There's a long history of crew fatigue as a factor in fatal accidents. All too often, flight crews don't recognize the risks posed by long flights, extended duty days and sleep loss. For instance, look at the facts surrounding the fatal October 2004 crash of a medevac Learjet 35A into Otay Mountain, just east of San Diego's Brown Field Municipal Airport (SDM). After flying three legs, the crew planned an FAR Part 91 deadhead IFR flight from SDM back to their base in Albuquerque. It was to be a short 1+15 jaunt.

On the previous afternoon, they'd left at 3:20 p.m. from Albuquerque to fly to El Paso, Texas, to pick up a medical technician. The second leg was a 3-hr. mission from El Paso to Manzanillo, Mexico, to board the medevac patient and another passenger.

After hours on the ground at Manzanillo, the crew departed at 8:40 p.m. for the 3+24 flight to San Diego, where an ambulance would transport the patient to a local hospital. They landed at Brown shortly after 11:00 p.m. due to the time zone change.

The CVR told much about the crew's fatigue. The dialogue between the captain and first officer reeks of impaired judgment and faulty decision-making. The two pilots might as well have been talking after being over-served in the airport bar.

The captain said he intended to depart eastbound on Brown Field's Runway 8L to avoid noise-sensitive populated areas to the west. The departure plan also would head them for home base at Albuquerque just after midnight. After several attempts to contact ATC on VHF at Brown Field and Tijuana Rodriguez, along with San Diego Flight Service Station, to obtain an IFR clearance, the crew hastily executed Plan B. They never thought to use their cell phones or the aircraft's satcom to contact ATC.

"All right," said the captain. "Let's just do VFR." Neither crewmember discussed the terrain hazards looming just 7 mi. east of the airport. For the takeoff brief, the captain told the first officer, "Uh, let's see. We'll be standard callouts tonight and, if you can't punch up through a nice hole then just, uh, you know, stay at a reasonably safe altitude and uh, underneath 250 kt., and I'll do the best I can to get somebody's attention." Power was set and the takeoff roll began.

The circumstances were eerily similar to the Hawker 125 crash on the side of Otay Mountain on the night of March 16, 1991, that killed the two pilots and eight members of Reba McEntire's band, an event that local San Diego aviators remember all too vividly.

After takeoff, the medevac Lear crew leveled off at 2,300 ft. to stay below the nighttime low coastal clouds so typical of San Diego. There was a 2,600-ft. overcast and a broken layer at 3,500 ft. The captain contacted Socal TRACON. The controller issued a transponder squawk and vectored the aircraft on a 020-deg. heading. Less than 10-sec. later, the aircraft slammed into terrain just south of Otay Mountain at the 2,256-ft. elevation.

This was a tired crew. Not only had they flown four legs in the previous 9 hr., they also had flown 7.4 hr. during a 10-hr. duty day two days prior to the accident. The day prior, they had flown 3.3 hr. On the day of the accident, they shifted from a daytime schedule to a nighttime schedule, perhaps disrupting their circadian rhythms. During the 24 hr. prior to the accident, the crew had logged close to 11 hr. of duty time and 6.5 hr. of flight time, according to the NTSB accident report.

Fatigue as a Critical Safety Issue

"As long as human beings are pilots . . . fatigue will be a critical safety issue that demands our attention," says NTSB member and human fatigue expert Mark Rosekind, Ph.D. "The human body is not designed to work around the clock. It has a vital requirement for sleep. Fatigue degrades every aspect of human performance, including reaction time, memory, judgment and the ability to communicate."

"Humans are hard-wired with a genetically determined biological need for sleep and with a circadian pacemaker that programs us to sleep at night and to be awake during the day on a 24-hr. schedule," Rosekind writes in "Managing Fatigue in Operational Settings 1: Physiological Considerations and Countermeasures," a research paper he co-authored that was published in the winter 1996 issue of Behavioral Medicine.

Fatigue can result from multiple time-zone changes, disruption of circadian rhythms, sleep disturbances during off-duty periods and long, irregular work schedules, among other factors. Pilots accumulate sleep deficits resulting in degraded alertness and impaired performance. Rosekind's research has shown similarity in symptoms between fatigue and high blood-alcohol levels.

The NTSB has placed human fatigue on its "Most Wanted" list. "The Board has long advocated for science-based regulations," he says, but notes that regulations are insufficient to "address the complex nature of fatigue." Education is vital and sleep disorders should be diagnosed and treated.

Countering fatigue starts by recognizing it as a risk factor. “Fatigue is insidious, it’s cumulative, it’s predictable and it’s getting worse,” says Capt. C. B. “Sully” Sullenberger. “We’re flying farther, faster and through more time zones than ever before. Ultimately, we have to schedule people around their circadian rhythms, with plenty of rest before and after missions.”

Rosekind’s research indicates that most people need 8 hr. of sleep, although some can get by on 6 hr. and others need 10 hr. He says missing just 2 hr. of sleep in one night can “degrade subsequent waking performance and alertness significantly.”

If you miss 2 hr. of sleep for four consecutive nights, you accumulate an 8-hr. sleep deficit. To make up the deficit, people sleep extra hours during off-duty days. Increased periods of deep sleep and sleeping longer hours are indications that the human body is recovering from a sleep deficit.

Disturbance of the natural circadian rhythms — the brain’s clock that regulates physiological and psychological functions during each 24-hr. period — is a key reason why people accumulate sleep deficits. The brain regulates day/night cycles of body temperature, chemistry, digestion, alertness and attitude, among other functions that have high and low points that fluctuate every 24 hr. Rosekind notes that people in sync with their body clocks sleep at night and have their lowest body temperatures between 3 a.m. and 5 a.m., the time period during which sleepiness is greatest and performance potential is weakest.

Body clocks do not adjust well to sudden changes in time zones or work times. Flying at night, for instance, creates a reversed pattern of working in the dark and then having to sleep when it’s light outside. The brain gets crossed signals as it attempts to change natural circadian rhythms.

Capt. Sullenberger feels that it’s more difficult to adjust to time zone changes as we age. Rosekind’s research confirms that “changing schedules [is] more difficult as one gets older.”

Duty and Flight Time Scheduling

Many corporate flight departments model their crew scheduling on principles set forth in FAR Part 117, “Flight and Duty Limitations and Rest Requirements: Flight Crewmembers,” the 2014 regulation that went into effect for FAR Part 121 passenger-carrying scheduled air carriers.

But long before Part 117 was published, most business aircraft operators were embracing maximum duty time and flight time concepts. Part 117 is based on science, taking into account peoples' "acclimated" time zone "in theater," the effects of jet lag, flight duty periods and rest recovery periods. "Theater," however, is broadly defined by the regulation as the geographic area in which a flight departs and arrives that is as laterally wide as 60 deg. (four time zones) longitude.

Part 117 treats the U.S. east and west coasts, or even Odessa, Texas, and Oahu, Hawaii, as having the same home time if the flight crew has spent 72 hr. or more in theater or they have had at least 36 hr. off duty.

Most corporate operators provide crews with at least 48 hr. off duty if the origin and last destination points are located in two theaters separated by 6 to 8 hr. If the layover in the second theater exceeds four days, then the rest period usually is extended because circadian rhythms have begun to reset to the new time zone.

The maximum permissible length of a flight duty period (duty time) is based on flight segments to be flown and the scheduled start time of the flight duty period, according to Part 117. In essence, the regulation allows longer duty periods and flight times if they're scheduled during daytime in the crew's home or "acclimated" time zone. Night missions are shorter because it's tougher to stay alert then.

Extra time off is allocated to recover from long duty periods during which the first flight originates and the last flight terminates at landing facilities that are separated by several time zones. To allow the crew to rest adequately, the regulation specifies 10-hr. "physiological night's rest" periods that include sleep between 0100 and 0700 in the home base or "acclimated theater" time zone. The rule also describes a "suitable accommodation" as a ground rest facility with temperature, sound and light controls, equipped with a flat bunk or fold-flat chair for sleeping.

Notably, Part 117 allows for duty and flight times to be extended for "augmented flight crews," meaning that relief pilots are onboard and available to assume cockpit duties for part of the mission.

To take advantage of crew augmentation, the aircraft must be equipped with an approved crew rest compartment in which off-duty crewmembers can sleep. For Part 121 operations, the regulation specifies Class 1, Class 2 and Class 3 rest areas that range from private crew condos to semi-reclining chairs in the cabin.

The Class 2 rest area is similar to the crew rest compartment in most current-generation long-range business jets. It includes “a seat in an aircraft cabin that allows for a flat or near-flat sleeping position; is separated from passengers by a minimum of a curtain to provide darkness and some sound mitigation; and is reasonably free from disturbance by passengers or flight crewmembers.”

It’s tough for a forward crew rest area to meet this requirement if the aircraft also has a forward galley and lavatory, some flight department managers say. Food prep, dish cleaning, beverage service and other galley tasks create enough noise to disturb the sleep of most people in the crew rest compartment. Noise generated by flushing an adjacent vacuum toilet in a forward lavatory also disturbs sleep.

In light of those limitations, some flight department managers discount the value of crew rest compartments aboard purpose-built business jets. They use augmented crews occasionally when needed, but it’s not routine practice.

Fatigue Countermeasures

To diminish sleep loss, it’s essential to take full advantage of off-duty rest periods. If you’re not caught up on sleep, then you’ll be at a performance disadvantage during your next flight assignment because of the cumulative effects of sleep loss. Two nights of uninterrupted sleep are sufficient to catch up from all but the most-severe sleep deficits, according to Rosekind.

On multi-day missions, it’s important to get as much sleep, or more, during overnight layovers as on off-duty nights. If that’s not possible due to interrupted sleep or disruption of circadian rhythms, then multiple sleep periods or naps may be necessary.

One’s body clock makes it easier to fall asleep at certain times and it’s set to be awake at other times. It’s nearly impossible to force your body to sleep when it’s programmed to be awake.

But there are several things you can do to help your body fall asleep. Most adults don’t sleep well if they’re sated with food and alcohol. Conversely, they don’t sleep well if they’re hungry or thirsty. Eating lightly, even if it’s just a snack, will help you sleep. Alcohol and caffeine disrupt sleep, according to numerous studies.

Even though alcohol remains a popular aid to falling asleep, it also interferes with the normal sleep cycle, preventing people from transitioning to rapid eye movement (REM)

sleep during the first half of the sleep period. After consuming excessive alcohol, it's not uncommon to awaken after disturbing dreams, find oneself in a cold sweat and suffering from a headache.

Such side effects and symptoms can result from blood alcohol content (BAC) levels as low as 0.04 to 0.80%, corresponding to having two to four drinks before bedtime. Since alcohol is metabolized at the rate of about one drink per hour, it's advisable to cease drinking in time to go to bed with almost 0.00% BAC, according to Rosekind.

"Alcohol also worsens breathing disorders during sleep, including apnea, and reduces associated oxygen levels," he says.

Caffeine is a potent stimulant, remaining active in the system for 3 to 5 hr. But some individuals can feel its effects for up to 10 hr. Consumption can lead to lighter sleep with more awakenings and reduced total sleep time. So, stop drinking caffeinated beverages at lunch or by early afternoon, if you want the effects to wear off before normal bedtime.

Once you bed down, the quality of sleep environment is important. A comfortable bed and bedding, quiet and dark environment, lack of interruptions from family or associates, and proper temperature control, among other factors, are essentials. Rosekind says that eyeshades and earplugs help with light and sound problems. White noise, such as that generated by a radio tuned off channel, can help mask small, irritating sharp sound disturbances as well.

If you can't fall asleep in 15 to 30 min. after going to bed, you may need to get up and pursue activities your body associates with pre-sleep periods, such as reading something light and entertaining — not work related. Autogenic training, including consciously relaxing muscle groups, practicing yoga and meditation have proven effective as techniques that help people fall asleep. Rosekind advises against watching TV before falling asleep, as much programming is designed to force you to stay awake.

Naps during non-sleep periods can be an effective fatigue countermeasure, so long as they're limited to 45 min. or less in duration if you're going to do work. Nap longer than that and you're likely to lapse into deep sleep, leading to "grogginess and disorientation for several minutes" upon awaking, a phenomena known as "sleep inertia." Rosekind is an advocate for napping in the cockpit, even though current regulations do not permit sleeping while on duty in cockpit seats.

If longer nap periods are available, sleeping for 2 hr. usually enables the body to complete one full sleep cycle, including both REM and non-REM phases.

Alertness Strategies in the Cockpit

Fatigue management starts before the mission by determining if each crewmember is fit for flight. Passenger-carrying airlines now are required to get affirmative responses from each crewmember as part of the dispatch release. Similar systems are used by top corporate flight departments as well.

It's also up to each crewmember to take full advantage of crew rest periods so they can arrive alert and ready for duty. For instance, if a crewmember is scheduled for an evening mission, it's up to that person to attempt to get a full night's rest before the trip and perhaps take a nap during the day before showing up for duty. It's not OK to get up at sunrise for a daily strenuous workout, then be up all day and report for the flight when your body is ready to go back to sleep. Sleep scientists say that you're most likely to fall asleep 24 hr. after you awaken in your acclimated time zone.

Many people attempt to reset their body clocks for night flights by going to bed late and sleeping in late the day before such missions. Once you're up, exposure to bright daylight or bright artificial light will help to awaken you, to make you alert for the tasks ahead.

Physical exercise can help ward off drowsiness. Exercising moderately before night flights may delay the onset of drowsiness. Some industry advocates suggest getting up and walking every 2 hr., but that's not practical for cockpit crews. Instead, stretching or isometrics may be the next best form of exercise.

Active participation in conversation, especially work-related discussions during the mission, can help keep crews alert. Mental activities, such as plotting flight progress on a paper chart and filling out waypoint-by-waypoint navigation logs also can boost alertness while keeping pilots "in the loop."

Changes of activity also help. Stare all night at the EFIS screens and you can be lulled into sleep. If you break up the instrument scan routine with other flight-related activities, the change can help keep you alert.

Diet may play a role in alertness. Several people believe that eating high-protein, low-carbohydrate foods before flight will raise hormone levels that promote awareness and physical activity. Switching to high-carbohydrate, low-protein foods after the flight and

before resting helps promote normal circadian sleep rhythms by raising serotonin levels. So-called anti-jet-lag diets, though, have not been unequivocally proven effective in scientific studies. But healthy snacks, such as carrots, yogurt, nuts, fruit and peanut butter on celery sticks can boost energy and alertness.

Cup of joe? Coffee or other caffeinated beverages can help improve alertness when you feel drowsy, particularly during diurnal low periods when your body is accustomed to sleeping, such as 3:00 a.m. to 5:00 a.m. For most people, it takes 15 to 45 min. for caffeine to take effect. And caffeine can prevent you from sleeping for up to 8 hr.

In addition, coffee is a diuretic and keeping properly hydrated is of key importance to staying alert. Dehydration can make you feel drowsy. Low humidity levels in jet aircraft make dehydration more problematic. And excessive caffeine consumption, such as drinking coffee while you're already alert, can result in mood swings, angst, irritability and jitters, as well as insomnia.

The efficacy of alertness strategies in the cockpit, though, isn't nearly as effective as getting enough rest prior to flight.

"The key to air crew fatigue management is sleep, and any of the fatigue management strategies . . . that do not result in increased or improved sleep are not addressing the root cause of this problem," writes U.S. Air Force Lt. Col. Christian G. Watt in "Aircraft Fatigue Management," a 2009 paper he wrote for the Air War College.

"All controls except sleep should be considered a 'Band-Aid,'" it states. Sleep is the only countermeasure that "provides recovery" from fatigue. And getting enough sleep mainly is a function of proper air crew scheduling and having access to facilities that provide quality sleep.

Sleep deprivation results in symptoms that are uncannily similar to symptoms of being intoxicated, says Rosekind. Pilots are scrupulous about being sober while on duty. It's just as critical that they're scrupulous about their sleeping patterns off duty. **B&CA**

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