mood, the competence and motivation of the team),
- Have a range of styles available (eg. delegative, consultative, coaching, facilitating, directive), and
- Match their style to the situation.

Studies examining the effectiveness of military teams (Salas & Cannon-Bowers, 1997) found that the following skills are essential:

- Defining the social structure, encouraging open communications and exhibiting self disclosure to develop team cohesion.
- Using effective communications and informing the other team members about matters affecting team performance.
- Planning, structuring and coordinating the team.
- Maintaining the team focus on their task.
- Asking for input from other team members and openly discussing potential problems.
- Maintaining coherence within the team by managing situation awareness.
- Providing feedback to the other team members, the degree of successful feedback depending on the leader’s style.
- Adjusting the leader’s role to match team progress.
- Defining and encouraging team goals and performance to promote commitment and consensus.

**CORE SKILLS TO MAKE AN AIRLINE CAPTAIN?**

A *Flight Safety Australia* article ‘Mind over matter’ summarises the eight key behaviours that a major airline regards as essential for command. These are summarised below, with supporting examples.

**Deciding:** This competency is concerned with efficient decision making and the willingness to evaluate whether the actual decision was the right one, given the circumstances. Good decision makers are measured by their ability to consider all the available options and remain flexible to fluctuating demands.

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**The right decision**

Airline pilots are often faced with time-critical decisions. In a recent incident, a B747-400 aircraft had departed Auckland bound for Los Angeles. At the top of climb, the customer service manager requested oxygen for a passenger who was having difficulty breathing. Two doctors on board examined the passenger, but unfortunately his condition deteriorated rapidly. The captain decided to carry out a high-speed descent back to Auckland, and in doing so, had to consider the overweight landing limitations of the aircraft, the amount of fuel to be dumped, coordinating descent clearance with ATC, communicating with cabin crew, as well as organising medical personnel to be waiting at the gate in Auckland. A mere three minutes had passed from the time the captain was informed of the passenger’s condition to the start of the air turn-back. This demonstrated very efficient decision-making on the captain’s behalf. It also proved to be the right decision for the passenger.
Commanding: This competency is about how well you manage and encourage people to maintain high work standards. Good commanding is also about understanding and following the regulations to ensure safe compliance. One of the key aspects of this behaviour is responding appropriately to emergencies. This may be managing operational problems on the flight deck, such as traffic collision avoidance, or responding to emergencies in the cabin, such as medical problems or disruptive passengers. Strict adherence to SOPs is one of the most critical success factors as it helps the error mismanagement rate. Consider the following flight and the strong SOP adherence by the crew and resultant good error management.

SOP adherence = good error management
At the dispatch desk, the captain and first officer discussed possible delays and planning requirement problems due to the day’s pattern of flying, which consisted of a mix of domestic and international sectors. They brought dispatch into the loop with their contingency plans. At the aircraft, there were 13 hold items in the techlog, which required the captain’s perusal and the application of the DDG MEL for two items. This was done in conjunction with the first officer for cross-verification. The load sheet needed correction with the number of people on board. This was done and load control informed. The flight attendant briefing set the tone for a cooperative cabin crew. The overall pre-flight taxi-out procedures were well handled.

The takeoff and climb was flown well with good use of automation. Weather conditions were fine with light winds. No problems were evident in this phase of flight, with the aircraft smoothly flown and good situational awareness.

The briefing for arrival using and cross-checking Jeppesen plates, minima etc, was carried out in a thorough and systematic manner prior to top of descent. The aircraft descended on VNAV profile and kept on it by close monitoring and occasional use of speed brake. All ATC requirements were complied with, and the aircraft was configured for arrival appropriately, which culminated in a very well-flown approach, manually from 2000ft in visual conditions. The landing was smooth in the correct touchdown zone.

The above sector was well executed by the captain flying, with disciplined support from the first officer. The possible threats to the operation were dealt with effectively through the strict application of SOPs.

Self control: This is about keeping a cool head in an emergency, keeping your emotions in check and concentrating on getting the job done calmly and professionally, despite what might be going on around you. This competency is important regardless of what aircraft type you operate.

Birdstrike
Calm and professionalism were demonstrated on the flight deck of a B737-400 departing Sydney bound for Auckland. At about 2,000ft AGL, the first officer sighted three birds passing below the nose of the aircraft to the right. Shortly after, vibration was felt throughout the aircraft and smoke was observed in the cabin. The right engine indicated rising engine gas temperature (EGT). The crew shut down the right engine using the non-normal checklist and made a Pan-pan call. The captain made an announcement to the passengers to ensure they were informed and remained calm. The aircraft returned and landed uneventfully on runway 34L. After the incident, the captain, in keeping with the professional and calm way the event was handled, conducted an operational debrief to ensure the cabin crew understood what
had happened. Investigation of the incident revealed that three pigeons had been ingested into the right engine and had fractured a fan blade, which partly broke away and entered the engine.

**Team managing:** A good team manager recognises that individuals have various strengths and limitations. Effective team managers are measured by how well they can harness individuals to work together in a coordinated effort.

A good leader will establish clear expectations and lead by example.

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**Good teamwork**

Excellent teamwork occurred on a B737-400 flight that was scheduled to operate from Melbourne to Canberra. During taxi for RWY27 at Melbourne, smoke and a strong acrid odour became evident in the cabin. The customer service manager reported to the captain that the source appeared to be the forward galley oven. The intensity of the smoke and odour increased and entered the flight deck.

As the cabin crew prepared themselves to combat the potential fire hazard, the first officer contacted ground control to inform them of the situation and to request assistance from company engineers to inspect the aircraft. The captain made a public announcement to the passengers to inform them of the situation and a ground return was executed. Good teamwork and coordination was displayed by all crew, and in particular, the captain demonstrated excellent command delegation. Company engineers later discovered that the source of the smoke was a discarded cloth hand towel left behind in the forward galley oven.

Consider how the captain of the following flight, during the pre-departure phase, failed to set a cooperative tone for the flight.

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**Captain sets the tone for the flight**

The captain made little attempt at team building. Each crewmember took a task at flight planning and worked in silence. The captain handed the first officer a completed fuel order without comment. The second officer had not even finished checking the Class 2 Intams when the captain started to leave. There was little interaction and cross-checking during flight planning. During the pre-flight, each crewmember completed their tasks in isolation. The captain checked the techlog and advised that there was nothing special about the minimum equipment list (MEL). The MEL was not cross-checked by the other pilots. Engineering asked for hydraulic pressure, giving no reason and the crew did not ask for an explanation. The second officer returned from the walk-around to say, ‘they think they have fixed the leak’. The captain did not respond. The first officer asked, ‘what leak?’ The second officer then briefed the first officer facing him on what he knew, with the captain ignoring them and continuing his pre-flight. An engineer brought up the techlog and explained to the second officer that an entry had been made and that they had tightened the nut that they thought had caused the leak. The entry in the log was not sighted or assessed. The captain never became involved. The departure brief was given verbatim with nil interaction from the other crew, simply covering the requirements of the flight manual.
**Communicating:** Good communication involves tailoring your message to best fit the audience. In aviation, this is about using standard phraseology and being receptive to what others have to say. Many communication problems develop from a lack of clear or common understanding about respective roles.

**Poor team communication**

The briefing was completed by TOD, given by the captain as read from a book, and there was little interaction from other crew. There was no use of the flight interphone, which led to the second officer being left out of most of the communication between the captain and first officer and the first officer missing a frequency change. The second officer picked the missed frequency change; the first officer asked ‘who?’ and the captain said ‘approach, I think’. No altimeter call on descent was done to SOPs. Neither ATC nor crew used recommended call-sign phraseology. The approach check was missed, as was the altitude check at 10,000ft. The second officer highlighted the missed check at 9000ft and called ‘altimeters’ on the other occasions. The captain made a change in the FMC and executed it without advising the first officer at 20nm to run. The captain did not check the ILS prior to use, but the first officer and second officer did. The autopilot was disconnected at 1600ft and glideslope intercept occurred at 2500ft. The second officer called ‘1000 to go’, approaching final level-off before glideslope intercept. Neither the captain nor first officer gave the correct response. The second officer also picked up that the missed approach altitude had not been set in the MCP window. The 2000ft call was not made, and there was no response from the captain to the 1000ft challenge. The auto brakes disconnect call was missed by the first officer, and made by the second officer. No manual braking was used until approaching the taxiway turnoff and then brakes had to be applied forcefully to reduce ground speed below 40 knots.

In contrast to the above, consider the following communication between the flight and cabin crew shortly after take-off.

**Plain language**

An example of excellent communication occurred on a B747-400 flight from Los Angeles to Sydney. During the take-off roll, a flight attendant heard a loud bang coming from under the aircraft, followed by a loud flapping noise. The CSM was informed, and instead of the information being relayed and unintentionally filtered, the CSM instructed the flight attendant to describe what she had heard directly to the captain. From the explanation given, the captain contacted Los Angeles and asked them to search the runway to ascertain whether something had fallen off the aircraft. A ground crew subsequently found a strip of rubber thought to have come from one of the tyres of the main body gear. This information enabled the crew to prepare for a possible tyre-out landing in Sydney, and the aircraft landed without incident. However, the actions of both the CSM and captain ensured that the information communicated was done so accurately.

**Systems knowledge:** This competency is about having a good understanding (mental model) of the aircraft you are flying, particularly its operational systems.
Electrical system failure
To ensure that pilots have good systems knowledge, most airlines invest a lot of time and money in flight training, so that responding to a problem such as an electrical system failure becomes a familiar routine. This was the case for the crew of a B767-300 aircraft, which experienced an electrical system failure between Hong Kong and Melbourne. The B767 aircraft has three generators or IDGs (integrated drive generators). There is a generator on each of its two engines and a generator run off the auxiliary power unit (APU) located in the tail of the aircraft. On this occasion, the right IDG failed and the APU was started. However, the APU indicated low oil, and had to be shut down. With only one electrical system remaining, the flight crew declared a Pan-pan and diverted to Darwin. The right IDG was replaced and oil topped up in the APU.

Flexibility: This competency involves adapting to changing circumstances and demonstrating a willingness to learn from mistakes – both your own and those of others. The aviation environment is such that often your game plan may have to change. If you are landing at an airport where the actual weather differs from that forecast – be prepared to adapt to changing circumstances. Even if you are on final approach and you notice the windsock indicating a 15kt tailwind, be flexible enough to go around. It is standard practice for airline pilots to brief themselves on the ‘what ifs’, given a go-around situation. There is no reason why you cannot apply this same standard by mentally briefing yourself.

Foreign object damage
The crew of a B767-300 scheduled to fly from Sydney to Cairns demonstrated flexibility. The aircraft was configured for take-off on runway 16R. On rotation about 100-200ft AGL, a series of six loud bangs was heard from behind the aircraft. The crew initially assumed that a tyre may have shredded. Observers on the ground, including ATC, observed flames extending the full length of the rear fuselage, and ATC contacted the crew to report their observations. The right engine indicated rising engine gas temperature and the aircraft’s performance began to degrade. The right-engine thrust was retarded to idle, and the thumping ceased. The captain requested a 1500ft visual circuit for runway 25, but during the base leg it became apparent that a visual approach would be difficult due to a passing rain shower. Rather than conduct an approach that he was not completely comfortable with, the captain elected to climb to 2100ft and overfly the field, and be radar vectored for an approach to runway 16R. The aircraft landed without incident, and after turning on to the taxiway, fire tenders inspected the engine and found no further indications of fire. Investigation revealed that the damage to the engine was caused by foreign object damage (FOD) most probably during the last ‘A’ check.

Overview: This competency is about being able to see the big picture and knowing what is going on around you – commonly called situational awareness. It also means not becoming distracted by niggling problems and thereby failing to perform the two fundamental tasks of flying – aviation and navigation. Seeing the big picture involves making the effort to stay ahead of the situation and knowing what is going on around you. To maintain good situational awareness, try conducting the ‘mental jump seat’ exercise. This is like sitting on the jump seat of your own flight so that you are an objective observer. Continually ask yourself three questions:
’Where am I?’; ’Where am I going?’ and ’What will I do when I get there?’ If you know the answers to these three questions at any given point in your flight – you have a good overview of your situation.

The following flight illustrates the important role of situational awareness.

**Am I still back in Sydney?**

During the cruise, the first officer was out of the loop trying to call the company for a bay number in Canberra. The approach briefing was conducted just after the flight management computer generated TOD, due to the fact the first officer was having trouble raising the company on the radio. Throughout the descent, the first officer was behind the aircraft and preoccupied with the radio. There was marginal cross-check behaviour as only one pilot listened to the ATIS. ATC asked if they could make a visual approach, turning inside Church Creek and remain visually clear of the noise-sensitive area. The first officer advised immediately that they could accept, but the captain suggested that he rescind the call with a requirement for radar vectors onto the localiser, due to glare from the sun. Throughout the approach, the captain made some speed selections on the MCP without consultation with the first officer, and it was he who initiated the 2000ft and 1000ft calls, as the first officer was well behind the aircraft. The aircraft continued to have a high rate of descent until intercept of the glide path around 800ft AGL. From that point on, the approach was stable and landing was good.

The first officer on the above flight was poorly prepared for the flight and throughout each phase of flight was well behind the aircraft, commenting after landing that ’I am still back in Sydney’. However, the captain displayed poor leadership and should have left the bay allocation to landing and asked the first officer support him.

In contrast to the above example, consider the ’good overview’ displayed by a second officer on the following flight.

**Cabin signal**

A second officer on board a B747-400 demonstrated good overview. There were many distractions for the flight crew prior to pushback. The aircraft had a faulty APU, which was distracting for the pilots conducting their pre-departure checks, as engineering staff made multiple trips to and from the flight deck. The lack of air conditioning and the 40°C temperature inside the aircraft also created an uncomfortable work environment. In addition, the sector was a route check for the first officer, which placed extra pressures on the captain. The aircraft pushed back 10 minutes after its scheduled departure time and was then faced with a long 14-minute taxi. As the captain manoeuvred the aircraft on to the runway, he forgot to give the cabin crew a warning (three chimes) to be seated for takeoff. Cabin crew are normally provided with a minimum of 60 seconds’ warning that the aircraft is about to take off. This warning is important, so that they are sitting down in their allotted seats and can mentally prepare themselves to be ready for a potential emergency on takeoff. On this occasion, one of the second officers on board had the ’big picture’ and was able to remind the captain that the cabin signal had not been given.
In summary, while the eight command competencies developed for these captains are just as relevant for any pilot, they are not instantly acquired. Like an aircraft, they require continual maintenance and nurturing throughout your flying career. Flight crew are referred to Chapter 11 Airmanship in this resource guide for more information on developing leadership capabilities.

**LEADERSHIP UNDER STRESS**

Team leaders in flight operations are sometimes faced with occasions when they may be required to lead in an emergency, i.e. take on an incident command role. The knowledge, skills and abilities of the leader in this role can play a major part in managing an incident (Flin, 1996).

Team leaders’ behaviours under stress often differ from those of team leaders in normal work situations. Under stressful conditions, team leaders typically initiate almost all team communications, consisting of commands, suggestions, observations and statements of intent and, although team leaders may be more receptive to task inputs from team members, they can be less likely to defer to those inputs. Insufficient time is usually a critical factor in which decisiveness rather than consultation is required to respond within a diminishing window of opportunity.

A summary of characteristics and competencies for leaders under stressful situations is provided in Table 24.

**Table 24  Summary of characteristics and competencies for leading under stress**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader characteristics</td>
<td>Willingness to take a leadership role</td>
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<tr>
<td></td>
<td>Emotional stability</td>
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<td>Stress resistance</td>
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<td></td>
<td>Decisiveness</td>
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<td></td>
<td>Controlled risk-taking</td>
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<td></td>
<td>Self-confidence</td>
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<td></td>
<td>Self-awareness</td>
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<tr>
<td>Leader competencies</td>
<td>Leadership ability</td>
</tr>
<tr>
<td></td>
<td>Communication skills, especially briefing and listening</td>
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<tr>
<td></td>
<td>Delegating</td>
</tr>
<tr>
<td></td>
<td>Team management</td>
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<tr>
<td></td>
<td>Decision-making, under time pressure and especially under stress</td>
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<tr>
<td></td>
<td>Evaluating the situation (situation awareness)</td>
</tr>
<tr>
<td></td>
<td>Planning and implementing a course of action</td>
</tr>
<tr>
<td></td>
<td>Remaining calm and managing stress in self and others</td>
</tr>
<tr>
<td></td>
<td>Pre-planning to prepare for possible emergencies</td>
</tr>
</tbody>
</table>

One of the most famous examples of exceptional leadership under stress is the case of Flight 143, a B767 on a routine flight from Montreal to Edmonton, via Ottawa, under the command of Captain Bob Pearson. There is a summary of the incident as recounted by Reason (2003) in the accompanying workbook.
FOLLOWERSHIP

Followership is defined as the ability to be a good team player and to help a recognised leader effectively; or the ability to contribute to task and goal accomplishment, through supportive technical, interpersonal and cognitive skills. Without followers, there are no leaders or leadership. For a follower, the skills are exercised in a supporting role that does not attempt to undermine the leader. This can be noted by how the leadership behaviour of a manager or team leader influences subordinates’ reactions towards the manager as a leader, and towards themselves as subordinates and their task efforts.

Followership is not a challenge to the captain’s authority, but neither is it unthinking compliance with directives. Good followership is proactive without diminishing the authority of the captain.

Ten rules for followership as applied to flight crew
(FAA leadership/followership instructor manual)

1. Don’t blame your captain for an unpopular decision or policy; your job is to support, not undermine.
2. Disagree with your captain if necessary; but do it in private, avoid embarrassing situations, and never reveal to others what was discussed.
3. Make the decision, then run it past the captain; use your initiative.
4. Accept responsibility whenever it is offered.
5. Tell the truth and don’t quibble; your captain will be giving advice up the chain of command based on what you said.
6. Do your homework; give the captain all the information needed to make a decision; anticipate possible questions.
7. When making a recommendation, remember who will probably have to implement it. This means you must know your own limitations and weaknesses as well as your strengths.
8. Keep the captain informed of what’s going on at all times; people may be reluctant to tell him or her of their problems and successes. You should do it for them and assume someone else will tell the captain about yours.
9. If you see a problem, fix it. Don’t worry about who would have been blamed, or who now gets the praise.
10. Put in more than an honest day’s work, but don’t ever forget the needs of your family. If they are unhappy, you will be too, and your job performance will suffer accordingly.
A team member is a valuable follower when they:

- Maintain an independent perspective and resist ‘group-think’
- Avoid the ‘let the aircraft captain do it’ attitude
- Maintain appropriate interpersonal skills
- Co-ordinate with others through active listening
- Practise assertive communication
- Become an active member of the team.

Take the time to consider the following styles of followership. Have a think about which style you tend to fall into and consider whether that’s where you want to be.

**Figure 10  Follower styles**

![Follower styles diagram](Blais 2001)
LEADERSHIP FROM BEHIND: ASSERTIVENESS FOR SUBORDINATES

Unfortunately, in aviation there is a long list of incidents/accidents where subordinate flight crew members have detected serious problems with the captain’s performance. Subordinate crew members were aware of the gravity of the situation, but were unable/unwilling to do anything about it. For example, the co-pilot or other subordinate crew were powerless in the following fatal aircraft accidents:

- Jetstream into Hibbing, Minnesota, (1994)
- DC-8 into Jeddah, Saudi Arabia, (1993)
- Beechjet into Rome, Italy (1992)
- DC-8 loss of control at Toledo, Ohio, (1992)
- L-1011 windshear accident, Dallas Fort Worth Airport, Texas, (1986)
- MS-748 electrical failure in Pinecraftyville, Illinois, (1985)
- DC-8 fuel exhaustion in Portland, Oregon, (1979)
- 727 into Dulles, New York City, (1975)
- L-188 into a thunderstorm at Dawson, Texas, (1969)
- Lear Jet out of Palm Springs, California, (1967)

In each of these accidents, subordinates knew that the captain was denying serious risks and displaying counterproductive and unreasonably perilous behaviour. Unfortunately, not one of them was able to do anything to change their captain’s performance, actions or strategies. Most of them could not even get the captain to acknowledge the problem.

What should subordinate crew members do when faced with the questionable performance of a captain? Such a critical situation can be very difficult for junior crew members, particularly if they are still in their new-hire, probationary period. If the organisation is one that sanctions fear, intimidation and reprisal, crew members may be very reluctant to suggest to an established captain that mistakes are being made.

Many airlines have recognised such issues and provide some practical interventions as guidance for crew. The PACE framework (Besco, 1994) and the ‘Managing Upwards’ strategy (Qantas, 1994) are described below and are representative of typical training initiatives provided to flight crew.

**PACE - A four-step progression to survival**

- **P** Probing for a better understanding.
- **A** Alerting captain of the anomalies.
- **C** Challenging suitability of present strategy.
- **E** Emergency warning of critical and immediate dangers.

‘PACE’ — Probing, Alerting, Challenging, Emergency warning — is a four step progression going from enquiry to disaster warning. The progression is incremental and operationally relevant. Each step is a building block for the next. Each step serves as a non-threatening signal to the captain that a response to each step is required.
The example below illustrates ‘PACE’ steps that could and should have been used by the co-pilot of the MS-748 in the Air Illinois, night instrument flight rules (IFR), complete electrical failure accident (NTSB, 1985). The aircraft departed Springfield in night VFR conditions, on an IFR flight plan through a line of predicted thunderstorms. The final destination was Carbondale, the corporate maintenance headquarters. Both generators became inoperative shortly after takeoff, while still in VFR conditions. The captain elected to continue on into the frontal system on battery power. The aircraft suffered complete electrical power failure when the battery went dead. All aboard were lost.

**Step 1: PROBING statement:**
‘Captain, I need to understand why we are flying like this.’
Example for the HS-748 co-pilot: ‘Captain, I don’t understand why we are proceeding into night IFR with a line of heavy rain showers ahead of us. Why don’t we maintain VFR (visual flight rules), go back to Springfield and land before the battery goes dead?’

**Step 2: ALERTING statement:**
‘Captain, it appears to me that we are on a course of action that is drastically reducing our safety margins and is contrary to both your briefing and to the company’s SOPs.’
Example for the HS-748 co-pilot: ‘Captain, if we proceed, from VFR conditions into the line of heavy rain showers, on battery power only, we will crash because we have no way to fly instruments when our battery goes dead. We should not even be flying day IFR with one generator inoperative, let alone flying night IFR into lightning and heavy rain showers with both generators inoperative.’

**Step 3: CHALLENGING statement:**
‘Captain, you are placing the passengers and aircraft in irreversible and immediate danger. You must immediately choose a course of action that will reduce our unacceptably high risk levels.’
Example for the HS-748 co-pilot: ‘Captain, you are placing the passengers in a position of a certain crash when the battery goes dead. You must immediately reverse course and get back to night VFR conditions.’

**Step 4: EMERGENCY warning:**
‘Captain, if you don’t immediately increase our safety margins, it is my duty and responsibility to immediately take over control of the aircraft.’
Example for the HS-748 co-pilot: ‘Captain, if you don’t immediately reverse course and get back to night VFR conditions, I must take over control of the aircraft. I cannot allow you to subject the passengers to such an unnecessary and high risk of certain death. Under these conditions, it is my duty and responsibility to relieve you of your command.’

The ‘PACE’ steps -- Probing, Alerting, Challenging, Emergency warning require that the captain makes a satisfactory response to the co-pilot at each level of enquiry and intervention. It should be an organisational SOP that if the captain ignores the co-pilot through all four steps of ‘PACE’, the co-pilot must proceed to assume command and control of the aircraft.
KEY POINTS

This section has covered the following key points:

- Safety research indicates that the most effective team leaders are those who communicate a clear rationale for change and minimise concerns about status differences. This helps their team members to speak up and engage in more proactive co-ordination.
- Team leaders need to adapt their leadership style to the situation at hand.
- In emergency situations, when time is critical, the team leader may take on the role of a direct commander which requires skills for working under stress.
- One of the most critical leadership skills required by ALL pilots is the willingness to report safety incidents and hazards, as organisations depend on this information to ensure threats to flight safety can be identified and managed.

When you are ready, please turn to page 55 of the Workbook for Pilots and complete the exercises.
RESOURCES

Further reading


References


Chapter 8

Situational awareness

This section examines situational awareness (SA), why it’s important to flying safety, and the relationship between SA and fatal controlled flight into terrain (CFIT) accidents. A model of SA is described, and specific clues to determine when you may have degraded SA are outlined. Finally, practical strategies for flight crew to maintain and enhance their SA are presented, which is often seen as a ‘barometer’ for good judgement and decision making. Throughout this section case studies demonstrating both poor and good SA are provided.
Situational awareness

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- A model of situational awareness 127
- Situational awareness and safety 128
- Relationship between controlled flight into terrain (CFIT) accidents and situational awareness 130
- Factors that can lead to a loss of situational awareness 131
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- Resources 134

“To most people, the sky is the limit. To those who love aviation, the sky is home.”

Unknown
Table 25  Situational awareness

<table>
<thead>
<tr>
<th>Category</th>
<th>Elements</th>
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</thead>
<tbody>
<tr>
<td>Situational awareness</td>
<td>Gathering information</td>
</tr>
<tr>
<td></td>
<td>Interpreting information</td>
</tr>
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<td></td>
<td>Anticipating future states</td>
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OVERVIEW

Simply, view about situational awareness (SA) basically involves paying attention to your surroundings. Having good SA allows you to respond faster to changing events – by knowing what is going on around you and predicting how things will change.

According to Dennehy and Deighton (1997), SA is the ability to ‘maintain the ‘big picture’ and think ahead’.

Good SA begins with having focused attention. This may involve maintaining focus on the current situation, such as driving a car or riding a bike, rather than being distracted by a phone call, a vehicle breakdown, or other events. This focus is directed at your surroundings and being mindful of what does and does not belong.

SA involves being proactive and continually identifying potential dangers in advance. The next step is looking for pre-incident indicators. These are the subtle clues that something is not quite right, or going ahead as planned. Identifying pre-incident indicators may provide additional time to avoid an unsafe condition, or react to an event.

According to Edwards, Douglas and Edkins (1998), managing SA involves not being caught off guard or being unprepared - making the effort to stay ahead of a situation.

Factors that reduce SA include:

- Insufficient communication
- Fatigue and/or stress
- Task overload
- Task underload
- ‘Press-on-regardless' philosophy
- Degraded operating conditions.

Being situationally aware means being fully aware of the big picture, at all times. This involves continually collecting and judging information, from sources inside and outside the cockpit. In flight, a pilot has to be several minutes ahead of the aircraft, not several seconds behind it – to perceive what’s going on and be able to impose sound judgement on every change, from a minor distraction to a major in-flight emergency. In an emergency, stress may build rapidly and the pilot will tend to focus unconsciously on a very few aspects of the situation, without noticing that other aspects are degrading – airspeed or attitude for example. Good handling of any unusual situation – particularly the first major emergency – provides a basis for confidence in abilities. Poor handling of an emergency will undermine confidence.

To better understand the concept of SA, it may be helpful to look at an illustrative model.
A MODEL OF SITUATIONAL AWARENESS

Probably the most widely cited definition of SA is from Dr Mica Endsley, one of the leading authorities on the subject:

‘... situational awareness is the [accurate] perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future’. (Endsley, 1988: p. 7).

She describes SA as comprising three levels:

Level 1: perception of elements,
Level 2: comprehending what those elements mean, and
Level 3: using that understanding to project future states.

Endsley (1995) has developed a model to help illustrate the factors that influence SA in complex and dynamic settings such as flying operations. This model is shown below.

Figure 11 Model of situational awareness. (Endsley, 1995)

The Endsley model shows SA as a stage separate from decision-making and performance. Applied to flying, SA is depicted as a pilot’s internal model of the state of the environment. Based on that representation, pilots can decide what to do about the situation and carry out any necessary actions. Therefore, SA is represented as the main precursor to whether a good or poor decision may be made. The model will be explained further when you complete the exercise in the workbook.

According to Endsley’s model there are three levels of SA.

Level 1 SA – Perception

Perception of cues (Level 1 SA) is fundamental. Without basic accurate perception of important information, the odds of forming an incorrect picture of the situation increase dramatically. For example, a pilot needs to perceive important elements such as other aircraft, terrain, system status and warning lights, along with their relevant characteristics.
**Level 2 SA – Comprehension**

Situational awareness goes beyond mere perception. It also encompasses how people combine, interpret, store, and retain information. Thus, it includes more than perceiving or attending to information, but also the integration of multiple pieces of information and a determination of their relevance to the person’s goals (Level 2 SA). This is analogous to having a high level of reading comprehension, as compared to just reading words without really understanding them.

For example, upon seeing warning lights indicating a problem during take-off, the pilot must quickly determine the seriousness of the problem in terms of the immediate airworthiness of the aircraft, and combine this with knowledge on the amount of runway remaining, in order to know whether or not to abort. A novice pilot may be capable of achieving the same Level 1 SA as more experienced pilots, but may fall far short of being able to integrate various data elements to comprehend the situation effectively.

**Level 3 SA – Projection**

At the highest level of SA, the ability to forecast future situation events and dynamics (Level 3 SA) represents operators who have the highest level of understanding of the situation. This ability to project from current events and dynamics to anticipate future events (and their implications) allows for timely decision making. This is the domain of skilled experts.

**SITUATIONAL AWARENESS AND SAFETY**

The link between poor situational awareness and accidents has been well documented in aviation. According to FAA statistics, spatial disorientation and loss of situational awareness cause up to 15–17 per cent of fatal general aviation crashes annually (about 2.5 per cent of the total). More significantly, nine out of 10 cases of spatial disorientation result in a fatality. Most of these mishaps occur when pilots are flying at night and/or intentionally, or inadvertently flying in instrument meteorological conditions. IMC.

Problems with SA were found to be the leading causal factors in a review of military aviation accidents/incidents (Hartel, Smith & Prince, 1991). Furthermore, according to Endsley (1995) in a study of accidents among major air transport operators, 88 per cent of those involving human error could be attributed to problems with situational awareness.

Gibson, Orasanu, Villeda and Nygren (1997) also performed a study of SA errors based on the US Aviation Safety Reporting System (ASRS) reports. They found multiple factors were commonly involved with each report. These included workload/distraction (86 per cent), communications/cooperation (74 per cent), improper procedures (54 per cent), time pressure (45 per cent), equipment problems (43 per cent), weather (32 per cent), unfamiliarity (31 per cent), fatigue (18 per cent), night conditions (12 per cent), emotion (7 per cent) and other factors (37 per cent).

Consequences of loss of SA were: altitude deviations (26 per cent), violations of Federal Aviation Regulations (25 per cent), heading deviations (23 per cent), traffic conflicts (21 per cent), and non-adherence to published procedures (19 per cent). Dangerous situations were found to result from 61 per cent of the cases. Clearly, the above statistics suggest that loss of SA is well represented in aviation accident figures, such as the case study outlined below.
The crew were operating a de Havilland Canada DHC-6 Twin Otter aircraft in Exercise Highland Pursuit 2/97. The purpose of the exercise, which was conducted by No. 173 Surveillance Squadron, 1st Aviation Regiment, Australian Army, was to provide tropical mountainous flying training in Papua New Guinea. There were three trainees and one training pilot on board the aircraft.

On Sunday, 9 November 1997, the third day of flying operations in Papua New Guinea, the crew were conducting a flight from Madang and return via a number of airstrips in the central highlands. When haze and cloud prevented them flying the flight-planned direct track between the Koinambe and Simbai airstrips, they decided to fly north-west via the Jimi River valley and one of its tributaries.

Two of the trainees were occupying the cockpit seats, one as flying pilot and the other as navigating pilot using a 1:1,000,000-scale chart. When the crew turned the aircraft to follow a tributary off the Jimi River, the training pilot was in the aircraft cabin. A few minutes later, their discussion regarding the progress of the flight attracted the attention of the training pilot. By this time, however, the position of the aircraft in the valley, and its available performance, were such that an escape from the valley was not possible. The aircraft collided with trees before impacting steeply sloping ground.

It was subsequently established that when the crew turned from the Jimi River, they entered the wrong valley. The training pilot and trainees made several errors during the exercise and the accident flight that contributed directly to the accident. The primary errors were:

- Incomplete planning, before the exercise began, of intended and alternative routes and aircraft en-route climb performance
- Pre-flight planning which did not adequately consider the terrain and aircraft en-route climb performance
- The use of a chart for navigation which provided insufficient terrain information for accurate visual navigation
- Twice changing the planned route from Koinambe to Simbai without adequate appreciation of vital terrain elevation information
- The absence of the training pilot from the cockpit at a critical stage of the flight
- The failure to conduct a heading check when the aircraft initially entered the wrong valley
- The failure to recognise that they had turned into the wrong valley; and
- The failure to recognise when a turn-back should have been conducted.

A lack of crew situational awareness was one of the key contributing factors to these errors.
Relationship between Controlled Flight into Terrain (CFIT) Accidents and Situational Awareness

Controlled flight into terrain (CFIT) continues to remain one of the leading causes of commercial aircraft accidents. More than 35,000 people have lost their lives in CFIT accidents from the emergence of civil aviation in the 1920s to the turn of the century (Bateman, 1999).

What is CFIT?
For an accident or incident (occurrence) to be classified as a CFIT, it must satisfy the following criteria:

- The aircraft is under the control of the pilot(s)
- There is no defect or unserviceability that would prevent normal operation of the aircraft
- There was an in-flight collision with terrain, water, or obstacles
- The pilot(s) had little or no awareness of the impending collision.

Australia has experienced its share of CFIT accidents in recent years, with two accidents alone accounting for a total of 24 fatalities:

On 28 July 2004, a Piper Aircraft Corporation PA-31T Cheyenne aircraft, registered VH-TNP, departed Bankstown, New South Wales on a private instrument flight rules (IFR) flight to Benalla, Victoria. Instrument meteorological conditions (IMC) at the destination necessitated an instrument approach and the pilot reported commencing a global positioning system (GPS) non-precision approach (NPA) to Benalla. When the pilot had not reported landing, a search for the aircraft was commenced. Late that afternoon the aircraft was located on the eastern slope of a tree-covered ridge, approximately 34 kilometres south-east of Benalla. The pilot and five passengers were fatally injured.

On 7 May 2005, a Fairchild Aircraft Inc. SA227-DC Metro 23 aircraft, registered VH-TFU, was being operated on an IFR scheduled passenger service from Bamaga to Cairns with an intermediate stop at Lockhart River, Queensland, with two pilots and 13 passengers onboard. While conducting an RNAV (GNSS) approach to runway 12 at Lockhart River aerodrome, the aircraft impacted terrain. There were no survivors.

The investigation of CFIT accidents over the years has identified loss of situational awareness as a key contributing factor.

For CFIT, the greatest concern is a loss of ‘place information’. Once a pilot’s mental picture of where they are at present, and where they will be in the future diminishes, safety becomes compromised. This is particularly crucial during those phases of flight when terrain clearance is unavoidably reduced (e.g. initial climb and approach). More than two-thirds of all CFIT accidents result from a loss of vertical situational awareness or an altitude error (Flight Safety Foundation, ICAO, & Federal Aviation Administration, 1996).

There are a number of factors that contribute to a loss of situational awareness. When comparing CFIT occurrences from the 1960s and 1970s to recent times, it is evident that despite the efforts of the international aviation community to reduce CFIT, some common factors have endured. These include: flight crews’ use of non-standard phraseology, non-compliance with procedures, fatigue, and visual illusions; ATC – the provision of erroneous altitude/heading directions; and weather, organisational issues, ambiguous aeronautical charts, and non-optimal approach procedure designs.

Other factors that have played a part in CFIT accidents and incidents include ‘get-home-itis’, where the pilot becomes fixated on reaching the destination point at all costs, and pilot workload. The latter is especially true...
for the approach and landing phase of flight where the pilot's workload becomes more demanding. In this phase, the pilot is interpreting approach charts, changing the aircraft's configuration, monitoring traffic, and monitoring the aircraft's altitude and airspeed.

Generally, good situational awareness increases safety, reduces workload, enhances performance and improves decision making. Achieving and maintaining a high level of situation awareness is a product of good operating philosophy, training, standard operating procedures, and crew coordination.

Thankfully CFIT accidents are rare events; however, they tend to have a higher potential to result in fatalities. For example, according to the ATSB (2006), 60 per cent of CFIT accidents result in fatal injuries to aircraft occupants. So the key message from this section is that poor, or loss of SA, have a very influential role to play in contributing to CFIT accidents, often with fatal outcomes.

Therefore, it may be helpful to look in more detail at some of the factors that can lead to a loss of situational awareness.

**FACTORS THAT CAN LEAD TO A LOSS OF SITUATIONAL AWARENESS**

The following story provides a number of clues as to the more common factors that may lead to a loss of situational awareness.

---

**Fixation**

Shortly after joining downwind, the pilot of a Mooney 201 selected the landing gear down. At the same time, the pilot heard a radio call from another pilot also on downwind. ‘It scared the hell out of me’, recalled the pilot. ‘I’d made an inbound call which had gone unanswered, so I assumed I was the only one in the circuit. Suddenly I was consumed with anger that this guy hadn’t radioed and feared that I might be about to hit him.’ The pilot’s attention was suddenly fixed on locating the other aircraft. ‘It turned out the guy was on base and there was no danger of us colliding. But the incident had distracted me and I forgot to check that I had three greens on downwind or final. Murphy’s law would usually dictate that this would be the one time there would be a gear problem, but I was lucky.’ The gear locked down and the flight ended safely. ‘I’d forgotten to make a call joining circuit and the other guy had probably taken off for circuit practice after my inbound call. I don’t think my look-out had been particularly good either. It was the first time I’d flown in a while, and I didn’t have that much time in the aircraft. When I really thought about the flight, I realised I’d been struggling since take-off to keep up with the workload.’

The above example illustrates a number of factors that affect your situation awareness, including:

- Lack of up-to-date knowledge or recent experience, which you use to interpret and process information
- Training, skill and recency, which influence the way in which you make control inputs and anticipate and assess outcomes
- The discipline to achieve safe, correct and accurate results
- Stress and personal pressure
- Time management skills to assign correct priorities and to actively manage multiple tasks.
Similarly, Kern (1997) lists eight precursors to lost situational awareness for pilots. These are:

- Ambiguity or confusion
- Fixation or single-focused attention
- Reduced frequency or poor communication
- Failure to meet targets
- Reduced manoeuvring
- Failure to stay ahead of the aircraft
- Use of an undocumented procedure or violation of a minimum standard
- Attempting to operate the aircraft outside known limitations.

**Distractions**

Crew distractions are a serious impediment to safety. Aircraft malfunctions can be a significant distraction. Sometimes the malfunctions are big and obvious. Sometimes they’re small and illusive. Someone has to attend to the malfunction and figure out the appropriate course of action. What often happens is that everyone is engaged in solving the problem and no-one is flying the aeroplane. This was the tragic case with an accident in New Zealand – see the accompanying workbook (page 62).

**Preparation is the key**

The amount of information you can process is obviously limited. Good flight preparation can reduce your in-flight workload, so that you can devote additional time to more sources of information. This increases your overall situational awareness, and therefore your preparedness for decision making. For example:

- Detailed pre-flight planning minimises the time taken for in-flight decision making.
- Knowing the current duty runway and weather conditions before flying will mean you rapidly absorb what the ATIS is telling you.
- Plan your actions in order to minimise your workload. For example, have the next VHF frequency dialled up ready to select – don’t wait until you need it.
- Use a ‘line of least resistance’ to access information. For example, if you can get the ATIS on the ADF, you will save yourself a radio frequency change.

It is clear that situational awareness is all about thinking ahead and actively scanning your environment, which leads to better decision making.
10 Clues to loss of situational awareness

These clues can warn of an ‘error chain’ in progress - a series of events that may lead to an accident. Most accidents involving human error include at least four of these clues.

1. Ambiguity: information from two or more sources that doesn’t agree.
2. Fixation: focusing on any one thing to the exclusion of everything else.
3. Confusion: uncertainty about a situation (often accompanied by anxiety or psychological discomfort).
4. Failure to fly the plane: everyone is focused on non-flying activities.
5. Failure to look outside: everyone is looking down.
6. Failure to meet an expected checkpoint on flight plan or profile.
7. Failure to adhere to standard operating procedures.
8. Failure to comply with limitations, minimums, regulations etc.
9. Failure to resolve discrepancies: contradictory data or personal conflicts.
10. Failure to communicate fully and effectively: vague or incomplete statements.

Adapted from Douglas Schwartz, Flight Safety International
Source: http://www.crm-devel.org/resources/article/flyingcareers.htm

HOW TO MAINTAIN AND ENHANCE SITUATIONAL AWARENESS

From a review of a number of SA resources, here are some simple tips to help maintain an adequate level of SA in your flying activities:

- Learn and recognise the symptoms that indicate you are losing situational awareness. Just as you’re taught to recognise the initial symptoms of a stall to promote recovery prior to fully developed stall, the same process is true for situational awareness.
- Be well informed. Learn everything you can about the situation. In order to make sound decisions as pilots, it is vital that you have appropriate and current information available and that it is utilised as much as is operationally useful.
- Plan well in advance. ‘Know before you go’ by properly researching flight plans and obtaining the timeliest data possible. Pre-flight planning can start days before a flight and includes knowing everything you can about the aircraft’s capabilities, the weather and the airports at which you will operate.
- Brief yourself and others on the plan. Take a few minutes to review your flight plan and to brief yourself and your passengers and/or crew on each phase of the upcoming flight. Cover the necessities such as airports, fuel planning, emergencies and anything else that might be useful for that particular flight.
- Fly to your plan. Continually monitor the flight’s progress against the original plan that you briefed prior to departure. Always know exactly where you are and be prepared for the tasks that are required next.
- Use an easily repeatable scanning technique. Make sure that it takes in engine instrument indications, flight instrument indications, aircraft heading, flight path, time, charts and the ground. Develop a scan that covers key items without distracting you too much. The scan should be well-rehearsed and second nature; be careful not to fixate on any one item. For a description of scanning patterns read ‘Eye on the sky’ in the September–October 2003 issue of Flight Safety Australia.
Think ahead and rehearse your actions at key points. For example, rehearse your actions should the engine fail in cruise flight, or immediately after takeoff.

Communicate clearly when operating at, or in the vicinity of airports. Listen for key words that indicate the positions and intentions of other aircraft. Be aware that not all aircraft will be radio equipped, and even those which are, may not be listening on the appropriate frequency. Think ahead and have a plan for safe and orderly traffic separation.

Fly the aeroplane within your limits and the aircraft’s performance limits.

Avoid locking on to a problem or task for too long – for instance, your intended landing point. Don’t keep looking only in one direction, keep the scan going, be aware of the relative position and movement of other traffic. Hold the heading and fly the aeroplane – at a safe airspeed appropriate to current atmospheric conditions and maintain your height above the surface.

KEY POINTS

This section has covered the following key points:

- Good situational awareness (SA) involves gathering all information available to you, making sense of the information and anticipating outcomes.
- Poor or degraded SA is a common factor in controlled flight into terrain (CFIT) accidents.
- Pilots tend to lose SA if they become distracted with minor events, manage workload inadequately, or are poorly prepared for their flight.
- SA can be managed by good preparation, using all available resources, good communication and anticipating potential problems well before they occur.

RESOURCES

Further reading


When you are ready, please turn to page 61 of the Workbook for Pilots and complete the exercises.
References


Chapter 9

Decision making

Decision-making is a critical skill in flight operations. Occasionally, decisions must be made instantly and pilots should be constantly vigilant and ready to counter hazards as they occur. This section outlines the usual decision-making process - assess the situation, select a course of action and review.
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“Never fly the ‘A’ model of anything.”

Ed Thompson
Table 26  Decision making

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OVERVIEW

Decision-making is a process for reaching a judgement or selecting an option to address or resolve a situation. Some decisions, such as when to turn onto final approach at a familiar airstrip, are so well practised that they are highly resistant to mistakes, although decision-making can be affected by fatigue or high stress levels. However, many decisions are non-routine.

For example, a pilot should give a great deal of thought to how to deal with different and unexpected circumstances, such as bad weather. Consider the following case study which highlights the effect of fatigue on flight crew performance and decision-making in adverse weather.

Wrong decision

On June 1, 1999, at 2350:44, American Airlines Flight 1420 (a McDonnell Douglas MD-82), overran the end of runway 4R during landing at Little Rock National Airport (Little Rock, Arkansas). The aircraft struck several tubes extending outward from the left edge of the instrument landing system localiser array (411ft beyond the end of the runway), passed through a chain-link security fence, careered over a rock embankment to a flood plain (approximately 15ft below the runway elevation) and collided with the structure supporting the runway 22L approach lighting system.

The captain and 10 passengers died; the first officer, the flight attendants, and 105 passengers received serious or minor injuries. The aircraft was destroyed by impact forces and a post-crash fire.

The investigation found the probable causes of this accident were the flight crew’s:

- Decision to continue the approach when severe thunderstorms (and associated flight hazards) had moved into the airport area and failure to ensure that the spoilers had extended after touchdown.

Factors contributing to the accident were:

- Impaired flight crew performance from fatigue and the situational stress associated with the intent to land in severe weather conditions.
- Continuing the landing when the company’s maximum crosswind component was exceeded.
- The use of reverse thrust greater than 1:3 engine pressure ratio after landing.
DECISION-MAKING PROCESS

Decision-making generally has four components:

- Defining the problem
- Considering the options
- Selecting and implementing the options
- Reviewing the outcome.

Defining the problem

*Weigh up the information gained from a number of sources and make an assessment of the available alternatives.* For example, the process to handle an aggressive passenger in commercial aviation might begin by evaluating comments from passengers and crew, as well as your own impressions of the passenger’s behaviour.

Considering the options

*Consider the various options.* From the above example, consider the choices available when a passenger is aggressive – e.g. request flight crew intervention, attempt to calm the passenger, threaten the passenger with restraint, apply physical restraint.

Selecting and implementing the options

*Choose an appropriate action based upon the pros and cons of the probable outcome.* A decision-maker never has complete information, so the most probable outcome is only an estimate. For example, the passenger’s aggressive behaviour based upon the information available may be a symptom of a fear of flying and excessive alcohol consumption. A possible action is to request a travelling companion and a crew member to sit with the passenger to reassure them, while drinks service is suspended.
Reviewing the outcome

Monitor the situation to ensure the decision is successful. This last step is a closed-loop process to ensure the decision made and action taken are effective in resolving the issue of the passenger’s aggression.

CHARACTERISTICS OF DECISION-MAKING

Decisions made in stressful or high arousal situations have a number of characteristics in common:
- Any decision made has a ‘deadline’. It is only valid for a short time in changing conditions
- A decision is only effective if it can be implemented within the time available
- The value of the decision depends upon understanding the situation
- Usually a decision is irreversible and cannot be undone.

Decision-making in safety critical settings

In safety-critical work settings such as aviation, pilots functioning under pressure and stress may make errors of judgement. Such errors can very rapidly lead to accidents as illustrated in the case study below.

Snow on the wings

On 10 March 1989, a Fokker F-28 left Thunder Bay about one hour behind schedule. The aircraft landed at Dryden at 11:39. The aircraft was refuelled with one engine running, because of an unserviceable auxiliary power unit.

Although a layer of 1/8-1/4 inch (3-7mm) of snow accumulated on the wings, no de-icing was done because de-icing with either engine running was prohibited by both Fokker and the airline. Since no external power unit was available at Dryden, the engines could not be restarted in case of engine shut-down on the ground.

At 12:09 the aircraft started its take-off using the slush-covered runway 29. The Fokker settled back after the first rotation and lifted off for the second time at the 5700ft point of the 6000ft runway. No altitude was gained and the aircraft ‘mushed’ in a nose-high attitude, striking trees. The aircraft crashed and came to rest in a wooded area, 3156ft past the end of the runway and caught fire. Of the 69 people on board, 24 sustained fatal injuries.

In the analysis of the accident, the Commission of Inquiry adopted a contemporary view of systemic factors that may have contributed to the accident. This is reflected in the statement below:

The pilot in command made a flawed decision, but that decision was not made in isolation. It was made in the context of an integrated air transportation system, that if it had been functioning properly, should have prevented the decision to take off … there were significant failures, most of them beyond the captain’s control, that had an operational impact on the events at Dryden … the regulatory, organisational, physical and crew components must be examined to determine how each may have influenced the captain’s decision.

After a 20-month investigation, it was concluded that The captain, as the pilot-in-command, must bear responsibility for the decision to land and take-off in Dryden on the day in question. However, it is equally
clear that the air transportation system failed him by allowing him to be placed in a situation where he did not have all the necessary tools that should have supported him in making the proper decision.

The Dryden accident has been utilised as a learning tool by many organisations and institutions as it is a classic example that major disasters are rarely, if ever, caused by any single factor such as a decision-making error by the pilot. Conversely, major disasters frequently arise from several diverse events unexpectedly appearing together.

FACTORS INFLUENCING DECISION-MAKING

Two sources of bias generally affect our ability to make good decisions:

- Social influences
- Situational limitations.

Social influences
Research and accidents demonstrate that people tend to comply with social pressure to avoid rejection or to gain social approval. Over the years, many university experiments have examined this concept, and demonstrate that such group pressure can be strong enough to make people conform to falsehoods.

Individuals are frequently influenced by the dominant opinions of a group or team and sometimes accept illogical decisions to avoid conflict. Studies on group conformity suggest that the second-highest member of a group is usually the most conforming member. On the airline flight deck the second-highest member of the flight crew group is the first officer. The higher the status of the authoritarian figure, the more likely conformity occurs. This was illustrated in the Tenerife disaster in the cockpit of the KLM B747, which is discussed in the Introductory and Communication chapters.

The KLM captain was the chief instructor of the KLM B747 fleet and was highly respected within the airline. Both the first officer and flight engineer questioned the situation on the day, but failed to resolve their concerns primarily due to the attitude and seniority of the captain.

Situational limitations
Situational limitations can affect our ability to make a sound decision.

Stress
Stress in a given situation is primarily caused by a feeling of inadequacy. Stress interferes with our ability to make sound decisions and encourages us not to make fully committed decisions. As a result, major problems may occur in highly dangerous or quickly-changing situations.

Time pressure
All the facts in a given situation may not always be taken into account when time is at a premium. Frequently, one poor decision is followed by another. Unfortunately, time pressure is greatest in emergencies where the consequences of error are least forgiving.
Fatigue
The cumulative effects of fatigue, particularly at the end of a day or after a long shift, often encourage people to persevere with a chosen course of action, despite the strategy not working. Fatigued workers frequently fail to review a plan and increasingly neglect information which contradicts decisions previously made.

SINGLE-PILOT APPLICATIONS
Efficient decision-making is concerned with the willingness to evaluate whether the actual decision was the right one for the circumstances. Good decision-makers are measured by their ability to consider all available options and to remain flexible to fluctuating demands. Good decision-making is just as important in light aircraft or single-pilot operations as it is for multi-crew operations.

This case study illustrates the consequences of a decision that in hindsight may not have been the best choice.

Lost? Just land and ask for directions
A Cherokee Six became lost on a flight from Ayers Rock to Alice Springs. The pilot decided to land on a gravel road to ascertain his whereabouts from passing traffic. On final approach, it became evident the area of road selected was unsuitable, but the pilot persisted with the landing. After touching down, the aircraft struck trees on the side of the road and crashed. The aircraft was damaged beyond repair, but the six occupants escaped unhurt.

There was no pressing reason why the pilot had to land so hastily - the weather was good, the day was young and the aircraft had at least three hours of fuel remaining. If the pilot had climbed to a higher altitude, he may have established his position, or followed the road, using it as a navigation aid.

PLANNING AND DECISION-MAKING
A central aim of crew resource management is to ensure that high quality decisions are taken across the whole spectrum of flight operations. In this context, thorough pre-flight planning not only provides a yardstick against which in-flight decisions are made, but also allows all members of the crew to manage their own specific areas of responsibility. By understanding the plan, individual crew members may contribute in the most effective way to decisions made in-flight.

During the flight, the captain should update the crew at regular intervals on changes to the original plan, so that individual crew members maintain good situational awareness. This is particularly important during abnormal operations, or in an emergency situation, where conditions affecting the progress of the flight and the safety of the aircraft are likely to change rapidly.

Degree of participation
The degree of participation from subordinate crew members depends to some extent on the type of behaviour which underpins the decision:
- **Skill-based behaviour** relies primarily on prior learning. Associated decisions are mainly made subconsciously. Other crew members provide a passive monitoring role, although assertive intervention occurs if the level of skill being displayed by the decision-maker falls below a safe standard - for example, a non-flying crew member observes that the aircraft is inadvertently descending in cloud towards high ground.

- **Rule-based behaviour** relies on previously-considered courses of action such as standard instrument departures (SIDs), standard operational procedures (SOPs), flight manuals, etc. Associated decisions are made partly subconsciously when previous experience and training come into play, and partly in the conscious mind, where previous learning is compared with the realities of the current situation. Participation by another crew member may be required to verify the situation and validate the course of action being proposed by the decision-maker.

- **Knowledge-based behaviour** is used when a situation has not previously been encountered. The crew makes a decision based upon a rational appraisal of the facts, so there is considerable scope for the involvement of other crew members. If time and circumstances permit, outside agencies such as ATC or technical control may also be involved.

Participation by subordinate crew members in the decision-making process does not mean that all decisions have to be made by committee.

The degree of participation in the decision-making process also depends to a considerable extent on the organisational culture, as well as current social norms. These factors include the captain’s perception of their role and authority, and the way in which this perception is shared by other crew members and the various supporting agencies. In today’s climate, captains who manage flights in an open style and state their intentions from time to time during the flight, are more likely to secure the co-operation and participation of other crew members than those who are overbearing and autocratic.

Command style is normally based on a perception of company or organisation expectations from each individual crew member. Effective CRM flourishes only where an organisational culture exists which empowers and encourages subordinate crew members to assist the captain.

### ENHANCING DECISION-MAKING SKILLS

How can you enhance your decision-making skills? A useful tool is a decision-making model called A-GRADE taught to airline pilots. It is also applicable to single-pilot operations. For example, if a single pilot operating a light twin propeller aircraft on an IFR flight discovers that the weather at the destination is different from the forecast, should the pilot divert? The following steps will help you to decide:

- **Aviate.** The most important priority is to fly the aircraft. Don’t become so consumed with the problem that you allow the speed to decrease, accidentally deviate from course, forget to extend or retract the gear, or neglect the checklists. Remember to fly the aircraft.

- **Gather all information.** You might study the cloud formation, obtain the TAF/METAR, consider diversion options, ascertain how much fuel remains, and evaluate the height of the terrain in the area. If you work for an air operator consider what the company alternatives are. At this initial stage use more than one source of information to ensure you know as much as possible about the situation.

- **Review what you know.** Break down all your information into two to three manageable chunks. Ask yourself, what else do I need? For example, obtain a weather update from ATC.
- **Analyse your options.** Weigh up everything and consider your options according to fuel, weather, and company requirements.
- **Decide.** Avoid procrastination and make your decision. If you decide to divert, consider how you are going to implement your decision. What heading do you need? What airspace considerations do you need to take into account? Do you need to switch tanks?
- **Evaluate.** The final and the most frequently forgotten step is to evaluate your decision for its wisdom. Have you forgotten something? What about the NOTAMS? If you are operating a twin propeller aircraft and the NOTAMS at your chosen destination specify that the main runway is closed, leaving only a wet grass strip, should you reconsider your decision?

### IMPROVING DECISION-MAKING

Be aware of the traps that pilots can fall into when making decisions. Some of the more common traps are:

- Too readily making assumptions or solutions
- Not communicating with others
- Being reticent to challenge others
- Complacency
- Assuming you do not have time
- Failing to consult
- Failing to review
- Always consider how time critical you may be, particularly when dealing with an abnormal or emergency situation. If you have any doubts and have sufficient fuel and time, it may be worth taking extra time to review the situation prior to committing to a decision.

### KEY POINTS

This section addressed the following key points: Decision-making is a critical skill in aviation.

The process of decision-making includes:

- Defining the problem
- Considering the options
- Selecting and implementing the options
- Reviewing the outcome.

The need to make a decision to address a problem or unexpected situation may cause stress and time pressures.

Pilots should prepare and train for contingencies to aid decision-making in critical emergencies.

When you are ready, please turn to page 69 of the *Workbook for Pilots* and complete the exercises.
RESOURCES

Further reading


Chapter 10

Threat and error management (TEM)

This section examines the concept of threat and error management (TEM) and its role in providing pilots with error countermeasures — that is, avoidance, trapping and mitigation of errors. Definitions and examples of threats, errors and ‘undesired aircraft states’ are provided and a model of TEM is described. Practical threat and error management countermeasures are discussed as a means of reducing errors, or more effectively managing their consequences, thereby improving flight safety.
Threat and error management

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“If I commit an error
I do it without bad intention.’

Stand Watie – Cherokee Confederate Brigadier General,
American Civil War
Traditional, human error in aviation has been viewed negatively: as undesirable or a sign of weakness. More recent research provides a very different perspective on operational errors, showing that such errors are a normal and expected part of human behaviour.

Regardless of regulations, technology or training, error will continue to be a factor in operational environments because it simply is the price humans pay for being able to ‘think on our feet’. The trouble with error in safety-critical industries such as aviation is the potential for negative consequences.

The key is managing error, before it has damaging consequences — acknowledging that we may not be able to avoid error, but can make the error inconsequential, by managing it successfully. This is the concept behind threat and error management (TEM) training.

The TEM concept in aviation originated from University of Texas research. There they developed a model which provides a framework for error management processes during normal flight operations (Helmreich, Klinect & Wilhelm, 1999). TEM programs focus on training flight crew in developing error countermeasures; minimisation, trapping and mitigation. The model is explained in more detail below.

### A MODEL OF THREAT AND ERROR MANAGEMENT

In Australia, you are 20 times more likely to be fatally injured riding a motorcycle than driving a car. To help protect yourself from harm as a motorcyclist you might purchase a good quality helmet, body armour protection and protective boots. However, your safety on the bike will be heavily dependent on how well you manage the hazards, such as other vehicles, road surface conditions and pedestrians, you encounter on the road. Consequently, many motorcycle riding courses do not just teach you how to ride the bike (e.g. cornering technique and gear selection), but also focus on identifying and anticipating potential hazards.

The same principle applies to TEM training for pilots. TEM does not teach pilots how to fly an aeroplane. Instead, it provides practical techniques for maximising safety margins and promotes anticipation or ‘thinking ahead’ in the constantly-changing environment of flight operations. TEM is similar to ‘stay upright’ training for motorcyclists.

There are three basic components to the TEM model:

- Threats
- Errors, and
- Undesired aircraft states.

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<td></td>
<td>Recognise and manage threats</td>
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<tr>
<td></td>
<td>Recognise and manage undesired aircraft states</td>
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</table>
The best way to illustrate the TEM model is to think about your last flight as an operating crew member. Ask yourself the following questions:

- Was it the perfect flight?
- Did anything not go as planned?
- Did you experience any pressures or stressors that took your attention i.e. did these events require some sort of response?

Most probably, you can recall something in your flight that required you or your crew members’ attention. Consider the following figure showing possible deviations from an optimum flight. The difference between the perfect flight, where nothing goes wrong (has this ever happened?) to something or everything going wrong is the threat.

**THREAT** = Anything that causes a variation to a ‘perfect’ flight.

**Figure 12** The ‘perfect’ flight

In this model, threats and errors are part of everyday aviation operations that must be managed by flight crews, since both threats and errors carry the potential to generate undesired aircraft states. Flight crews must also manage undesired aircraft states, since they carry the potential for unsafe outcomes. Undesired aircraft state management largely represents the last opportunity to avoid an unsafe outcome and thus maintain safety margins in flight operations.

Another way of looking at this is to think about what you must do as a flight crew member of a ‘normal’ flight. Figure 13 below suggests that to manage operational goals while maintaining flight safety, flight crew must:

- Manage ‘normal’ everyday operational difficulties and problems, referred to as ‘threat management’
- Manage their own errors, or those made by other people they are working with, known as ‘error management’.
- Manage ‘bad’ or unsafe situations they find themselves in, called ‘undesired aircraft states’ (UAS).
On a normal flight, pilots must:

- Manage everyday operational problems ➔ Threat management
- Manage their own errors ➔ Error management
- Manage unsafe situations ➔ Undesired aircraft state management

The following diagram from the 2005 Qantas Airways Command course illustrates the TEM framework.

**Figure 13  The TEM model in summary**

Firstly, on any given flight, flight crew will encounter a number of threats or ‘red flags’, which may or may not require a response to maintain safety. Examples of threats include poor weather, clear air turbulence, maintenance unserviceability, non-standard phraseology, fatigue and hazardous attitudes (complacency or over confidence). As individuals and as a team, flight crew will have a number of strategies to manage these threats. Some of these strategies will be well-practised standard operating procedures (SOPs) but some will require crews to use their critical decision-making and to troubleshoot solutions.

The model implies that if the strategies used to deal with the threats are inadequate, then errors may occur. Examples of errors include: not confirming ATC clearance, setting incorrect altitude, failing to make a safety announcement e.g. ‘crew to be seated for landing’.

Even if errors occur, the aviation system contains many defences that will resist and resolve these errors. The ‘resist’ part of the aviation system is the hardware and software that exist even before human responses kick in, such as:

- Ground proximity warning systems (GPWS)
- Traffic collision avoidance systems (TCAS)
- Checklists
- Automation
- Air traffic control (ATC)
- Standard operational procedures (SOPs).
The ‘resolve’ part of the system represents human responses (human factor skills), including:

- Decision making
- Leadership
- Situational awareness
- Vigilance
- Assertiveness
- Monitoring and cross-checking.

Sometimes even well-placed defences will not be effective, resulting in adverse consequences, such as undesired aircraft states - an unstabilised approach, for example, with the potential for an incident/accident.

Flight crew should manage threats proactively - so they have the time to think through alternative strategies, and ‘capture’ errors before they have adverse consequences.

The TEM philosophy stresses three basic concepts:

- anticipation
- recognition
- recovery.

The key to anticipation is accepting that while something is likely to go wrong, you can’t know exactly what it will be or when it will happen. This is the vigilance factor that is necessary in all safety-critical professions. Anticipation builds vigilance, and vigilance is the key to recognising adverse events and error.

The following sections describe the concept of threats, errors and undesired aircraft states in more detail, and provide examples throughout.

**DEFINING THREATS**

Threats are everywhere in flight operations (adverse weather, airport conditions, ATC, aircraft malfunctions, cabin interruptions, fatigue, complacency etc.) and flight crews have to divert their attention from normal flight duties to manage them. The more complex or challenging, and/or distracting the operating environment becomes, the greater the flight crews’ workload.

Therefore, a threat can be defined as:

- a situation or event that has the potential to impact negatively on the safety of a flight, or
- any influence that promotes opportunity for pilot error(s).
Threats can be considered as:
- *external* to the flight crew and
- *internal* - those the flight crew bring to the operation.

**External threats**
Examples of influences that can lead to crew error:
- Distractions
- Cabin crew
- Weather
- Maintenance
- Ground crew
- Heavy traffic
- Unfamiliar aerodrome
- Automation
- Missed approach
- System malfunction
- Flight diversion
- Time pressures
- Similar call sign
- Terrain
- Air traffic control
- Passengers

Generally there are of three types of external threats:

**Anticipated**: Some threats can be anticipated, since they are expected or known to the flight crew. For example, flight crews can anticipate the consequences of a thunderstorm by briefing their response in advance, or prepare for a congested airport by making sure they keep a watchful eye for other aircraft as they execute the approach.

**Unexpected**: Some threats can occur unexpectedly, such as a sudden, in-flight aircraft malfunction. In this case, flight crews must apply the skills and knowledge acquired through their training and operational experience to manage the threat.

**Latent**: Some threats may not be directly obvious to, or observable by, flight crews immersed in the operational context, and may need to be uncovered by safety analyses. These are considered latent threats or ‘mousetraps’ waiting to be sprung. Examples of latent threats include equipment design issues, optical illusions, or shortened turn-around schedules.
## Table 28: Threat types with examples

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<th>Examples</th>
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<td>Adverse weather</td>
<td>Thunderstorms, turbulence, poor visibility, wind shear, icing conditions, IMC</td>
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<tr>
<td>Airport</td>
<td>Poor signage, faint markings, runway/taxiway closures, INOP navigational aids, poor braking action, contaminated runways/taxiways</td>
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<tr>
<td>ATC</td>
<td>Tough-to-meet clearances/restrictions, reroutes, language difficulties, controller errors</td>
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<tr>
<td>Environmental operational pressure</td>
<td>Terrain, traffic, TCAS TA/RA, radio congestion</td>
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<table>
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<th>Airline threats</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Aircraft</td>
<td>Systems, engines, flight controls, or automation anomalies or malfunctions MEL items with operational implications Other aircraft threats requiring flight crew attention</td>
</tr>
<tr>
<td>Airline operational pressure</td>
<td>On-time performance pressure, delays, late arriving aircraft or flight crew</td>
</tr>
<tr>
<td>Cabin</td>
<td>Cabin events, flight attendant errors, distractions, interruptions</td>
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<tr>
<td>Dispatch/paperwork</td>
<td>Load sheet errors, crew scheduling events, late paperwork, changes or errors</td>
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<tr>
<td>Ground/ramp</td>
<td>Aircraft loading events, fuelling errors, agent interruptions, improper ground support, de-icing</td>
</tr>
<tr>
<td>Ground maintenance</td>
<td>Aircraft repairs on ground, maintenance log problems, maintenance errors</td>
</tr>
<tr>
<td>Manuals/charts</td>
<td>Missing information or documentation errors</td>
</tr>
</tbody>
</table>


### Internal threats

Internal threats are those arising from the flight crew themselves, and may include:

- **Fatigue**: flight duty times at night or other times of the day when you would normally be sleeping.
- **Team familiarity**: how well you know your flight crew colleagues, whether you have flown together before. Too much familiarity can produce problems, just as too little can.
- **Language and culture issues**: organisational/professional/national/cultural differences.
- **Health and fitness**: whether you report for duty feeling capable of doing the job. This can be affected by illness, lack of sleep, substance abuse, hangovers, etc.
- **Lack of experience in a role**: Note also that too much experience can also be a threat due to complacency.
- **Operational recency and proficiency**: This means being ‘current’ or up-to-date and ‘practised’ at performing specific procedures of flying certain routes. Absence from flying for an extended period of time can cause your familiarity with, and competence in that role to be reduced.

When flight crews lack both knowledge and familiarity/experience with the operation, they tend to make more errors and also mismanage those errors at a greater rate. This is illustrated in the following LOSA flight, in which the captain had only held a command on type for one month and the first officer less than five months.
Lack of knowledge and proficiency

After the TOD transition, the captain violated the sterile cockpit rule commenting on the appearance of Brisbane. Descending through to 7000 ft, the aircraft was given a visual approach to runway 19. The captain gave no indication of his intentions and the first officer asked no questions and no use was made of the FMS. Descending on an extended base leg, the aircraft began to converge with the runway with no comment from the first officer. At 2000 ft, ATC jointly said ‘continue approach’, then ‘clear to land’ although the latter phrase was not clearly enunciated. The first officer copied and replied to ‘continue approach’, but missed the landing clearance. The captain did not query the clearance. The captain commenced the turn onto final at less than 1000 ft and rolled out on localiser and glide slope at 640 ft. On becoming established both crew immediately queried if they had been cleared to land. The first officer confirmed the landing clearance and missed the ‘500 ft stable’ call, looked hurriedly at the panel and called 400 ft stable. At this point the aircraft was starting to diverge from glide slope, being one dot low with a descent rate of 1100fpm. Both pilots kept their head up while the aircraft continued below profile, until at 100 ft AGL, the aircraft was two dots low with 1200fpm rate of descent. As the aircraft was carrying +15 knots, the captain was able to arrest the descent rate, but landed between the 150m – 300m runway marking.

The captain of this flight was still settling in to his new position, with the LOSA observer commenting that his hand did not automatically find the correct switch or knob. There was a lack of leadership shown, with the captain discussing non-operational matters below 20,000 ft and not considering the difficulties of a night visual approach or possible contingency strategies. This resulted in a low and late turn onto final and a missed landing clearance. The first officer failed to detect the runway convergence or the diverging flight path below 500 ft, demonstrating poor situational awareness and a lack of confidence to speak up.

A sound knowledge of the operation is no guarantee that a flight crew won’t make mistakes. But good operational knowledge and familiarity will result in fewer mistakes, fewer serious mistakes, and more quickly discovered and corrected ones than those made by pilots without sufficient knowledge.

Threat management

Threat management can be broadly defined as how crews anticipate and/or respond to threats. A mismanaged threat is defined as a threat that is linked to, or induces flight crew error. Some of the common tools and techniques used in commercial aviation to manage threats and prevent crew errors include:

- Reading weather advisories
- Turning weather radar on early
- Thorough walk-arounds during pre-departure
- Correct use of procedures to diagnose unexpected aircraft malfunctions
- Briefing on an alternate runway in case of a late runway change
- Briefing cabin crew on acceptable times and reasons for interruptions
- Loading extra fuel when the destination airport is in question due to poor weather or restricted access
- Changing mindset in the pre-flight planning phase e.g. ‘I know I’m predisposed to rush the walk around and checks when I’m running late, I will deliberately slow down these cycles to minimise the chances of further error.’
DEFINING ERRORS

Errors are defined as flight crew actions or inactions that lead to a deviation from crew or organisational intentions or expectations; reduce safety margins; and increase the probability of adverse operational events on the ground and during flight. Flight crew errors can vary from minor deviations, such as entering the wrong altitude but quickly identifying the mistake, to something more severe, such as failing to set the flaps before takeoff.

Broadly speaking, there are:

- handling errors (flight controls, automation)
- procedural errors (checklists, briefings, callouts) and
- communication errors (with air traffic control, ground, or pilot-to-pilot).

Flight crew errors can be the result of momentary diversion of attention (slip), or memory failure (lapse) induced by an expected or unexpected threat. Other errors are more deliberate and are known as intentional non-compliance errors. These are often shortcuts used by flight crews to increase operational efficiency, though they are in violation of standard operating procedures.

Understanding how the error was managed is as important, if not more important, than understanding the prevalence of different types of error. It is of interest to know if and when the error was detected and by whom, as well as the response(s) upon detecting the error, and the outcome or consequence of the error.

As with threats, some errors are quickly detected and resolved leading to inconsequential outcomes, while others go undetected, or are mismanaged.

Regardless of cause or severity, the outcome of an error depends on whether the flight crew detects and manages the error before it leads to an unsafe outcome. This is why the foundation of TEM lies in understanding error management rather than solely focusing on the error occurrence (Maurino, 2006).

Examples of specific error types are provided in the following table.

<table>
<thead>
<tr>
<th>Aircraft handling errors</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Incorrect altitude, speed, heading, autothrottle settings, mode executed, or entries</td>
</tr>
<tr>
<td>Flight control</td>
<td>Incorrect flaps, speed brake, autobrake, thrust reverser or power settings</td>
</tr>
<tr>
<td>Ground navigation</td>
<td>Attempting to turn down wrong taxiway/runway, missed taxiway/runway/gate</td>
</tr>
<tr>
<td>Manual flying</td>
<td>Hand flying vertical, lateral, or speed deviations, missed runway/taxiway, failure to hold short, or taxi above speed limit</td>
</tr>
<tr>
<td>Systems/radio/instruments</td>
<td>Incorrect pack, altimeter, fuel switch or radio frequency settings</td>
</tr>
</tbody>
</table>
POOR THREAT AND ERROR MANAGEMENT: UNDESIGNED AIRCRAFT STATES

An Undesired Aircraft State (UAS) is defined as a position, condition or attitude of an aircraft that clearly reduces safety margins and is a result of actions by the flight crew (Merritt & Klinect, 2006). It is a safety compromising state that results from ineffective error management.

The following example, observed during a line operations safety audit (LOSA) flight, clearly illustrates the link between error management and undesired aircraft states (UAS). In other words, if errors are not detected and recovered by crew, there is an increased risk that an undesired aircraft state will occur.

**Poor error management = UAS**

During the descent the captain had a simple miss on a ‘1000 to go’ call. Things then quickly started to go wrong. At about 3,500 ft, we were at 250 knots with about 12 track miles to go, and ATC asked if we were visual. Without reference to the first officer, the captain accepted a visual approach and prompted the first officer to start slowing up. Flaps were run, speedbrake as well, but by 2,500 ft on left base we were visually going high. The first officer could not see this from his side of the cockpit and the captain made a good decision in lowering the gear at this point. The first officer then cut the turn onto final inside the LNAV track. The captain did not intervene. A difficult rollout on C/L distracted the first officer from path...
control and we ended up at 1000 ft with 3 dots to fly down on the T-VASIS, thrust still at idle, landing flaps still to go. The vertical deviation was called by the captain and acknowledged by the first officer. At 800 ft ROD was 1200fpm, which resulted in G/S intercept at about 500 ft with engines starting to spool up and speed at CAC +15. ‘Stable approach’ was called, the ROD reduced to normal but the first officer did not properly coordinate the thrust increase relative to the speed bleed. At 150 ft the speed had dropped to CAC-5, which was called by the captain. Although a positive thrust correction was made, Vref was just maintained till flare. The first officer conducted a smooth touchdown but during taxi-in the captain forgot to retract the flaps after landing. The first officer forgot to double-check them.

In the above flight there were multiple errors made by the flight crew, which were not detected and ultimately led to a vertical deviation and unstable approach. The captain missed the ‘1000 to go’ call, the first officer made an unintentional vertical deviation during the turn onto final, the captain incorrectly called the approach stable at 500 ft, at 150 ft the first officer made an unintentional speed deviation and both pilots forgot to retract the flaps on taxi-in.

Apart from unstable approaches as illustrated above, other examples of UAS include, lateral deviations, firm landings, and proceeding towards the wrong taxiway/runway. Events such as equipment malfunctions or ATC command errors can also place the aircraft in a compromised position, but these would be considered threats. As with errors, UAS can be managed effectively, returning the aircraft to safe flight; or flight crew action or inaction can induce an additional error, or result in an incident, or accident.

A UAS is often considered at the cusp of becoming an incident or accident and therefore must be managed by flight crews.

Table 30 presents examples of undesired aircraft states, grouped under three basic categories.

Table 30 Undesired aircraft states

<table>
<thead>
<tr>
<th>Undesired aircraft state</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft handling</td>
<td>Vertical, lateral or speed deviations</td>
</tr>
<tr>
<td></td>
<td>Unnecessary weather penetration</td>
</tr>
<tr>
<td></td>
<td>Unstable approach</td>
</tr>
<tr>
<td></td>
<td>Long, floated, firm or off-centreline landings</td>
</tr>
<tr>
<td>Ground navigation</td>
<td>Runway/taxiway incursions</td>
</tr>
<tr>
<td></td>
<td>Wrong taxiway, ramp, gate, or hold spot</td>
</tr>
<tr>
<td></td>
<td>Taxi above speed limit</td>
</tr>
<tr>
<td>Incorrect aircraft configuration</td>
<td>Automation, engine, flight control, systems, or weight/balance events</td>
</tr>
</tbody>
</table>


An important learning and training point for flight crews is the timely switch from error management to undesired aircraft state management. An example would be as follows. A flight crew select a wrong approach in the flight management computer (FMC). The flight crew subsequently identify the error during a crosscheck prior to the final approach fix (FAF). However, instead of using a basic mode (e.g. heading) or manually flying the desired track, both flight crews become involved in attempting to reprogram the correct approach prior
to reaching the FAF. As a result, the aircraft ‘stitches’ through the localiser, descends late, and goes into an unstable approach. This would be an example of the flight crew getting ‘locked in’ to error management, rather than switching to undesired aircraft state management. The use of the TEM model assists in educating flight crews that, when the aircraft is in an undesired state, the main task of the flight crew is undesired aircraft state management instead of error management. It also illustrates how easy it is to get locked in to the error management phase.

It is important to establish a clear differentiation between undesired aircraft states and outcomes. Undesired aircraft states are transitional states between a normal operational state (i.e. a stabilised approach) and an outcome. Outcomes, on the other hand, are end states, most notably, reportable occurrences (i.e. incidents and accidents). An example would be as follows: a stabilised approach (normal operational state) turns into an unstabilised approach (undesired aircraft state) resulting in a runway excursion (outcome).

While at the stage of undesired aircraft state, the flight crew have the opportunity, through appropriate TEM, of recovering the situation and returning to a normal operational state, thus restoring margins of safety. Once the undesired aircraft state becomes an outcome, recovery of the situation, return to a normal operational state, and restoration of margins of safety is not possible. This stresses the importance of anticipation in the TEM approach.

**APPLICATION OF TEM**

**Practical applications of the TEM model**

**TEM as a training tool**

TEM is the foundation of human factors training programs at several airlines and is beginning to be used on other domains such as healthcare and air traffic services. TEM training emphasises the value of threat anticipation and management, error minimisation, and error detection and recovery. The model allows pilots to analyse their own performance strengths and vulnerabilities. The International Civil Aviation Organization has adopted the TEM model in its Human Factors Training Manual (ICAO Document 9683), produced in 2002 to help airlines design human factors curricula.

As a training tool, TEM can help individuals clarify their performance needs and vulnerabilities from a different perspective. Hence, threat and error management concepts could be introduced and explored as one component of CRM training.

**TEM as a reporting tool for incidents**

In the United States, TEM has been integrated into the Aviation Safety Action Program (ASAP). This is a national confidential safety reporting program. The TEM framework has been incorporated into the ASAP report form and instructs the pilots to describe the event at the level of threats and errors. The TEM format prompts pilots to report information about the threats that were present, the errors they may have made, how well the event was managed, and how the event may have been avoided or handled better.
TEM as a systematic observation tool

The TEM model was first conceived in conjunction with the development of the LOSA program, a behavioural audit methodology that studies flight crew threat and error management capabilities during normal flight operations. Therefore, its original application was as an observation tool. Feasibility studies are currently underway to explore the transfer of the methodology to other operational areas within aviation such as airline flight dispatch, air traffic control and cabin crew, as well as other industries such as healthcare and rail.

TEM as a proactive analysis tool

When TEM is used as the framework for safety data collection, a wealth of information can be extracted. An organisation can use the data to understand patterns at the organisational level. The data can also be collected across the industry and analysed for systemic trends. An analysis based on TEM can:

- Quantify those aspects of the working environment that can pose a problem for the efficiency or safety of the operation (threat prevalence)
- Quantify the management of those threats as either effective or ineffective (threat management)
- Recognise high rates of threat prevalence and mismanagement as systemic vulnerabilities
- Codify and quantify the errors that individuals commit (error prevalence)
- Codify and quantify the error management process from diagnosis to response and outcome (error management)
- Recognise high rates of error prevalence and error mismanagement as systemic flaws in procedures, policies, training, equipment design, and or inter-agency coordination; and
- Locate strengths as well as vulnerabilities in organisational safeguards.

TEM COUNTERMEASURES

According to Merritt and Klinect (2006), flight crews who develop contingency management plans, such as proactively discussing strategies for anticipated threats, tend to have fewer mismanaged threats; crews that exhibit good monitoring and cross-checking usually commit fewer errors and have fewer mismanaged errors; and finally, crews that exhibit strong leadership, enquiry and workload management are typically observed to have fewer mismanaged errors and undesired aircraft states than other crews.

Many of the best practices advocated by crew resource management (CRM) can be considered TEM countermeasures.

Planning countermeasures: Planning, preparation, briefings and contingency management. These are essential for managing anticipated and unexpected threats.

Execution countermeasures: Monitor/cross-check, taxiway/runway management, workload and automation management. These are essential for error detection and error response.

Review/modify countermeasures: Evaluation or questioning of plans. These are essential for managing the changing conditions of a flight, such as undesired aircraft states.

These countermeasures along with examples, from Maurino (2005), are provided below in Table 31.
Table 31  Examples of individual and team countermeasures

### Planning countermeasures

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOP briefing</td>
<td>The required briefing was interactive and operationally thorough</td>
<td>• Concise, not rushed, and met SOP requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Bottom lines were established</td>
</tr>
<tr>
<td>Plans stated</td>
<td>Operational plans and decisions were communicated and acknowledged</td>
<td>• Shared understanding about plans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ‘Everybody on the same page’</td>
</tr>
<tr>
<td>Workload assignment</td>
<td>Roles and responsibilities were defined for normal and non-normal situations</td>
<td>• Workload assignments were communicated and acknowledged</td>
</tr>
<tr>
<td>Contingency management</td>
<td>Crew members developed effective strategies to manage threats to safety</td>
<td>• Threats and their consequences were anticipated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Used all available resources to manage threats</td>
</tr>
</tbody>
</table>

### Execution countermeasures

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor/cross-check</td>
<td>Crew members actively monitored and cross-checked systems and other crew members</td>
<td>• Aircraft position, settings, and crew actions were verified</td>
</tr>
<tr>
<td>Workload management</td>
<td>Operational tasks were prioritised and properly managed to handle primary flight duties</td>
<td>• Avoided task fixation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Did not allow work overload</td>
</tr>
<tr>
<td>Automation management</td>
<td>Automation was properly managed to balance situational and/or workload requirements</td>
<td>• Automation setup was briefed to other members</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Effective recovery techniques from automation anomalies</td>
</tr>
</tbody>
</table>

### Review countermeasures

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation/modification of plans</td>
<td>Existing plans were reviewed and modified when necessary</td>
<td>• Crew decisions and actions were openly analysed to make sure the existing plan was the best plan</td>
</tr>
<tr>
<td>Enquiry</td>
<td>Crew members asked questions to investigate and/or clarify current plans of action</td>
<td>• Crew members not afraid to express a lack of knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ‘Nothing taken for granted’ attitude</td>
</tr>
<tr>
<td>Assertiveness</td>
<td>Crew members stated critical information and/or solutions with appropriate persistence</td>
<td>• Crew members spoke up without hesitation</td>
</tr>
</tbody>
</table>

The following TEM countermeasures are provided in the 2005 Qantas Airways Command Training course.

As an illustration of how TEM countermeasures should work in practice, consider how the following threats encountered on a LOSA observation flight were well managed by the crew.
The training video flight

The crew for this service had already operated from MEL earlier in the morning. Both pilots had their original patterns disrupted and were not originally planned to operate this service or fly together. Fog in MEL had severely disrupted all company services on the Eastern seaboard on this day. The operating crew only found out about the return to MEL 23 mins before scheduled departure. The departure formalities were therefore compressed, but the crew handled this well. The first officer was pilot flying and neither pilot rushed his duties. The pre-flight was punctuated by on-going cabin crewing problems, which kept interrupting the pilots. This did not detract from the quality of their work. Information flowed freely across the cockpit and indeed into the cabin. The first officer gave an outstanding briefing with only a minor correction from the captain regarding actions in the event of an uncontrollable fire. There was good cross flow of information with confirmation from both regarding depth of understanding. A long taxi was anticipated. Push back was 20 mins late due to company crewing, delaying a decision about which cabin crew were to operate the service. The captain made a special briefing to the LOSA observer to ensure adequate knowledge of evacuation procedures. On initial taxi a change of runway was notified which shortened the taxi to about 300m. A new clearance was issued. The captain asked the first officer if he was happy with the change before acceptance. This procedure was handled 'by the book'. A short delay at the runway ended whilst the first officer checked the FMC and T/O data. An outstanding effort in crew coordination and conservative methods applied to minimise error.

This flight can be almost characterised as a perfect example of the ‘training video’ flight. The crew encountered multiple threats, including forecast weather, crew scheduling, load sheet anomalies, and later in their flight, late runway change and ATC frequency congestion. However, at all times there was a high degree of cooperation between PF and PNF and good threat anticipation and resultant contingency planning.

KEY POINTS

This section has covered the following key points:

- The threat and error management (TEM) approach has been developed based on the recognition that human error is a normal part of human behaviour and should be managed.
- TEM promotes a philosophy of anticipation or ‘thinking ahead’ in the constantly-changing environment of flight operations.
- The three basic components of the TEM model are threats, errors and undesired aircraft states.
- Flight crews who develop strategies or countermeasures such as planning, execution and review/modify plans tend to have fewer mismanaged threats. They commit fewer errors, have fewer mismanaged errors and fewer undesired aircraft states than other crews.
Prior to completing the exercises in the workbook, please read the single pilot human factors threat and error management advisory publication.

When you are ready, please turn to page 81 of the *Workbook for Pilots* and complete the exercises.

**RESOURCES**

**Further reading**


Chapter 11
Airmanship

This section examines the meaning of airmanship, its relationship to flight discipline and the influence of both on pilot performance. Case studies of effective and ineffective airmanship are presented as a means of identifying how airmanship skills may be improved.
Airmanship

- Overview 166
- Models of airmanship 170
- How to improve airmanship 173
- Key points 174
- Resources 175

“The emergencies you train for almost never happen. It’s the one you can’t train for that kills you.”

Ernest K. Gann, advice from the Old Pelican
Table 32  Airmanship

<table>
<thead>
<tr>
<th>Category</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airmanship</td>
<td>Maintain effective lookout</td>
</tr>
<tr>
<td></td>
<td>Maintain situation awareness</td>
</tr>
<tr>
<td></td>
<td>Assess situations and make decisions</td>
</tr>
<tr>
<td></td>
<td>Set priorities and manage tasks</td>
</tr>
<tr>
<td></td>
<td>Maintain effective communications and interpersonal relationships</td>
</tr>
</tbody>
</table>

**OVERVIEW**

The physical and technical part of flying is simple to understand - after all physics has well-defined rules and principles. However, there is something less clearly definable and more difficult to ascertain which is a critical part of flying. That ‘something’ is commonly called *airmanship*. Have you ever flown with a pilot who stood out from the crowd, or was just simply superior in their knowledge and skill than you perhaps expected?

Airmanship is that ‘something’ which separates the superior pilot from the average. It is not simply a measure of skill or technique, but a measure of a pilot’s awareness of the aircraft, the environment in which it operates and of their own capabilities. One of those capabilities is physical skill, but equally important components are wise decision-making and an elevated sense of self-discipline.

Some people consider airmanship to be the cornerstone of pilot competency. Competency has been defined as the combination of knowledge, skills and attitude required to perform a task well – or to operate an aircraft safely in all foreseeable situations.

The following section outlines some examples of ineffective and effective airmanship.

**Case studies of ineffective airmanship**

**Airline jet joy ride**

Federal crash investigators blamed a pair of joking pilots who flouted safety rules for a 2004 crash in Missouri. The crash highlighted shortcomings in training and safety oversight at regional airlines.

Capt. Jesse Rhodes, 31, and co-pilot Peter Cesarz, 23, died when Pinnacle Airlines Flight 3701 crashed 2 1/2 miles short of an airport in Jefferson City on 14 October, 2004, after losing power in both engines.

The pilots of the Bombardier CRJ-200, who were moving the jet from Little Rock to Minneapolis with no passengers aboard, repeatedly violated company safety rules, the National Transportation Safety Board (NTSB) said. They whooped and joked on what became a joy ride, pulling the jet into steep climbs and attempted to fly at the plane’s highest altitude, 41,000 feet.

They allowed the jet to slow down too much, causing the engines to snuff out. The NTSB ruled that the accident resulted from the pilots’ ‘unprofessional behaviour, deviation from standard operating procedures and poor airmanship’.
Pinnacle Airlines (Northwest Jet Airlink) Bombardier CRJ-200

The National Transportation Safety Board (NTSB) determined that the probable causes of this accident were:

1. ‘The pilots’ unprofessional behavior, deviation from standard operating procedures, and poor airmanship, which resulted in an in-flight emergency from which they were unable to recover, in part because of the pilots’ inadequate training;

2. The pilots’ failure to prepare for an emergency landing in a timely manner, including communicating with air traffic controllers immediately after the emergency about the loss of both engines and the availability of landing sites; and

3. The pilots’ failure to achieve and maintain the target airspeed in the double engine-failure checklist, which caused the engine cores to stop rotating and resulted in the core lock engine condition.

Contributing to this accident was 1) the engine core lock condition, which prevented at least one engine from being restarted, and 2) the airplane flight manuals that did not communicate to pilots the importance of maintaining a minimum airspeed to keep the engine cores rotating.’

Helicopter pilot landed on car park roof to get keys cut

A pilot landed his helicopter on the top of a multi-storey car park because he wanted to get keys cut at a nearby shopping centre, it emerged today. The attendant at the Athlone car park, who claimed he waved the small aircraft away from the empty roof when it tried to land last July, said he was forced to take refuge behind a door to protect himself.

But he said he was injured when the downwash caused by the main rotor blew the door closed on his hand. The Air Accident Investigation Unit found the pilot, who believed he had permission to land, had broken Irish Air law.

‘The shopping centre was open for business at the time and for obvious safety reasons the area should have been completely avoided. ‘In landing at such a site the pilot displayed poor airmanship,’ the investigation found.

The attendant said he tried to wave the helicopter away because it had landed some months previously and his supervisor told him this was not allowed.

But the pilot, who claimed the attendant was not on the roof, said that on the previous occasion he was travelling with the owner of the shopping centre who had given him permission to land on the roof, which was always empty.

He said he phoned the duty manager of the Texas Centre the day before this latest incident to confirm he had permission to land again.

The centre manager said he had not given permission, adding the car park was not owned by the shopping centre. But the duty manager of the Texas Department Store, a shop in the centre, said he did allow the landing not realising he did not have the authority.

The investigation report noted the landing was contrary to the rules of the air and that the area was congested and should have been avoided.
A case study of effective airmanship

In contrast to the above examples of poor airmanship, the following describes the actions by the crew of a Delta Airlines flight from Houston to Dallas, who demonstrated superior airmanship by landing the aircraft safely, despite smashing into a flock of birds that destroyed one engine, damaged another and caused serious airframe damage.

Snow geese wipe-out

An air traffic controller had asked the crew to participate in a ‘no airspeed restriction’ test being run by the FAA. The 727 accelerated, as requested, and at 6,000ft struck a flock of snow geese. The crew instantly found the aircraft vibrating intensely and all power was lost in one of its three engines. The first officer’s cockpit instruments had also failed, and the noise in the cockpit was deafening. The crew worked as a team to return the crippled aircraft to Houston. The first officer flew using the captain’s instruments, while the captain, second officer and line-check second officer analysed the situation and performed the appropriate emergency procedures. They declared an emergency in the air with ATC and informed passengers of their situation. With the captain taking the controls on the aircraft’s final approach, they landed safely with no injuries.

From such incidents, it is clear that there are several qualities commonly found in displays of effective airmanship, not the least being the ability of the flight crew to control a situation by using both their training and a certain amount of on-the-spot ingenuity, as demonstrated above by the Delta Airlines crew.

Other qualities associated with effective airmanship include the following:

- **Discipline** – abiding by procedures, despite the peculiarity of the situation.
- **Communication** – keeping others (e.g. ATC) informed of developments.
- **Teamwork** – working well together to resolve problems and maintain control.
- **Knowledge** – having a deep understanding of aircraft systems and operation.
- **Expertise** – transfer/retention of knowledge and skills.
- **Situation assessment** – analysing and assessing unusual developments.
- **Judgement** – calling upon prior training and expertise to resolve unusual problems.
- **Decision making** – taking decisive action.
- **Resource management** – allocating resources to ensure control of the larger situation is maintained whilst specific problems are being addressed.
- **Goal prioritisation** – prioritising safety above personal concerns.
- **Situational awareness** – maintaining awareness; being alert to any unforeseen situations arising.
- **Foresight** – anticipating potential hazards.
- **Planning** – working out courses of action to deal with potential hazards.

The next section provides a description of different levels of airmanship.
Are there different levels of Airmanship?

There seems to be a close correlation between levels of experience and effective airmanship.

**Experience = Airmanship.**

The three levels of airmanship, seem to agree closely with the normal career progression for an airline pilot:

**Basic airmanship** – At this level you have a basic competence (skills, knowledge and experience). Your foundation of knowledge and skills evolves further through continuous improvement, and sometimes through making mistakes. You teach this level of knowledge during your initial flying training and in your first experiences as a pilot. With further exposure to real-life situations and increasing experience you progress to the next level. This first level can thought of as the learning stage.

**Superior airmanship** – At this level you have gained enough experience in the real world to enable situation management (foresight, problem solving, situational awareness etc.). You reach this level by observing other more experienced pilots (your captain when you’re a first officer), reading aviation and safety articles, upgrades, conversion courses, type ratings and so on. Sometimes you get to this level by almost killing yourself or by making big blunders you get away with. You are proactive rather than reactive, and can think outside the square. This is usually thought of as the level that you need to get to in order to pass command training. This can be thought of as the good operator stage.

**Outstanding airmanship** – At this level you have the drive, motivation and the will to be an excellent, professional, safe and competent aviator and are dedicated to self-improvement. This should be the level you strive to achieve. Flight crew operating at this level seek airmanship excellence and this manifests itself in outstanding performance. When you get to this stage you’re at the professional aviator stage. At this level, nothing is ever taken for granted and you are constantly on the look-out for ways to improve. Safety experts often define very safe organisations as having *chronic unease*. They are never satisfied with their level of safety and always strive to do better. Displaying outstanding airmanship is much the same at an individual level.
MODELS OF AIRMANKSHIP

The most well-known approach to defining airmanship is that developed by Dr Tony Kern. During a four year study of the elements found in more than 150 aviation ‘near misses’, Dr Tony Kern discovered several common key clues to the nature of good airmanship.

There are three fundamental principles of expert airmanship: skill, proficiency and the discipline to apply them in a safe and efficient manner. Beyond these fundamental principles, expert aircrew have a thorough understanding of their aircraft, their team, their environment, their risks and themselves. With all of these elements in place there is the best opportunity to exercise consistently good judgement and maintain a high state of situational awareness. Total airmanship blends technical and tactical expertise, proficiency, and a variety of crew resource management (CRM) knowledge, skills and attitudes. His approach is illustrated in the following model.

Figure 14  The Kern ‘Bedrock’ approach to airmanship

Kern uses the analogy of building a structure like a house or temple.

Bedrock principles

The foundations of the structure are the ‘Bedrock Principles’ consisting of three foundation stones.

Discipline. This is about respecting and applying SOPs, standards, regulations, unless emergency circumstances dictate otherwise.

Skill. This is developed by knowledge, demonstration and practice. Flying must be continually practised to maintain the skill. This can be in the aircraft, the simulator or any ground-based flight training device. Competence will quickly diminish without practice.
Proficiency. Practice and repetition are the key drivers towards competent proficiency. It is more than just clocking up logbook flight hours. Seek to obtain quality, not just quantity.

Once the foundation is firmly established the pillars of knowledge can be erected.

**Pillars of knowledge**

There are five ‘pillars of knowledge’:

**Self.** This is about knowing your own limitations and having the preparedness to assess and analyse your own flying performance.

**Aircraft.** This is having a thorough knowledge and understanding of the aircraft, its systems and components, speeds and limitations, including the airworthiness status and all maintenance requirements.

**Team.** A thorough understanding of what it means to be operating in a team environment, whether it’s the pilot beside you, the cabin crew, ATC, loading, airport, outport, maintenance, engineering, dispatch, operations and your aircraft fleet staff.

**Environment.** This includes the physical, regulatory, and organisational elements that you operate within, not just the weather.

**Risk.** This involves gathering information, and making an assessment, and then a considered decision, based on your knowledge, previous experience and common sense to pursue the safest, least-risk option. You will be required to judge and evaluate the amount of risk you (and your crew/team) are prepared to accept to achieve your goal.

The final structure which covers all the previous building blocks and could be thought of as the pinnacle of this ‘airmanship building’, Kern calls the ‘capstone outcomes’.

**Capstone outcomes**

Capstone outcomes consist of:

- **Situational awareness.** Any pilot is required to have situational awareness (SA). You need to have enough spare mental capacity to be able to take in all the things occurring around you such as: weather, traffic, navigation, ATC, aircraft serviceability/defects, what the aircraft is doing and where you want it to go and how you will accomplish that (aviate, navigate, communicate), flight schedule keeping, potential hazards, terrain, nearest suitable airfields and so on, so that you can formulate plans and keep ahead of the aircraft.

  A more complete description of situational awareness is provided in Section 8: Situational Awareness, of this guide.

- **Judgement.** This can also be referred to as decision making. Using good judgement and making the right decisions are essential to leadership and vital to the safe conduct of any flight. The topic of decision making is explored in more detail in chapter 9: Decision Making, of this guide.

  A more simplistic model of airmanship is provided by Ebbage and Spencer in their publication, *Airmanship training for modern aircrew*. 
Judgement is used in the broadest sense to emphasise the need for aircrew to make conscious, intuitive, timely and well-founded decisions.

Guidelines for good decision making
A simple way to remember the guidelines of good decision making is to employ the AVIATE acronym:

- **A**ssess the problem
- **V**erify information
- **I**dentify solutions
- **A**nticipate consequences of decisions
- **T**alk to others regarding decision and rationale
- **E**valuate decisions.

Control is used as a reminder to maintain control of an aircraft whilst evaluating a situation, and to execute a planned course of action with precision and accuracy — many good judgements are undone by failures in execution.

Discipline is needed to detect potential errors at the earliest opportunity and to formulate considered judgements and execute controlled actions. The foundations of airmanship are built on a specific set of knowledge, skills and attitudes.

Pilots should ask themselves: ‘Am I maintaining a disciplined approach to all procedures—pre-flight, in-flight and post-flight? If I am not, then why? Am I sacrificing discipline (and safety) to save a few dollars or a few minutes?’ All pilots have a moral responsibility to inform a passenger, intending to fly with a person known to engage in illegal or doubtful activities (e.g. unauthorised low flying or inappropriate manoeuvres around the airfield), that flight with that person is inadvisable. If a person is known to consistently indulge in illegal flight then there is a responsibility to inform an appropriate authority.
‘Aviation in itself is not inherently dangerous. But to an even greater degree than the sea, it is terribly unforgiving of any carelessness, incapacity or neglect.’

Captain A. G. Lamplugh (British Aviation Insurance Group, London, circa early 1930s)

HOW TO IMPROVE AIRMANSHIP

Some examples of good airmanship:

- Look out the window when turning to check visually for traffic or visually acquire TCAS targets displayed on your navigational display. In other words, don’t just blindly rely on TCAS and ATC. The same goes for weather avoidance - look outside and manoeuvre visually around build-ups if possible. A good visual eyeball peek is worth a thousand cross-references!

- If there is any doubt - there is no doubt. For example, if you are unsure whether to use take-off and go-around (TOGA) rather than reduced thrust for take-off when windshear is forecast or reported, opt for the safer option and use TOGA. If you’re unsure if the runway will be wet or dry when getting take off performance data then use ‘wet’.

- Do not blindly follow SOPs or operations manuals if that course of action will result in greater risk and reduced safety. SOPs are usually written for routine and standard conditions. If you experience an unusual situation it may be better to do something slightly different (but safer). Of course this should not give you licence to disregard SOPs unilaterally - you need to have a justifiable reason for pursuing an alternative course of action.

‘Rule books are paper - they will not cushion a sudden meeting of stone and metal’

Ernest K. Gann, Fate is the Hunter

- Think ahead and have a plan for when things might go wrong. This is about applying basic threat and error management skills, discussed in chapter 10. For example, while you may be waiting for take-off clearance in a long line of departing aircraft, mentally review the actions you would take in the event of a rejected take-off. What might you do in the event of a time critical emergency such as a cargo fire? You should have quick answers to the following questions:
  - Will it be a visual approach?
  - Is it a left or right circuit?
  - Will I need immediate radar vectors for an ILS or a procedure turn for a landing on the reciprocal runway?
  - Will I need to do an overweight landing or dump fuel?
Treat every landing as a go-around, so that on the day you have to do one for real, you can execute it flawlessly.

Strive for excellence in your aviation skills and demand the same from your crew. Act with integrity and display leadership for both your subordinates and superiors.

Prepare for each and every flight you conduct. Where are my nearest suitable alternate airfields? What runways, length, elevation and approach aids are there? Discuss new ports or routes with your peers and mates to get information about potential threats, before you encounter them by surprise. Ensure you have good technical knowledge of your aircraft and its systems. This is a continually-evolving learning experience.

When approaching possible weather-induced turbulence, inform your passengers or put the ‘seat belts’ sign on early, so that the cabin is secure.

A pilot exhibiting good airmanship will understand the limit of his capabilities and abide by a ‘personal minimums checklist’. Checklists ensure you do not just take a brief stock of your personal situation and overlook complicated situations and multiple stressors and simply forge ahead. This behaviour at the least can lead to added stress during the flight, and at worst can lead to a mishap—precisely why having a checklist is important.

**I’M SAFE Checklist**

A quick, simple assessment of your physical condition to fly:

- **I**llness—Do I have an illness or any symptoms of an illness?
- **M**edication—Have I been taking prescription, or over-the-counter drugs?
- **S**tress—Am I under psychological pressure?
- **A**lcohol—Have I been drinking within eight hours? Within 24 hours?
- **F**atigue—Am I tired and not adequately rested?
- **E**ating—Am I adequately nourished?

**KEY POINTS**

This section has covered the following key points:

- Airmanship separates the superior pilot from the average, and is not just about physical skill but wise decision-making, knowledge of self, the aircraft and the environment.
- Effective airmanship seems to be highly related to a good level of experience, with three progressive levels from basic, superior to outstanding.
- There are a number of models of airmanship, but all agree that judgement, control and discipline underpin effective airmanship.
- Airmanship can be improved by a dedication to self improvement.

When you are ready, please turn to page 87 of the *Workbook for Pilots* and complete the exercises.
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<td>Australian Defence Force</td>
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<td>AFDS</td>
<td>Automated Flight-Director System</td>
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<td>AGL</td>
<td>Above Ground Level</td>
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<tr>
<td>ALAR</td>
<td>Approach-and-Landing Accident Reduction</td>
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<td>ALARP</td>
<td>As Low as Reasonably Practicable</td>
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<tr>
<td>AME</td>
<td>Aircraft Maintenance Engineer</td>
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<td>AOC</td>
<td>Air Operator’s Certificate</td>
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<td>AOD</td>
<td>Alcohol and Other Drugs</td>
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<tr>
<td>AQS</td>
<td>Australian Qualification Standard</td>
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<tr>
<td>APU</td>
<td>Auxiliary Power Unit</td>
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<tr>
<td>AS/NZS</td>
<td>Australian/New Zealand Standard</td>
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<tr>
<td>ATC</td>
<td>Automated Traffic Control</td>
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<tr>
<td>ATIS</td>
<td>Automated Traffic Information Service</td>
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<tr>
<td>ATS</td>
<td>Air Traffic Service</td>
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<tr>
<td>ATSB</td>
<td>Australian Transport Safety Bureau</td>
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<tr>
<td>AVIATE</td>
<td>Assess, Verify, Identify, Anticipate, Talk, Evaluate</td>
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<tr>
<td>BAC</td>
<td>Breath Alcohol Concentration</td>
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<tr>
<td>BITRE</td>
<td>Bureau of Infrastructure, Transport and Regional Economics (formerly BTCE)</td>
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<tr>
<td>CAA</td>
<td>Civil Aviation Authority (of the UK)</td>
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<tr>
<td>CAAP</td>
<td>Civil Aviation Advisory Publication</td>
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<td>CAO</td>
<td>Civil Aviation Order</td>
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<td>CAR</td>
<td>Civil Aviation Regulations</td>
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<tr>
<td>CASA</td>
<td>Civil Aviation Safety Authority</td>
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<td>CASR</td>
<td>Civil Aviation Safety Regulation</td>
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<tr>
<td>CCK</td>
<td>Church Creek</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
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<tr>
<td>CFIT</td>
<td>Controlled Flight Into Terrain</td>
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<tr>
<td>COA</td>
<td>Certificate of Approval</td>
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<tr>
<td>CoA</td>
<td>Certificate of Airworthiness</td>
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<tr>
<td>CRM</td>
<td>Crew Resource Management</td>
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<tr>
<td>CSM</td>
<td>Customer Service Manager</td>
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<tr>
<td>DAMP</td>
<td>Drug and Alcohol Management Plan</td>
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<tr>
<td>DDG</td>
<td>Dispatch Deviation Guide</td>
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<tr>
<td>EFOB</td>
<td>Extra Fuel On Board</td>
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<tr>
<td>EGPWS</td>
<td>Enhanced Ground Proximity Warning System</td>
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<td>EGT</td>
<td>Exhaust Gas Temperature</td>
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<tr>
<td>ERP</td>
<td>Emergency Response Plan</td>
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<td>FAA</td>
<td>Federal Aviation Administration (of the USA)</td>
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<td>FDA</td>
<td>Flight Data Analysis</td>
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<td>FDAP</td>
<td>Flight Data Analysis Programme</td>
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<td>FEG</td>
<td>Force Element Group</td>
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<td>FMC</td>
<td>Flight Management Computer</td>
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<td>FMS</td>
<td>Flight Management System</td>
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<td>FOD</td>
<td>Foreign Object Damage</td>
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<td>FRMS</td>
<td>Fatigue Risk Management System</td>
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<td>GA</td>
<td>General Aviation</td>
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<tr>
<td>GPWS</td>
<td>Ground Proximity Warning System</td>
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<td>HF</td>
<td>Human Factors</td>
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<tr>
<td>ICAO</td>
<td>International Civil Aviation Organisation</td>
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<tr>
<td>IDG</td>
<td>Integrated Drive Generator</td>
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<tr>
<td>IFR</td>
<td>Instrument Flight Rules</td>
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<td>ILS</td>
<td>Instrument Landing System</td>
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<tr>
<td>INTAM</td>
<td>Internal Notice to Airman</td>
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<tr>
<td>IMC</td>
<td>Instrument Meteorological Conditions</td>
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<tr>
<td>IMSAFE</td>
<td>Illness, Medication, Stress, Alcohol, Fatigue, Eating</td>
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<tr>
<td>IRM</td>
<td>Immediately Reportable Matter</td>
</tr>
<tr>
<td>IRS</td>
<td>Internal Reporting System</td>
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<tr>
<td>LAME</td>
<td>Licensed Aircraft Maintenance Engineer</td>
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<tr>
<td>LOSA</td>
<td>Line Operations Safety Audit</td>
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<tr>
<td>MCP</td>
<td>Mode Control Panel</td>
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<tr>
<td>MEL</td>
<td>Minimum Equipment List</td>
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<tr>
<td>MRO</td>
<td>Medical Review Officer</td>
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<tr>
<td>MOU</td>
<td>Memorandum of Understanding</td>
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<tr>
<td>NASA</td>
<td>National Aeronautical and Space Administration</td>
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<tr>
<td>NDARC</td>
<td>National Drug and Alcohol Research Centre</td>
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<tr>
<td>NOTAM</td>
<td>Notice to Airmen</td>
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Airmanship: In addition to skill and technique, airmanship is the measure of a pilot’s awareness of the aircraft, the environment in which it operates and of his or her own capabilities; physical skills, decision making and self-discipline.

Airmanship: The consistent use of good judgement and well developed skills to accomplish flight objectives (ICAO definition).

Attention: The mental faculty that controls the subject matter chosen for conscious information processing; that information which we choose to focus on.

Behavioural markers: Short, precise statements describing single non-technical skills or competencies. They are observable behaviours that contribute to competent or not yet competent performance within a work environment.

Circadian rhythm: A cycle lasting approximately 24 hours, which regulates the biochemical, physiological and behavioural processes of living beings.

Error: Crew actions or inactions that:
- lead to a deviation from crew or organisational intentions or expectations:
- reduce safety margins: and
- increase the probability of adverse operational events on the ground and during flight.

Crew Resource Management: Training that is provided to both flight crew and cabin crew encompassing communication, situational awareness, decision making, and teamwork. The goal of CRM is to enhance aviation safety by improving efficiency and optimising human resources.

Decision Making: A process for reaching a judgement or selecting an option to address or resolve a situation.

Drug: Any substance – solid, liquid or gas – that brings about physical and/or psychological changes.

Fatigue: The experience of physical or
psychological weariness; primarily due to increased duration of wakefulness, or a reduction in the quality or quantity of sleep.

**Hazard**: see Threat

**Human Factors**: The minimisation of human error and its consequences by optimising the relationships within systems between people, activities and equipment.

**Judgement**: An opinion formed after analysis of relevant information.

**Latent conditions**: “Mouse traps” which may lay dormant within the work system, but have the potential to increase safety risk and create error producing conditions in the workplace. E.g. Ambiguous procedures may not directly result in an incident or accident, but instead may combine with bad weather or poor decision-making, to result in an undesired outcome.

**Leadership**: The ability of the pilot in command to induce the trainee member(s) to use their skills and knowledge to pursue a defined objective.

**Motivation**: Causal factors which determine an individual's likelihood to engage in or repeat a particular behaviour.

**Manage(ment)**: To plan, direct and control an operation or situation.

**Non-technical skills**: Specific human factors competencies, sometimes referred to as ‘soft skills’, such as lookout, situational awareness, decision making, task management and communication.

**Organisational Culture**: The attitudes, norms, beliefs, and values shared by individuals in an organisation which govern their interactions and behaviours.

**Personal Limitations**: The boundaries of human performance in terms of both physical interaction with one's surroundings and the human cognitive limitations of information processing. It is the human performance equivalent of an aircraft’s flight envelope.

**Psychomotor abilities**: The physical functions of movement, associated with coordination, dexterity, and reaction time; also called motor or sensorimotor abilities.

**Risk Management**: The overall process of identifying, evaluating, controlling or reducing, and accepting risks.

**Safe(ly)**: Means that a manoeuvre or flight is completed without injury to persons, damage to aircraft or breach of aviation safety regulations, while meeting the standards specified by the Civil Aviation Safety Authority.

**Situational Awareness**: Knowing what is going on around you, being able to predict what could happen, and taking the appropriate action in a timely manner.

**Standard Operating Procedure**: Any procedure included in the operations manual of an AOC or OC holder.

**Stress**: A state of emotional arousal associated variously with overload, fear, anxiety, anger and hostility, which can threaten individual and team performance.

**Stressor(s)**: Disturbing physiological or psychological influences on human performance which may adversely affect the safety of a flight or situation.

**Team Coordination**: A group of individuals working collaboratively to accomplish a shared goal or outcome through communication and negotiation.

**Technical skills**: The manipulative and knowledge skills a pilot employs when operating an aircraft.

**Threat**: (University of Texas/GAPAN definition for multi-crew/LOSA operations):

Events or errors that:
- occur outside the influence of the flight crew;
- increase the operational complexity of the flight; and
- require crew attention and management if safety margins are to be maintained.
**Threat:** (CASA modified definition for single-pilot operations): A situation or event that has the potential to impact negatively on the safety of a flight, or any influence that promotes opportunity for pilot error(s).

**Threat and Error Management:** The process of detecting and responding to threats and errors to ensure that the ensuing outcome is inconsequential, i.e. The outcome is not an error, further error or undesired state.

**Undesired Aircraft State:** Pilot-induced aircraft position or speed deviation, misapplication of flight controls, or incorrect systems configuration, associated with a reduced margin of safety.

**Vestibuloocular abilities:** Pertaining to the vestibular and oculomotor nerves, or to the maintenance of visual stability during head movements.

**Violations:** Intentional deviation from rules, regulations, operating procedures or standards.

**Workload:** The combined physical and cognitive demands placed upon an individual, requiring a form of action or outcome.

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