Sleepy, strung-out, dry, hungry pilots

Pilot fatigue, stress, dehydration and hypoglycaemia continue to play a part in accidents and incidents. In this roundup, Dr David Newman outlines the latest findings on the problems.

DIGITAL IMAGE DESIGN BY P MARKMANN

ON AUGUST 6, 1997, a Korean Air Boeing 747-300 crashed on approach to Guam, killing 228 people on board. The US National Transportation Safety Board found that fatigue was implicated in general flightdeck confusion and impaired reactions of the crew in the lead-up to the tragedy.

The finding was based in part on cockpit voice recorder data revealing that the captain was "really sleepy". Although his recent flying hours in the days and weeks leading up to the accident were within legal limits, the accident occurred after midnight and the NTSB concluded that the captain's fatigue contributed to his mishandled approach.

The aircraft hit Guam's Nimitz Hill about 3 nm short of the runway.

In Australia, fatigue has been implicated in at least seven fatal civil aviation accidents, in which 14 people died, over the past 10 years, according to Australian Transport Safety Bureau data. However, the bureau stresses that it is difficult to prove fatigue was a contributing factor in particular cases.

Compelling evidence of a link between fatigue and accidents is emerging from international datasets, however. Between 1974 and 1992, 25 per cent of major US Air Force accidents involving fighter aircraft at night were attributed to crew fatigue. Between 1977 and 1990, 12 per cent of major US Navy accidents were due to fatigue. In the US Army between 1990 and 1999, four per cent of all accidents (both major and minor) were fatigue related.

Meanwhile, a study in 2000 found that in a group of executive and corporate jet crews, 75 per cent reported having "nodded off" during flights. Eighty-five per cent of them considered fatigue to be a safety issue. A similar study examining US Army crews found that 45 per cent reported having "dozed off" during flight, with 81 per cent considering fatigue to be a safety issue in their operations.

In 1998, the NASA Ames Research Centre conducted a series of field studies on fatigue. The investigators found that crew members in short-haul fixed-wing operations slept less, with 67 per cent having a sleep loss of one hour or more a night. Crew woke earlier, had more trouble falling asleep and had lighter and less restful sleep. They also reported drinking more alcohol and caffeine on trip days.

The researchers recommended on the basis of these findings that successive duty days should begin at the same time, or progressively later, and that crews should be provided with information on alternatives to alcohol as a pre-sleep relaxant.

The only recognised antidote to fatigue is adequate sleep. We need seven to eight hours of sleep a night. Failure to get enough racks up a sleep debt that must be repaid. This accounts for the often deep, prolonged sleep that we experience after intense activity with long duty days or a series of late nights. There is no sleep bank that would allow us to get sleep in advance to offset subsequent fatigue.

Sleep cycle There are four stages of sleep, ranging from fairly light sleep in stage one to deep sleep in stage four – the phase of restorative sleep that kills off fatigue. In a typical sleep cycle, most of the stage four sleep occurs early, in the first third of the cycle.

Rapid eye movement (REM) sleep is another important phase of sleep. In this lighter phase the sleeping person dreams. Each eight-hour sleep cycle has four or five episodes of REM sleep, during which memories are thought to be organised and laid down. When a person is learning new tasks in the day, they often get more REM sleep that night.

Fatigue reduces performance on every level. Decision-making is impaired, vigilance and attention are reduced, judgement is often less than optimal, and people are more inclined to accept a lower standard of performance than they would normally.

Reducing sleep by just one hour a night leads to increased daytime sleepiness, which is cumulative over successive nights. Reducing sleep by two hours a night leads to impaired alertness and measurable levels of reduced performance. The pattern of subsequent sleep changes, with the person falling asleep more quickly and drifting into a deeper sleep with fewer awakenings. Such patterns indicate a significant level of fatigue.

Alcohol Many people use alcohol as an aid to sleep, and although drinking reduces the time taken to fall asleep, it interferes with the normal pattern of sleep. It increases the number of awakenings and suppresses early REM sleep. In large doses, it can suppress REM sleep entirely. It also increases the level of subsequent daytime sleepiness.

Caffeine Caffeine is often used to offset the effects of fatigue. As a central nervous system stimulant, it improves alertness and vigilance, but don't consume it too late in the duty day or its effectiveness as a fatigue mitigator will be significantly reduced.

Sleep inertia Sleep inertia is the transition phase between sleep and wakefulness. It is that groggy feeling you have when you are awoken from a deep sleep. It interferes with many aspects of task performance, including decision-making ability. The degree of sleep inertia depends on what stage of sleep you are woken up from. Sleep inertia is likely to be more pronounced if you are woken suddenly from stage four sleep. If enough time elapses between waking up and being required to perform a task, the effects are likely to be less obvious, but sleep inertia can last for up to half an hour.

Photo by James Ostinga. Digital image design by P Markmann

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Flight operations The combination of long duty periods, night flying, a relatively hypoxic environment, and transmeridian travel make the issue of fatigue in aviation a big one. Our biological or circadian rhythms evolved to ensure we got adequate rest and sleep, by making us sleepy at regular, predictable intervals. Modern 24-hour aviation operations force crewmembers to work against their biological programmes.

Soon, ultra-long range flight involving sectors of more than 18 hours will become routine, with aircraft such as the A340-500 and B777-300ER. Issues of fatigue management will take on greater importance. Much research is being conducted around the world on fatigue modelling and management systems, and Australia is a major player (See *Unlocking the secrets of sleep*, page 41).

Fatigue management takes into account much of what we currently know about fatigue and work–rest cycles. It can involve such areas as on-board crew rest facilities, napping strategy, appropriate flight scheduling and adequate crewing. Maintaining crew alertness in the modern automated cockpit can be a real challenge on long-haul flights, however.

Stress Understanding stress and learning how to effectively cope with it could help reduce accidents.

Stress is the response to unfavourable environmental conditions. If excessive demands are placed on a person, they may exceed the person's ability to cope with them. Continued stress can create physical symptoms such as insomnia, lack of appetite, headache and irritability. And the body's natural "fight or

flight" response to stress produces physiological effects, including muscle tremors, increased heart rate,sweating and incoordination.

Stressors are factors that create stress. They can be broadly grouped into environmental, life, reactive and organisational stressors.

Environmental stressors include noise, with exposure to more than 90 dB of noise impairing performance. Another environmental stressor is temperature. Temperatures below 15° C or above 30° C can be stressful. Very low and very high humidity are other stress factors, with levels below 40 and above 60 per cent causing problems. Vibration and hypoxia may also be factors.

Life stressors are emotional, domestic,social and financial woes. They can create problems in the cockpit and are, at the very least, distracting for the pilot.

Typical life stress score tables rate events according to the level of stress they induce. A total score of 60 to 80 points represents a normal level of modern life stress. A score well over 100 represents serious life stress.

Death of a spouse scores the highest, at 100 points.Going on holiday rates only 13 points.

Reactive stress is the mental and physical response to certain situations. Examples of reactive stress in aviation include running out of fuel,narrowly avoiding a mid-air collision or experiencing windshear on final approach.

Organisational stressors relate to your workplace. Examples include poor communication, role conflict or ambiguity, high workload, poor perceived autonomy levels,lack of career development, pay inequality or red tape.

Stressors are cumulative and additive. Everyone has a personal stress limit. If this limit is exceeded, even a moderate workload can be hard to cope with, and the person goes into stress overload. This can affect performance and decision making, and can be a real problem in safety-sensitive industries such as aviation and nuclear power generation.

If stress is not managed, other problems, such as denial, aggression, and alcohol and substance abuse can result. These "coping strategies" can make the problem worse.

Stress management involves recognition of the factors causing stress, and removing stressors that can be eliminated. Prioritisation of multiple tasks is critical, as is adherence to standard operating procedures and checklists. Time management is also important, and the ability to delegate tasks can help in reducing workload and therefore stress. Other measures include keeping fit, taking rest breaks, learning appropriate relaxation strategies, maintaining a healthy lifestyle and recognising your limitations.

Dehydration Dehydration is a big risk in Australia. Reduced humidity levels in aircraft and reduced fluid intake to limit urination can increase the risk. Hot weather operations, especially at low altitudes, also increase the risk of dehydration and heat stress. High workload, poor cabin ventilation and work in hot climates to which the pilot is not acclimatised, also increase the risk.

The "greenhouse effect" of the cockpit canopies and windows can send temperatures soaring. Solar radiation enters the cockpit at a certain wavelength and heats up the internal structures. These structures reradiate the energy, but at a different wavelength, one at which it cannot easily escape the cockpit glass.

Under normal conditions, you need to replace about 1,500 mL of fluid a day. Every 24 hours, you lose approximately 500 mL of water through the skin, 500 mL in the urine and a further 500 mL via the respiratory tract. This fluid loss would happen even if you sat in front of the TV for 24 hours. Exercise,high workloads and hot ambient conditions increase the fluid loss, so you will need to consume more than 1,500 mL.

Dehydration seriously reduces your performance, impairs your judgement and decision-making abilities, and reduces your G tolerance. It can increase your risk of developing kidney stones, and might also put you at risk of suffering heat disorders. These range from simple sunburn to heat exhaustion and heat stroke.

Heat exhaustion is an intermediate level of heat stress. It results from the combination of water and salt depletion. Clinically, the signs and symptoms include weakness, fatigue, headache, impaired judgement,

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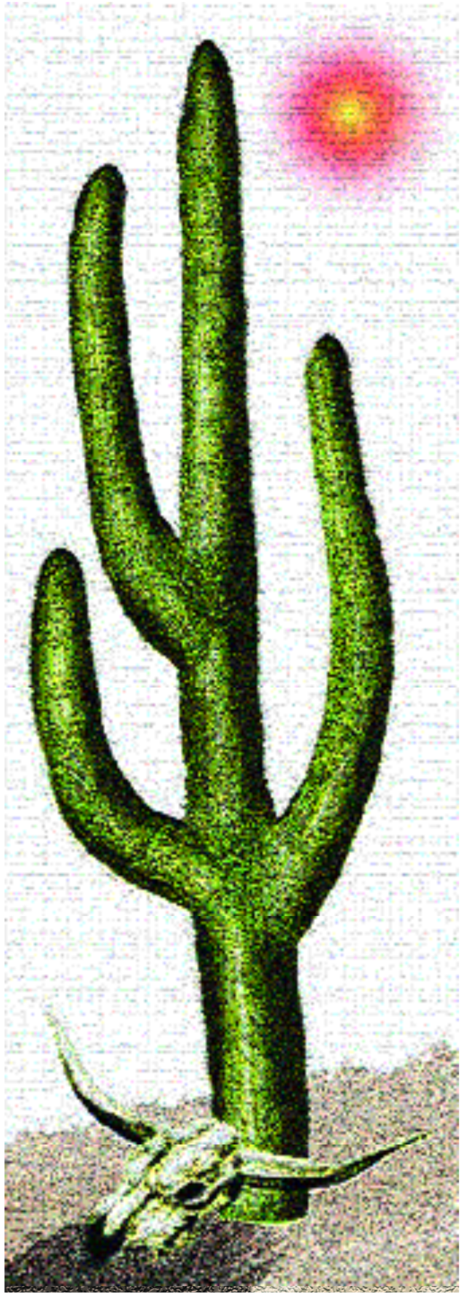

nausea, vomiting, dizziness, fainting, sweating (which may be profuse), and a modest rise in core body temperature.

Heatstroke – the failure of the body's thermoregulatory systems – is more dangerous. It results in an inability to control body temperature, sending the core temperature to 40° C, against the normal level of about 37° C. The nervous system malfunctions,and the sweating mechanism fails, leaving the skin dry and hot. Muscles can break down because of the high internal body temperature, causing at least some degree of kidney failure.

Thirst represents a fluid loss equivalent to 2 to 3 per cent of body weight. Symptoms such as a lagging pace, weariness,nausea,and emotional instability will be evident when fluid loss is only a little worse, at 5 per cent of body weight. Much more severe fluid loss, at 10 per cent body weight, causes delirium, a swollen tongue, circulatory problems, concentrated blood with reduced volume, and kidney problems. Twenty per cent fluid loss by body weight is at the limit of human survival.

It can be difficult to work out your level of dehydration. Do not rely on how thirsty you are, because thirst is not a reliable guide to dehydration. Urine is, however, and pilots should take notice of the colour and quantity of their urine. An adequate hydration level is reflected by good amounts of light-yellow urine. Dark urine is concentrated urine, suggesting that the body is conserving fluid as much as possible.Drink enough to return the urine to the normal straw colour.

Avoid or minimise alcohol, coffee, tea and soft drinks because they affect the kidneys, increasing urine production and exacerbating dehydration. Water is the best replacement fluid. Always carry some, even in temperate climates.

Hypoglycaemia Low blood sugar level caused by improper eating leads to weakness, tremors, dizziness, sweating, disturbed thinking, slow reaction times, changed behaviour, reduced G tolerance,lethargy and eventually unconsciousness.

Eating will help to correct these problems, but studies have shown that symptoms, such as slow reaction times, do not return to normal for up to 30 minutes after the blood sugar level returns to normal. It is better to avoid hypoglycaemia in the first place. You should eat within six hours of a flight, and take food with you if the flight is long.

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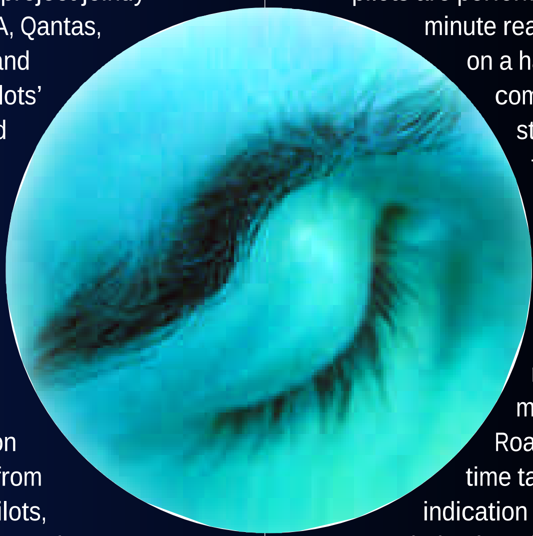
Unlocking the secrets of sleep

The amount of sleep obtained by long-haul pilots depends on their level of fatigue at the start of the flight and the period they have been awake before the flight, according to a study at the University of South Australia's Centre for Sleep Research.

The study, forming part of a multi-million-dollar fatigue risk management system (FRMS) project jointly funded by CASA, Qantas, the Australian and International Pilots' Association and the Australian Research Council, is aimed at improving pilot fatigue management.



Preliminary results, based on data collected from 131 long-haul pilots, indicate that pilots who rate themselves as being more fatigued at the start of a flight obtain more sleep during the flight.

Researcher Tracey Sletten presented the results at the Australian Aviation Psychology Symposium in Sydney in December. According to Sletten, the results demonstrate that methods used to manage crew in-flight rest opportunities are working.

"It makes good sense for pilots who are less refreshed at the start of a flight to get more sleep during the flight," says Sletten. "It shows that long-haul pilots are taking measures to ensure that they are alert during approach and landing, which are among the most critical phases of flight.

"The results suggest that Qantas crew are taking measures, such as allocating rest periods on a needs rather than seniority basis, to maximise sleep obtained by those who need it most."

Rank did not affect the amount of sleep obtained, she said.

The study also found that pilots obtain more sleep during long-haul flights when there are four pilots rather than three. In the next phase of the study, which began in December, long-haul pilots are performing a five-minute reaction time task on a hand-held computer at the start and end of flights, and at the start and end of in-flight sleep periods. According to the project's research manager Greg Roach the reaction time task gives an indication of neurobehavioural capability. "In the first phase of the study, we have been investigating the amount and quality of sleep that pilots obtain at home, during layovers, and particularly during long-haul flights," Roach says. "In the second phase of the study we will examine the impact that sleep has on neurobehavioural performance."

The results of these and other studies being undertaken as part of the FRMS project will aid in the development of a system to manage pilot flight and duty times.

"Early morning starts, long flights, unfamiliar sleeping quarters and time zone changes all contribute to the challenge of managing pilot fatigue," Roach says.

"Ultimately, the data will enable us to develop a system of managing and regulating pilot duty schedules that has a sound scientific basis."