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## **Pilot Fatigue Manageable, But Remains Insidious Threat**

*When a pilot becomes tired, problem-solving slows, motor skills degrade and attentiveness is impaired. Many accident-causing human errors are probably the result of pilot fatigue.*

—  
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“Pilot fatigue is a major safety concern in long-haul flying,” wrote David F. Dinges, Ph.D., and R. Curtis Graeber, Ph.D., in a paper presented at a Flight Safety Foundation (FSF) workshop. “Although today’s automated flight systems prevent the sleeping pilot from losing control of the aircraft, the less extreme effects of fatigue can seriously jeopardize flight safety.

“Each month [the U.S. National Aeronautics and Space Administration] Aviation Safety Reporting System (ASRS) receives reports from long-haul flight crews describing how fatigue and sleep loss have contributed to major operational errors such as altitude busts, track deviations, landing without clearance, landing on the incorrect runway and improper fuel calculations. Such reports are not surprising to any pilot who has flown all night over the ocean while trying to stay awake and alert in the dim light and constant hum of the long-haul cockpit. The problem worsens during trips as the effects of jet lag and sleep loss begin to accumulate.”<sup>1</sup>

A pilot’s duties in the cockpit require care, vigilance and physical and mental well-being. Cockpit noise, vibration, long flights, irregular work schedules or too little sleep can result in fatigue, which can compromise a pilot’s performance.



The management of human fatigue in flight operations is the primary responsibility of the pilot, but responsibility also falls on the operator and on government authorities. Air carriers must provide sufficient time in schedules to allow for crew rest. Aviation regulations must provide for proper balance between duty and off-duty periods for flight crews.

Fatigue is defined as a subjective feeling of tiredness that makes concentration on a task difficult. John A. Caldwell, Ph.D., wrote, “As [the pilot’s] fatigue levels increase, accuracy and timing degrade, lower standards of performance are unconsciously accepted, the ability to integrate information from individual flight instruments into a meaningful overall pattern is degraded and a narrowing of attention occurs that leads to forgetting or ignoring important aspects of flight tasks.

“In addition, the fatigued pilot tends to decrease physical activity, withdraw from social interaction ... and lose the ability to effectively divide his mental resources among different tasks.”<sup>2</sup>

Generally, performance becomes less consistent as sleeplessness increases. Problem-solving slows, motor skills

## Pilot Fatigue Cited in DC-8 Accident

The McDonnell Douglas DC-8 was making a daylight approach to Runway 10 at Leeward Point Airfield, U.S. Naval Station, Guantanamo Bay, Cuba, in visual meteorological conditions (VMC) when it struck level terrain in uncontrolled flight about 0.4 kilometer (0.25 mile) from the approach end of the runway.

The plane was destroyed by postaccident fire. The three flight crew members, the only persons aboard the cargo aircraft, received serious injuries in the Aug. 18, 1993, accident.

The aircraft was cleared for a landing on Runway 28, which has an unobstructed approach. The reciprocal Runway 10 required a crosswind leg within 1.6 kilometers (one mile) of Cuban national airspace, which was restricted from overflight. The Cuban airspace boundary was marked with a fence and a high-intensity flashing strobe light; the light was not operational on the day of the accident, but the accident flight crew was not provided that information.

At 1641:53, when it was about 118 kilometers (70 nautical miles) south of Guantanamo Bay, the accident aircraft began its letdown from 6,710 meters (22,000 feet). At that time, the captain said, "otta make that one zero approach just for the heck of it to see how it is; why don't we do that, let's tell them we'll take [Runway] one zero; if we miss we'll just come back around and land on two eight."

The aircraft was cleared for landing on Runway 10, and a right-hand approach (from the south) was made.

The following conversation, quoted from the official cockpit voice recorder transcript, begins when the accident aircraft was about 3.5 kilometers (two nm) south of the runway:<sup>3</sup>

Time	Source	Content
1652:22	Flight engineer	slow airspeed
1653:28	Captain	where's the strobe
1653:29	Flight engineer	right over there
1653:31	Captain	where
1653:33	First officer	right inside there, right inside there
1653:35	Flight engineer	you know, we're not getting our airspeed back there
1653:37	Captain	where's the strobe
1653:37	First officer	right down there
1653:41	Captain	I still don't see it
1653:42	Flight engineer	[expletive] we're never goin' to make this
1653:45	Captain	where do you see a strobe light

degrade and the ability to pay attention is impaired. A severely fatigued pilot may even have temporary perceptual illusions, such as seeing lights that are not present.

An example of the effects of pilot fatigue is the McDonnell Douglas DC-8 accident at the U.S. Naval Air Station, Guantanamo Bay, Cuba, on Aug. 18, 1993, the first major U.S. aircraft accident in which the U.S. National Transportation Safety Board (NTSB) cited flight crew fatigue as the probable cause. (See "Pilot Fatigue Cited in DC-8 Accident.")

Falling asleep is a not conscious act. Brief periods of sleep can occur involuntarily, after which the fatigued pilot will not remember falling asleep, or will not have any idea of how long the sleep lasted. Warnings of the onset of sleep include difficulty in focusing the eyes or holding the head up; frequent yawning; strange or disconnected thoughts; and erratic flight control, such as wandering off heading or altitude without becoming immediately aware of the variation.

Another common symptom of fatigue is a change of mood. Fatigued persons tend to be uncharacteristically argumentative or irritable.

Often, fatigued persons do not recognize their own impairments, but consider themselves to be fully alert and capable. These feelings may be enhanced if the fatigued person has tried to offset the effects of fatigue with stimulants, such as amphetamines.

The only way to avoid the effects of fatigue is to ensure that adequate, restful sleep takes place while off duty or between work cycles. There are steps that can be taken to slow the onset of fatigue, but once fatigue sets in, there is no substitute for sleep.

There are several causes for fatigue among pilots. One cause is nontraditional work schedules, especially night flying, which disturbs the pilot's circadian rhythms — the body's normal sleep and wake cycles that are attuned, respectively, to night and day — making it difficult for the pilot to get adequate, restful sleep.

Another cause for pilot fatigue is flight across several time zones — the "jet-lag" phenomenon. When flying in a westerly direction, the pilot's day is lengthened. When flying east, against the movement of the sun, the pilot's day is shortened. The pilot's biological clock and the clock on the wall can differ by several hours.

The effects of disturbing the circadian rhythm can be significant. One investigation showed that the ability to operate a flight simulator at night, when compared to normal daytime pilot proficiency, decreased to a level corresponding to that after moderate alcohol consumption.<sup>4</sup>

Loss of sleep can be cumulative; it is possible to acquire a "sleep debt." Mark R. Rosekind, Ph.D., et al. wrote, "An

individual who requires eight hours of sleep and obtains only six hours is essentially sleep-deprived by two hours. If the individual sleeps only six hours [per night] over four nights, then the two hours of sleep lost per night would accumulate into an eight-hour sleep debt.”<sup>5</sup>

Sleeping late on weekend mornings is an example of repaying the sleep debt that has been acquired over several working days.

On average, a person needs eight hours of sleep a night.<sup>6</sup> During the remaining 16 hours of wakefulness, the level of alertness is affected by several external factors. These include sensory stimulation, cognitive (conscious) thought content, nutrition, general health and the presence of an artificial stimulant such as caffeine.

High noise levels on ramps and in flight can contribute to fatigue. Earplugs can be worn to reduce noise levels while still allowing normal conversation. In the cockpit, noise can also be reduced by the use of high quality headsets, some of which are designed for noise suppression.

Unexpected flight delays, such as those caused by weather or maintenance problems, contribute to the development of fatigue. When these delays — downtime disruptions — occur during a series of flights, their cumulative effect can become serious. Flight delays may also result from improper scheduling. For example, a schedule that contains four hours of duty time, four hours of non-duty time, followed by another four hours of duty time may, if there are not adequate rest facilities available, be very fatiguing.

Even extremes of temperature, such as would be encountered when taking off from Scandinavia in January, for example, and landing in Jamaica, can cause stress, and that may contribute to fatigue.

Fatigue is also a personal matter. A pilot who exercises regularly, does not smoke tobacco, eats a healthy diet, drinks alcohol sparingly and gets adequate sleep will be less susceptible to fatigue than a pilot who does not follow a healthy regimen.

Several measures can be taken to encourage sleep. When daytime rest is necessary, a fully darkened room is highly desirable. If sunlight seeps around the window shade, masking tape can be used to make a better light seal. This technique is also useful at night if exterior lights illuminate the room enough to trigger night vision, which will promote wakefulness.

Carrying something from home — for example, a book to read before sleeping — may help the environs seem familiar. Setting more than one alarm clock or wakeup call will reduce concern about not awakening on time.

Request hotel rooms located away from traffic or other noises. The temperature in the room should be comfortable.

1653:48	First officer	right over there
1653:57	Captain	where's the strobe
1653:58	First officer	do you think you're gonna make this
1653:58	Captain	yeah ... if I can catch the strobe light
1654:01	First officer	five hundred, you're in good shape
1654:06	Flight engineer	watch the, keep your airspeed up
1654:09	Sound similar to stall warning	
1640:10	Unidentified crew	stall warning
1654:11	Captain	I got it
1654:12	First officer	stall warning
1654:13	Flight engineer	stall warning
1654:13	Captain	I got it, back off

The conclusions of the U.S. National Transportation Board (NTSB) included:

“The flight crew members had experienced a disruption of circadian rhythms and sleep loss, which resulted in fatigue that had adversely affected their performance during a critical phase of the flight;

“The captain did not recognize the deteriorating flight path and airspeed conditions due to preoccupation with locating the strobe light on the ground. This lack of recognition was despite the conflicting remarks made by the first officer and the flight engineer questioning the success of the approach. Repeated callouts by the flight engineer stating slow airspeed conditions went unheeded by the captain; [and,]

“There was no loss of roll authority at the onset of the artificial stall warning (stick shaker) and no evidence to indicate that the captain attempted to take proper corrective action at the onset of stick shaker.”

The NTSB accident investigation report determined that the probable causes of the accident included “impaired judgment, decision-making and flying capabilities of the captain and the flight crew due to the effects of fatigue.”

The report said, “There are at least three core psychological factors to examine when investigating the role of fatigue in an incident or accident.”

The first is cumulative sleep loss. The second is the number of continuous hours of wakefulness prior the incident. The third is the time of day. The report said, “Scientific studies have revealed that there are two periods of maximal sleepiness during a usual 24-hour

day. One occurs at night roughly between 3:00 a.m. and 5:00 a.m., and the other in midday roughly between 3:00 p.m. and 5:00 p.m.”

Figure 1 shows the sleep/wake histories for the accident flight crew flight for the three days before the accident. The report said, “Overall, this information demonstrates that the entire crew displayed cumulative sleep loss and extended periods of continuous wakefulness. It should be noted that the cumulative sleep loss can be partially attributed to the reversal of the circadian pattern, with nighttime sleep periods at home followed by daytime sleep periods. Sleep obtained in opposition to the body’s circadian rhythms is more disturbed than sleep that coincides with times when the body is programmed for sleep. ... Also, the accident occurred at about 4:56 p.m., in the 3:00 p.m. to 5:00 p.m. window of sleepiness.”

Most critical is the information for the captain, who was the pilot flying. The report said, “For the entire 65-hour period, ... the captain was awake for 50 hours with 15 hours of sleep. Including the two-hour nap in the last 48 hours, the captain was awake for 41 hours with seven hours of sleep. In the last 28.5 hours, ... the captain was awake for 23.5 hours with five hours of sleep.”

These data can be translated into sleep debt based on the captain’s stated usual sleep requirement of eight hours. The data show that the captain acquired a personal sleep debt of about eight hours over the three-day period, the equivalent of one full night of sleep.

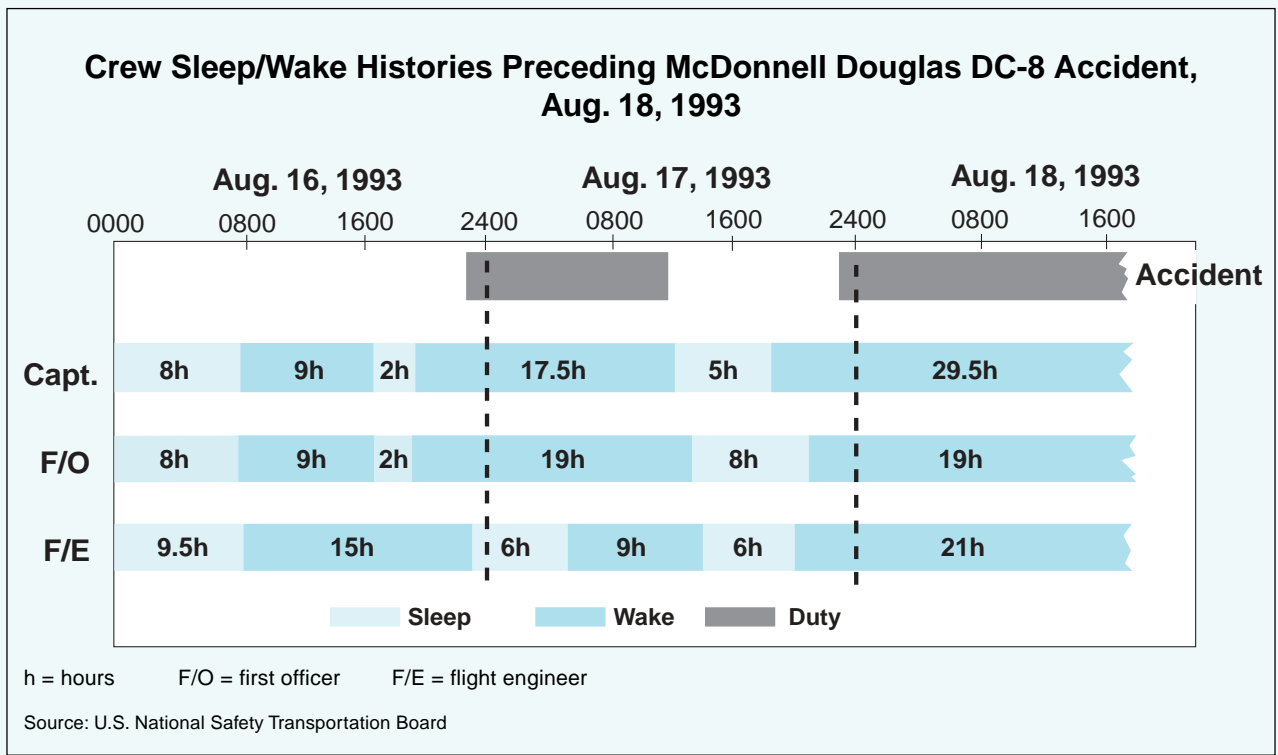
The captain later described his experiences at an NTSB public hearing.

“All I can say is that I was — I felt very lethargic or indifferent,” said the captain. “I remember making the turn from base to final, but I don’t remember trying to look for the airport or adding power or decreasing power.

“On the final ... I heard Tom [the flight engineer] say something about he didn’t like the looks of the approach. ... It was along the lines of, are we going to make this?”

“I remember looking over at him, and there again, I remember — being very lethargic about it or indifferent. I don’t recall asking him or questioning anybody. I don’t recall the engineer talking about the airspeeds at all. So it’s very frustrating and disconcerting at night to try to lay there and think of how this — you know — how you could be so lethargic when so many things were going on, but’s that’s just the way it was.”

A U.S. National Air and Space Administration (NASA) scientist testified about the captain’s behavior and associated fixation on the strobe light. He said, “I counted seven comments in the [CVR] transcript about the strobe. ... I think what’s really critical about that is that ... in sleep-loss situations, you get people with tunnel vision. They get fixated on a piece of information to the exclusion of other things. ... Right in the middle of [the approach:] the captain] disregards a critical piece of information[:] the first officer or flight engineer — someone saying, ‘I don’t know if we’re going to make this.’”♦



**Figure 1**

## Some Airlines Permit Pilots to Nap During Long Flights

Research has shown that short in-flight naps increase subsequent pilot wakefulness and performance on extended flights.

In a joint study conducted by the U.S. National Aeronautics and Space Administration (NASA) and the U.S. Federal Aviation Administration (FAA) in 1994, the effectiveness of planned cockpit crew rest was tested. In the test, two groups of crew members made the same nine-hour trans-Pacific flight, but one group was allowed a 40-minute nap during a low-workload period of the flight.

Ninety-three percent of the crew members who were allowed to nap were able to fall asleep, and they slept for an average of 26 minutes. After waking, they showed better performance (based on reaction time and vigilance) and higher alertness (measured by brain waves and eye movements) than the group of pilots who had not napped.<sup>7</sup>

Nevertheless, there are two potential negative effects of such naps. The first is sleep inertia, or the grogginess and disorientation that may occur on first awakening from a deep sleep. Sleep inertia can last for a few minutes or as long as a half an hour but generally dissipates within 10 minutes to 15 minutes. The second potential negative is the effect of a nap on subsequent sleep periods. A recent nap may make it difficult for the crew member to sleep during the normal ground resting time.

Some airlines, acknowledging the debilitating effects of in-flight fatigue on pilot performance, have established formal policies for providing pilots in both two- and three-person crews with the opportunity for controlled rest.

Lufthansa German Airlines, Swissair and British Airways allow planned in-flight crew rest during low-workload periods near the end of the flight, but not within the 30 minutes before beginning the letdown to their destination. Generally, rest periods are from 30 minutes to 45 minutes, only one crew member may rest at any one time and rest is taken in the respective pilot's cockpit seat. Eyeshades and earplugs may be used, if desired, to help the resting pilot fall asleep. Depending on the airline, the preflight planning includes the crew-rest sequence, criteria for unplanned wakeup and coordination with cabin staff.

Air Canada presently has no provisions for in-flight crew rest, but has submitted a request to Transport Canada to begin a test program of methods and procedures for allowing pilots on long flights to sleep for short periods before starting letdown to landing. The Air Canada test, if authorized, will be conducted in airplanes with three-pilot flight crews.

KLM Royal Dutch Airlines also has controlled flight-deck crew rest under consideration.

For U.S. air carriers, regulations for crew scheduling and crew rest are promulgated in the U.S. Federal Aviation Regulations (FARs). The FARs specify the maximum number of accumulated flight hours permitted within certain calendar periods, how and when ground rest periods are scheduled, how duty time is defined and conditions under which a flight crew member may exceed the stated flight time limitations without being considered in violation of regulations. Nevertheless, the FARs make no reference to controlled crew rest.♦

Consider sleeping in the nonsmoking section of the hotel, where coughing is less likely to be heard.

If a pilot cannot avoid being on duty while fatigued, there are short-term measures that can be taken to reduce the effects of fatigue.

- Eating high-protein foods and drinking plenty of water can temporarily offset fatigue;
- Caffeinated beverages can temporarily enhance alertness; and,
- Talking with other crew members; getting out of the seat; and moving about the aircraft for a few minutes will tend to promote wakefulness.

Generally speaking, pilots who transition to a new time zone or work schedule for a short period should not try to readjust their circadian rhythms to the new environment. Circadian

rhythms change slowly, sometimes by as little as one and one-half hours per day. As much as possible, temporarily transplanted pilots should maintain their usual circadian schedules: sleep and rest on their "at-home" clocks.

Fatigue is manageable. A better understanding of its causes and consequences ensures that pilots are fully alert while on duty.♦

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### **Further Reading from FSF Publications**

"Principles and Guidelines for Duty and Rest Scheduling in Corporate and Business Aviation." *Flight Safety Digest* Volume 16 (February 1997).

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