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Managing Sleep for Night Shifts Requires Personal Strategies

Aviation professionals — pilots, flight attendants, maintenance technicians, air traffic control personnel and others — can adopt sound sleep practices to counteract sleepiness at work, improve performance and reduce safety risks by understanding factors that affect human ability to sleep during the day and to work at night.

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Aviation professionals have no immunity to sleepiness or the related challenges to human performance associated with shift work. Some aspects of their work environment today — such as increasingly automated flight decks — make these issues more complex. Continuing education and training about sleep and physiology — especially the operational significance for flight safety — are vital to establish effective personal strategies to meet these challenges.

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Shift work generally refers to an extended production process in industry (or other cyclical work activity) that is covered by two or more groups (shifts) that relieve each other based on a schedule. In sleep research, shift work sometimes is differentiated as permanent or rotating, and as diurnal (day), nocturnal (night) or nychthemeral (combined day and night).[1]

One of the major concerns of researchers is the conflict between working late-night hours or predawn morning hours, and the human body's circadian rhythms — clocklike biological mechanisms that control many functions essential to health.

One research group said, "Typical work hours [in shift work] may be 0600 [hours] to 1400 [hours] for the morning shift, 1400 to 2200 for the afternoon shift, and 2200 to 0600 for the night shift. Roster work, which is more irregular and may contain more overlaps or gaps between shifts, also belongs [in this description of shift work]. Work hours that are only slightly displaced from daytime and do not constitute part of an extended production process (i.e., 'displaced work hours') [should be studied separately from shift work]."[2] Scheduling of the 24-hour day into shift-work periods varies among employers. One schedule in the United States, for example, is 0800 to 1600 for the day shift, 1600 to 0000 for the evening (or swing) shift and 0000 to 0800 for the night shift. In other schedules, the day shift may begin between 0400 and 0700.

Although some assignments in aviation require working many hours for weeks at a time, or responding to unpredictable emergencies at any hour, "reverse-cycle" shifts raise especially difficult theoretical and practical issues. ("Reverse cycle" means working primarily during times other than conventional daylight hours.)

Nevertheless, ongoing research has identified sleepiness, diminished performance and other effects of shift work, and has suggested some appropriate countermeasures. The fundamental concept is that in any aviation environment where pressures for reduced sleep time are beyond the individual's control, development of good personal sleep practices — sleep hygiene — helps to maximize the value of sleep time.

The work of many pilots has characteristics of shift work. While flight crews may be restricted by crew-rest guidelines in how *many* hours they may fly within a specified time period, there is usually no restriction on *when* these hours may be flown. Many times, aviators are required to fly at times when they may need to reverse their work hours from typical day periods to evening periods and morning periods.

When such rotations occur, the aviation professional becomes a "shift worker" in that he or she no longer works set hours, but must change work schedules every two days to three days, every week, every few weeks or possibly even daily, for the short term or long term. Thus, aviation professionals may face problems of sleepiness at work in common with approximately 20 percent of workers in industrialized nations who perform shift work.[3]

The U.S. National Transportation Safety Board (NTSB) and U.S. Federal Aviation Administration (FAA) in 1997 recognized the need for additional study of duty time and scheduling practices for safe maintenance of air carrier aircraft following NTSB's investigation of the ValuJet Flight 592 accident in 1996.[4]

The NTSB's report also contained the following recommendation: "According to Part 121 of the U.S. Federal Aviation Regulations (FARs) that establishes limitations on duty time for individuals performing maintenance on Part 121 airplanes, including those who work in a Part 145 repair station, individuals must be off duty for 24 consecutive hours every seven consecutive days. However, the option exists to give the equivalent number of off-duty hours within the span of a calendar month. This regulation allows for mechanics to work as many as 26 consecutive days, taking all of their off-duty time at the end of the month. … The [NTSB] concludes that the current duty-time limitations … may not be consistent with the current state of scientific knowledge about factors contributing to fatigue among personnel working in safety-sensitive transportation jobs. Accordingly, the [NTSB] believes that the FAA should review the issue of personnel fatigue in aviation maintenance; then establish duty-time limitations consistent with the current state of scientific knowledge for personnel who perform maintenance on air carrier aircraft."

FAA's response to this NTSB recommendation said, " … [FAA's *Human Factors Guide for Aviation Maintenance*, published in 1995] is the principal reference used by the aviation industry and includes a chapter on personnel shift work and scheduling as they affect human performance. FAA data suggest that night shift and/or mixing of day/night work schedules affect performance more than an extended length of duty time; however, no current definitive studies are available to evaluate these parameters as comparable measurements. Consequently, the FAA will expand its human factors research program to include studies of duty-time fatigue that will investigate factors regarding duty length and shift scheduling."[5]

In the mid-1990s, scientifically based recommendations relevant to night work emerged from Flight Safety Foundation's Fatigue Countermeasures Task Force. Beginning in 1994, the task force focused on human fatigue during corporate flight operations, recognizing that increasing numbers of segments are flown by crews in a single day and some aircraft are capable of 14-hour flight endurance. The task force said that significant differences exist among individuals in their tolerance for shift changes and night work, required sleep, effects of sleep loss, recovery time and special factors such as long commutes before beginning a duty period. Off-duty periods of at least 10 hours within any 24-hour period were recommended to provide an eight-hour sleep opportunity, awake time off and time for transportation to and from layover accommodations, meals, bathing and other personal needs. Task-force recommendations also specified longer off-duty periods for crews operating during the "window of circadian low" (0200 to 0600 for individuals who are adapted to the usual day-wake/night-sleep schedule) or when crossing multiple time zones. Two-week, monthly and yearly limitations on cumulative duty periods and flight time were recommended to reduce the potential for long-term fatigue effects on performance.[6]

The amount and quality of sleep that flight crews obtain during a succession of long-haul flights with 24-hour rest periods (layovers) also have been shown to be significantly affected by adaptation to local time, prior flight direction and the disruption of environmental time cues needed by the body's "internal clock."[7] The result is that any of the physiological symptoms typically experienced in shift work may occur. The symptoms include increased fatigue, sleep deprivation, sleepiness, insomnia, moodiness and others. Along with these symptoms come diminished performance and errors.

For example, some U.S. flight crews have reported their belief that too little sleep and irregular work schedules have contributed to major operational errors such as altitude deviations, navigation-track deviations, landing without clearance, landing on an incorrect runway and improper fuel calculations, said a 1989 study.[8]

One researcher said in 1988, "Each year, increasing numbers of shift workers must work at times in conflict with their circadian rhythms. … Given the evolutionary legacy and pervasiveness of circadian rhythmicity, it is not surprising that most pilots have difficulty countering its influence."[9]

Shift work is difficult because several factors affect people when they alter their normal work hours and sleep hours from society's predominant work/rest pattern. These biological, circadian and social factors all must be addressed when a person has to adapt to varying schedules. Working nonstandard periods also means sleeping during nonstandard periods, which goes against the body's natural rhythm and against society's schedule. Several studies — some in aviation — have documented the problem.

One 1996 study — in which flying at night required crews to sleep during the day — said, "The organization of sleep during daytime layovers [among pilots flying a series of overnight cargo trips] reflected the interaction of duty timing with circadian physiology. ... These data clearly demonstrate that overnight cargo operations, like other night work, involve physiological disruption not found in comparable daytime operations." Also, reports of headaches quadrupled, reports of a congested nose doubled and reports of burning eyes increased nine times among overnight-flight crewmembers on duty days compared to pretrip days, said the researchers.[10]

Reverse-cycle work can restrict a person's sleep period to less than the seven hours to eight hours needed by the average adult. But effects of the reductions that people commonly experience — that is, periodically sleeping for only five hours to six hours — are unclear because of limited research. Human sleep research, however, has found that restriction of the sleep period to four hours or less definitely increases sleepiness and decreases performance when the person is awake — and these effects are cumulative (that is, they produce sleep deficits that require recovery sleep).[11]

Reverse-cycle Shift Work Presents Several Problems

Almost every person who works rotating schedules experiences sleepiness during the night when alertness is needed to perform safely and effectively. Then the person experiences difficulty sleeping during the day when trying to recoup from this reverse-cycle work day. This is normal because night activity and day sleep are in opposition to the body's natural programming — the day-active orientation dictated by the human circadian clock.

Although there are individuals who prefer to work late hours and awaken late in the day, and others who retire early and arise early, most people cannot comfortably tolerate extreme shifts of sleep/wake periods. They consistently obtain the majority of their sleep during nighttime hours and are active during daylight hours.

Circadian rhythms govern predictable natural patterns of being awake and being asleep, with related hormonal secretions, changes in physical and mental performance, digestion, moods and small variations in core body temperature during the 24 hours of each day. These rhythms do not adjust rapidly to change. The following stages are typical:

- As the day begins, body temperature, alertness and performance gradually increase;
- These increases continue into the day, with a slight dip in the midafternoon;
- Body temperature, alertness and performance begin to decrease as the day ends and night begins; and,
- The lowest point occurs during the early morning — generally between 0200 and 0600.

Figure 1 (page 4) shows these temperature rhythms and performance rhythms.[12]

In contrast, the following stages of sleepiness occur in the circadian rhythm:

- Sleepiness declines as the day begins;
- A small increase in sleepiness occurs in the midafternoon; and
- Sleepiness then steadily increases as the day ends and night begins.

Thus, the ability to fall asleep and to remain asleep — sleep propensity — is naturally low during daylight hours. After evening comes, sleep normally is easier to obtain, with sleep propensity being greatest in the early morning between 0200 and 0600 — the times at which performance and alertness are lowest.

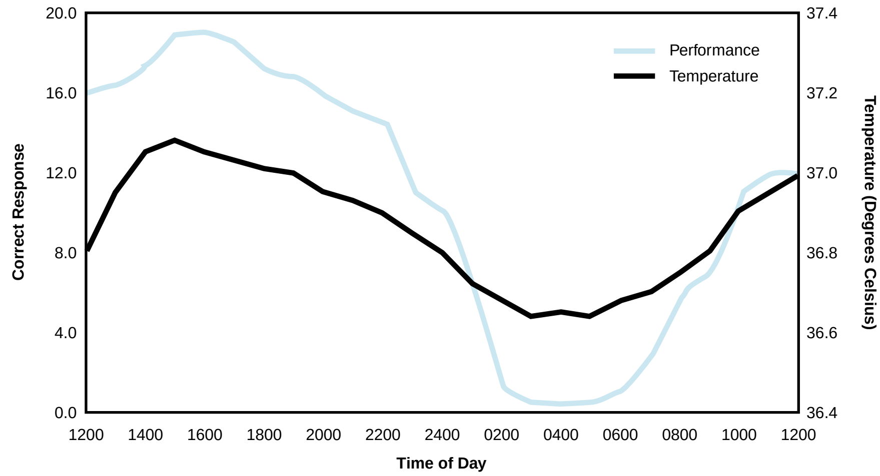
Figure 2 (page 4) shows the average amount of time that a person can maintain sleep when sleep begins at various hours of the day, as well as the average time for sleep onset.[13]

The effects of disturbing the circadian rhythm can be significant. One study showed that the ability to fly a flight simulator at night, when compared to normal daytime pilot proficiency, decreased to a level corresponding to that after moderate alcohol consumption.[14]

Sleep researchers also said that some common practices in aviation — such as requiring early report times for pilots — may make it difficult for flight crews to obtain adequate sleep because circadian rhythms impede falling asleep earlier than usual, except after major sleep loss.[15]

Sleep researchers have found that many external factors affect a person's ability to sleep during the day. A powerful cue to

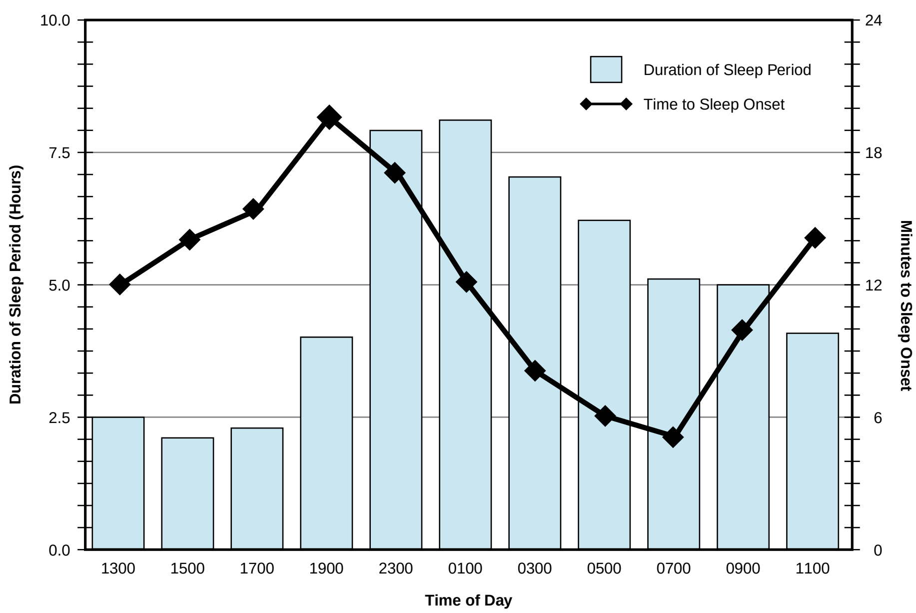
Test-subject Performance and Body Temperature, by Time of Day



Source: J. Lynn Caldwell; adapted from Timothy H. Monk et al., "Circadian Rhythms in Human Performance and Mood under Constant Conditions." *Journal of Sleep Research* Volume 6 (1997).

Figure 1

Duration of Sleep Period and Time to Sleep Onset, by Time of Day



Source: J. Lynn Caldwell; adapted from A. Smiley, "Fatigue Management: Lessons from Research." In *Proceedings from the Third International Conference on Fatigue and Transportation: Coping with the 24-hour Society*. Fremantle, Western Australia, 9–13 February 1998, and Mary A. Carskadon and William C. Dement, "Daytime Sleepiness: Quantification of a Behavioral State." *Neuroscience and Biobehavioral Reviews* Volume 11 (1987).

Figure 2

the human body is sunlight, which increases alertness and helps resynchronize the natural 24-hour rhythm of daytime alertness and nighttime sleep. Many airline passengers and crewmembers have felt a "second wind" (feeling of renewed alertness) that occurs when arriving in the midmorning to late morning after a night flight. Sleepiness may increase before dawn, but when the aircraft is flown into the sunrise, sleepiness dissipates and alertness increases. Although this early-morning alertness may be an advantage for approach, landing and performing postflight duties, this alertness also can interfere with sleep during daylight.

Sunlight thus may shorten the subsequent daytime sleep period, leading to sleep deprivation. As the length of sleep decreases and sleep deprivation increases, the difficulty in remaining awake increases during the next night's duties. Eventually, cumulative sleep deprivation may result in extended sleep during the day, but after the sleep debt is satisfied, the cycle may recur. Such an endless loop can be diminished by using coping strategies, or can be stopped by returning to the natural rhythm of night sleep and day activity. (See "Strategies Make Rotating Shifts Easier to Manage" on page 6.)

Crew Study Finds Shorter Sleep Periods during Daylight Hours

A 1996 study by the U.S. National Aeronautics and Space Administration (NASA) of flight crews engaged in an eight-day shift of successive overnight cargo operations made the following observations concerning sleep during daylight hours:

- "Daytime sleep episodes were about three hours (41 percent) shorter than nighttime sleep episodes and were rated as lighter, less restorative and poorer overall;
- "The incidence of sleeping more than once in 24 hours tripled on days with duty, compared to days without duty;
- "Overall, crewmembers averaged 1.2 hours less sleep per 24 hours on duty days than on pretrip days;
- "Crewmembers were also accumulating a sleep debt across the eight days of the trip patterns; and,
- "Regardless of the time that they went to sleep after coming off duty in the morning, [crewmembers] tended to wake up around 1410 local time, even after as little as [four hours to five hours] of sleep. This clustering of wake-up times coincides with the timing of the circadian 'wake-up signal' identified in laboratory studies."[16]

Rotating Cycles May Have Social Consequences

Constant change of work schedules affects a host of activities and relationships, including work performance, safety, health, family life and social life.

Work-performance decrements may occur when aviation professionals feel sleepy most of the time. This sleepiness normally is caused by sleep deprivation, difficulties in obtaining adequate sleep and circadian-rhythm factors. When sleepiness increases, performance decreases; attention to detail, accuracy and motivation are affected. This is particularly a problem when work is scheduled during hours when the circadian effects are most pronounced.

According to the 1997 National Sleep Foundation Poll, workers on a night shift accomplish only about 70 percent of the work that they normally accomplish on a day shift.[17]

Safety decrements also may occur. Data have shown that workplace accidents such as falls, electrocutions and fires in many settings increase during the night shift. A peak in vehicular-accident data occurs during the early morning hours as well.

Sleepiness is considered a major cause of accidents in many industries. Sleep researchers have taken special interest in some major industrial mishaps involving human error that have occurred between 0200 and 0600. The Three Mile Island Nuclear Power Plant reactor accident in Pennsylvania, U.S., occurred at 0400 on March 28, 1979.[18] The Davis-Besse Nuclear Power Plant reactor shutdown in Ohio, U.S., occurred at 0130 on June 9, 1985.[19] Russia's Chernobyl nuclear power plant accident began at 0123 on April 26, 1986.[20] (Although a causal relationship between the time of day and the events cannot be assumed, investigators consider time of day among other possible human factors.)

Health detriments may occur when normal schedules are disrupted. Individuals vary in their required sleep period and sleep-recovery time, age, experience, health, off-duty lifestyle and other personal factors. Nevertheless, most individuals need a relatively consistent schedule of work and sleep to avoid physical and mental stresses and sleep disruption. On average, adults need seven hours to eight hours of sleep in a 24-hour period — although a range of normal sleep needs greater than and less than this amount has been documented.

When times for meals, exercise and sleep constantly change, susceptibility to health problems such as gastrointestinal distress, menstrual irregularities, cardiovascular problems such as hypertension, viral illnesses such as colds or flu, depression and insomnia may increase for some people. Digestion disrupted by irregular eating schedules may lead to gastrointestinal problems and weight gain. Psychological stress may lead to family problems and social difficulties. Lack of a consistent sleep period and period of being awake can contribute to insomnia, chronic sleepiness, depression and sleep deprivation.

Chronic sleepiness that some aviation professionals experience when working rotating and/or reverse-cycle shifts can lead to problems in the home and in social arenas. Spouses and children may feel neglected. This is especially true when the duty period occurs between 1500 and 2300 — that is, while the family is home. Dinner time cannot be shared, for example, and other evening social activities are missed.

Compounding the problem is a schedule of night flights (or other duties) during a short period of time — after which the person may feel too tired to participate in family activities at normal times because sleep was not satisfactory during the day. Similarly, many people who work rotating shifts reduce their social activities because such schedules do not allow consistent involvement, which can lead to a feeling of social isolation. Some friends and family members may not readily grasp the complexities that affect the ability of shift workers to find adequate time for work, family, social life and rest.

Strategies Make Rotating Shifts Easier to Manage

Many shift workers have difficulty sleeping during the day because so many cues say, "stay awake." Pilots may be requested to report to work during the day to complete administrative tasks that cannot be done at night. Some people experience sleep problems because they feel lazy sleeping while others are working. Family members may expect errands to be accomplished by the person who is home during the usual business day.

The answer is to explain to managers, family and friends the critical importance of getting adequate sleep. Family members and friends appreciate knowing about sleep schedules so they can be considerate. If someone occasionally must reach the daytime sleeper, a pager kept by the bed gives peace of mind in knowing that an emergency will not go unanswered.

Psychological cues can help convince the mind and body that the time for sleep has come. A person should dress, bathe, brush teeth and perform other "sleep rituals" (consistent routines) just as if the sleep period were at night. The bed, pillows and bed clothes should be comfortable. Sleeping in bed is recommended — not on a couch or in a reclining chair. Napping on the living room sofa is a poor strategy for getting enough quality sleep during a sleep period.

Psychological factors also affect perceptions of the sleep environment. The design and familiarity of the room in which one sleeps can increase the ability to settle down without distractions and obtain quality sleep. One strategy is to make the bedroom very dark, because light is the major cue that tells the body to wake up. Black-out shades can be installed under drapes. Aluminum foil also blocks daylight effectively.

To avoid door-to-door salespeople, unexpected deliveries and unwanted visitors, disconnect the doorbell or hang a sign on the door with the message SHIFT WORKER — PLEASE DO NOT DISTURB.

The level of noise can interfere seriously with sleeping. For example, noises from deliveries, construction and traffic greatly increase during daylight.

Use low-volume background noise to muffle distracting sounds. A fan is a good choice. Sound from TVs or radios does not work well because the varying volume levels can disturb sleep — even if the sleeping person seems unaware of the sound. If distracting light and sounds cannot be blocked, slumber masks to cover the eyes and ear plugs are useful.

Make sure the room is cool (65 degrees Fahrenheit [18 degrees Celsius]); most people typically sleep better in a cool room than in a warm room. In a warm room, people have more difficulty adjusting to the ambient temperature. In a cool room, they can use a blanket to easily adjust the temperature so that they feel neither too hot nor too cold.

Other strategies may be necessary to remain asleep for the planned sleep period. Many day sleepers awaken about three hours into their sleep, and have difficulty returning to sleep. People who begin their sleep a few hours before dawn — for example, between 0300 and 0500 — after an early morning flight often have difficulty completing the sleep period in the late morning. Staying in the dark room even after awakening, to avoid circadian cues such as exposure to sunlight, can minimize this problem and can lead to a rapid return to sleep.

When unable to return to sleep, the best approach is to do something quiet and relaxing, such as reading a book or listening to music until sleepiness recurs. If sleep does not return, a person should not try to force sleep. Trying to force sleep will cause a person to become frustrated, which defeats the sleep mechanisms. If sleep does not return after 20 minutes, the shift worker should get up and try to sleep later in the day. Two short sleep periods are better than only one.

Some countermeasures for sleepiness have been found to improve sleep during the day and alertness during the subsequent night shift. Such strategies for better sleep in healthy adults may require a few weeks of practice to show a noticeable benefit. The following strategies may be appropriate:

- Careful attention to shift design can help. Rational and physiologically based scheduling practices — many adopted successfully by airlines and other aviation organizations — have been recommended to the aviation industry during the 1990s. Researchers at the FAA Civil Aeromedical Institute (CAMI) said, following studies of shift-work performance by air traffic controllers in the mid-1990s, that shift designs must consider not only how many shifts occur during daylight hours, but the time available for people to travel home, obtain sufficient sleep and report to work on the next assigned shift. In the shift schedule studied by CAMI, workers theoretically could maintain relatively stable sleep/wake cycles with one night shift every four days, but the schedule provided as little as eight hours between shifts. Thus, the 1995 study recommended redesigning shifts "to minimize quick turnarounds."[21]

  "Employees should be instructed about the importance of maintaining a stable sleep/wake schedule, even on days off from work," said the study, which urged caution in drawing general conclusions from CAMI's experimental results. "This includes standardizing arise times, as well as times for exposure to sunlight in the mornings to maintain the timing of the biological clock."

Other researchers have recommended that shift designs for aviation professionals provide sufficient awake time off (breaks from continuous performance of required tasks, in addition to adequate time for sleep between shifts) and frequent recovery periods of several days to reduce cumulative lack of sleep (sleep debt) that can accrue during the duty cycle (that is, weekly recovery periods provide greater benefit than monthly recovery periods).[22]

One school of thought concerning rotating shift work is that it is preferable for workers to change from one shift to another shift as infrequently as possible, allowing the body to adjust to the new schedule. When a person rotates from one shift to another shift, the easiest rotation is to change from day shift to evening shift to night shift. This direction of rotation fits the body's natural rhythm. If a person rotates shifts in the opposite direction — from nights to evenings to days — the body will take longer to adjust to the change of shifts.

- Good sleep during the day requires careful planning of activities and behaviors, even before reaching home or another rest location. Prepare for changes of shifts on days off before the shift changes (for example, prior to the change to an evening shift, remain awake later and sleep later in the morning). Schedule a block of at least six hours for sleep and adhere to this time just as for any other important appointment. Then let friends and family know the time of the sleep period.

- Poorly timed caffeine consumption is a common reason that night workers have trouble sleeping during the day. Many people consume coffee, tea, soft drinks, chocolate and other products containing caffeine toward the end of the shift to stay awake those last few hours. Used appropriately, caffeine can be a convenient and effective countermeasure for sleepiness, but caffeine also may interfere with sleep later. Thus, sleep scientists recommend avoiding caffeine within four hours to six hours of the sleep period.

- Rotating-shift workers especially benefit from good sleep hygiene (such as the following behaviors) to improve the quantity and quality of daytime sleep:

  – Relax before going to sleep, avoiding work-related tasks if possible;

  – Stay indoors and avoid sunlight exposure until the sleep period is complete;

  – Pay attention to the comfort of the sleeping room in terms of physical preferences (clean air, near-total darkness, adequate ventilation and air movement, temperature, humidity, noise level and cleanliness) and psychologically important preferences (peaceful and familiar furnishings, personally significant items from home);

  – Take a hot bath about 90 minutes before retiring (the drop in body temperature that follows may cause sleepiness);

  – Read a calming book, watch a nonstressful television program or find another relaxing activity to "tune out" thoughts about the day's frustrations and prepare for sleep;

  – Turn off the telephone ringer in the sleeping room, if possible, and use an answering device to record messages;

  – Avoid placing the clock in a direct line of sight or watching the clock while waiting to fall asleep;

  – Eat a light snack and drink just enough water before sleeping to avoid hunger or dehydration later, but not enough for prolonged digestion (an empty stomach may disturb sleep as much as a full stomach);

  – Avoid alcohol within three hours before the sleep period (alcohol — a sedative — may increase sleepiness initially, but disturbs sleep later in the sleep period);

  – Avoid nicotine for four hours to six hours before sleeping (quitting smoking provides important health benefits, including better sleep);

  – Avoid vigorous exercise within three hours to four hours before the sleep period; and,

  – See a health-care professional to relieve symptoms such as chronic headaches from allergies, chronic joint and muscle pain, and similar problems that may disturb sleep.

There are many medical and psychological conditions that can affect an individual's good sleep, recovery from insufficient sleep, sleepiness and other factors. For any unexplained or chronic fatigue, insomnia or other sleep problem, a health professional should be consulted. Major sleepiness during any period when a person expects to be awake should not be ignored.

Some over-the-counter medications contain caffeine, and some prescription medications have comparable stimulant effects that interfere with sleep. Ask a physician or pharmacist about such side effects, mentioning the aviation work environment, to avoid safety problems and sleep interference. The physician may want to change the dosing regimen or change medications for a patient who must sleep during the day.

Regarding alcohol, NASA sleep researchers in 1996 said: "The widespread use of alcohol as a means of relaxing before going to sleep has deleterious effects on subsequent sleep. It thus seems likely that the quality of sleep on trips could be improved in many cases by providing pilots with information on alternative relaxation techniques which have been well tested in the treatment of sleep disorders."[23]

An aviation professional driving home after night duty may be at increased risk of falling asleep at the wheel. Similarly, an aviation professional with an early-morning report time may be sleep deprived while driving because many people do not begin their sleep periods earlier than usual when they must work in the early-morning hours. Reasons include being unable to sleep earlier in the evening because of circadian factors, or simply choosing to remain awake for social reasons. When leaving work after a night shift, exposure to sunlight should be reduced as much as possible because the morning alertness that sunlight triggers is counterproductive to daytime sleep. Wrap-around sunglasses may help reduce this effect.

Car pooling or hiring a taxi is a method for a night worker who feels sleepy to avoid an accident while driving home. In car pools, conversation will help the driver stay alert. Depending on other safety factors, the driver also may choose not to wear sunglasses to take advantage of the wakening effect of sunlight. While the driver later may have difficulty sleeping this one day, the tradeoff may be necessary for highway safety. Other car-pool participants can wear sunglasses and, by rotating drivers, only one driver at a time would have the potential sleep problem.

The Expert Panel on Driver Fatigue and Sleepiness for the U.S. National Highway Traffic Safety Administration made the following observations:

- Drowsy-driver accidents usually are serious and occur most frequently during late night/early morning and midafternoon with the driver alone in the vehicle;
- At highest risk for such accidents are young people (ages 16 to 29), especially males; shift workers whose sleep is disrupted by working at night or working long or irregular hours; and people with untreated sleep-apnea syndrome (in which momentary cessation of breathing causes the sleeper to awaken);
- One or more of the following major factors typifies these accidents: acute or chronic sleep loss, driving between 0000 and 0600, use of sedating medications, untreated or unrecognized sleep disorders, and consumption of alcohol; and,
- Key countermeasures against such motor-vehicle accidents are education of young drivers and shift workers about these risks, and installation of rumble strips (raised areas in pavement that jar drivers awake when tires strike them) along the shoulders of highways.[24]

Strategies Can Help Crewmembers Stay Alert while Working at Night

Although sleeping during the day enables one to be alert during night work, sleepiness at night still occurs naturally. A person cannot completely trick the human body into being fully alert throughout the night because of the strong physiological drive for sleep at certain hours. The body can adapt somewhat to staying awake all night and performing work safely, but many days of strict schedules are required before the body adjusts to reverse-cycle work — and most shift workers are off the night shift or morning shift by the time maximum adaptation occurs. Nevertheless, there are some proven strategies that can improve alertness at night.

A common method to counteract the feeling of sleepiness is to consume caffeine in some form. This is an acceptable way to increase alertness, but the timing and amount of caffeine consumption are very important. The recommended guideline is to wait to use caffeine until the stimulation is really needed — and consider the unwanted effects on sleep later. If caffeine consumption begins before work, alertness will reach a plateau so that when the person needs a boost in the early morning hours, more caffeine is ineffective. By waiting until sleepiness begins, consuming caffeine can boost alertness levels when needed. About 30 minutes are required for caffeine to become effective.

Some studies indicate that diet can make a difference in sleepiness at work. Foods high in carbohydrates tend to promote sleepiness, while protein increases energy (and so should be avoided close to the planned sleep period). Foods like potatoes, rice, cereals, breads and pastas — all high in carbohydrates — promote sleep. High-protein foods such as meat, fish, cheese and eggs, in contrast may lessen sleepiness at night.

Staying active is a good strategy for workers who can manipulate their work environment. For some aviation professionals — such as flight crews — this may not be feasible, but similar strategies may be helpful. If possible, change posture and move around frequently to help stay alert. Stretching and isometrics in the cockpit can help. Use appropriate opportunities to leave the duty position to stand and move rather than remaining stationary for hours at a time. Interesting conversation and other social interaction also will help increase alertness.

Keep the air temperature of the work environment on the cool side of the comfort range. Feeling slightly cool helps the shift worker avoid becoming too comfortable, which may lead to drowsiness. If control of the workplace temperature is limited, adjust items of clothing.

Advance planning for a change in rotating shifts is helpful. Ideally, preparation for reverse-cycle duty should include gradually delaying the sleep period and wake-up time before the change. To ease the transition, some sleep researchers recommend a nap to obtain as much sleep as possible before reporting for night duty, even when there has been a satisfactory sleep period.

One research team said in 1989, "Naps, especially afternoon naps of approximately [one-hour] duration, are a common feature of the sleep of healthy adults in many countries. … If nocturnal sleep is inadequate, daytime napping is more prevalent. ... Naps generally do not adversely affect nocturnal sleep or indicate disordered sleep at night. Although sleep inertia [a temporarily lowered psychological state upon waking or brief time after waking when a person is not yet fully awake] can occur after [waking] from naps, as it can after nocturnal sleep, naps generally have later overall beneficial effects on mood and performance. Thus, the available data on nap patterns and nap effects in otherwise healthy adults suggest that napping is a normal, appropriate and beneficial feature of adult wake/sleep patterns."[25]

In relation to prolonged work, other researchers said: "Naps taken during prolonged work periods can prevent or reduce sleep decrements after they have occurred. ... The length of the nap required depends on the duration of sleep loss involved and the type of task to be done. There is evidence that sleep fragmented into two [two-hour] naps can be as beneficial as one four-hour sleep. Moreover, at least one study has reported that a nap before prolonged work can be as beneficial as one taken during or after such work. … The problem is that napping is a double-edged sword; its beneficial effects must be balanced against the negative effects of sleep inertia, which, although transient, are nevertheless important in some operational situations."[26]

Studies have found that planned and controlled in-flight rest periods for flight crewmembers are effective in promoting performance and alertness in nonaugmented long-haul flight operations. Research also is continuing into creative uses of flight-deck automation techniques to help flight crews maintain performance and alertness, said a 1996 report. Such developments have the potential to help offset some of the adverse effects associated with shift work and operations during the window of circadian low.[27]

Research Reinforces Need for Shift-work Countermeasures

Many night workers sleep as soon as they reach home or another designated place for rest, so they wake up many hours before the time to return to work. This is the opposite of what happens on a day shift. The typical order of activity for day shift is wake up, work, socializing and sleep. For most night workers, the order of the day is wake up, socializing, work and sleep. Thus the time elapsed between the end of the sleep period and work is longer for night workers than for day workers. If the night worker can take a short nap (perhaps an hour) before reporting to work, the nap will alleviate some of the sleep debt that may accumulate between the end of a sleep period and the beginning of the next work period. Such a nap does not "store up" alertness for later use, researchers believe, but does help assure that accumulated sleep needs are met. The shorter the time between sleep and work, the more one can delay sleepiness at night.

NASA researchers said in 1996: "Currently, there are no countermeasures, which have been shown to be safe and effective in operational settings, to overcome the incomplete adaptation of the circadian clock to night work. ... [There are] several approaches for minimizing sleep loss. In trip construction, particular attention can be given to the timing and duration of rest periods and to the number of consecutive nights of flying."[28]

Adjusting to rotating schedules and reverse-cycle shifts is not easy. Nevertheless, taking care of some of the manageable variables will lead to better work performance, social relationships and health. Planning adequate time for sleep should be a constant priority because of the safety implications in aviation.[29]♦

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2. Åkerstedt et al., 205.

3. Åkerstedt et al., 205, citing M. Maurice. *Shift Work*. Geneva: ILO, 1975.

4. On May 11, 1996, ValuJet Airlines Flight 592, a McDonnell Douglas DC-9-32, departed from the Miami [Florida, U.S.] International Airport. An intense fire erupted in the forward cargo compartment and burned through the aircraft's control cables. The aircraft collided with terrain about 17 miles (27 kilometers) northwest of the departure airport. The two pilots, three flight attendants and all 105 passengers were killed. The aircraft was destroyed. The accident occurred during daylight in visual meteorological conditions. The U.S. National Transportation Safety Board said, "The probable cause of the accident, which resulted from a fire in the aircraft's class-D cargo compartment that was initiated by the actuation of one or more oxygen generators being improperly carried as cargo, were (1) the failure of SabreTech [ValuJet's maintenance contractor] to properly prepare, package and identify unexpended oxygen generators before presenting them to ValuJet for carriage; (2) the failure of ValuJet to properly oversee its contract maintenance program to ensure compliance

with maintenance-training and hazardous-materials requirements and practices; and (3) the failure of the U.S. Federal Aviation Administration (FAA) to require smoke-detection and fire-suppression systems in class-D cargo compartments. Contributing to this accident was the failure of the FAA to adequately monitor ValuJet's heavy-maintenance programs and responsibilities including ValuJet's oversight of its contractors and SabreTech's repair-station certificate; the failure of the FAA to adequately respond to prior chemical oxygen generator fires with programs to address the potential hazards; and ValuJet's failure to ensure that both ValuJet and contract maintenance-facility employees were aware of the carrier's 'no-carry' hazardous-materials policy and had received appropriate hazardous-material training."

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17. The National Sleep Foundation (NSF) conducted two polls in 1997. Results of "NSF Harris Poll: Sleeplessness and the Workplace" were released March 27, 1997 (http://www.sleepfoundation.org/pressarchives/newsurvey.html). Results of "NSF Gallup Poll: Sleepiness in America" were released June 3, 1997 (http://www.sleepfoundation.org/pressarchives/newsurvey.html). Both polls are discussed in a 1997 NSF brochure titled *Strategies for Shift Workers*, available at this web site.

18. In the Three Mile Island Nuclear Power Plant (TMI) reactor accident, a malfunctioning pump, a jammed valve and a series of operator actions caused a loss of cooling water from the core of one of two reactors. Plant officials closed the damaged reactor and said that no radiation was released to the environment. Nevertheless, state authorities advised pregnant women and children living within five miles (eight kilometers) of the plant to evacuate the area temporarily. The consensus of state and federal authorities during the following decade was that the accident would cause no significant physical health effects. The second reactor was restarted in October 1985. A news summary said that a federal commission that studied the accident cited poor training as a causal factor. (Source: Peterson, Cass. "A Decade After Accident, Legacy at TMI Is Mistrust." *The Washington Post*. March 28, 1989, 1A.)

19. In the Davis-Besse Nuclear Power Plant reactor shutdown, plant technicians used emergency methods to temporarily resupply water to a reactor-cooling system that lost water after the failure of various components of the main cooling pumps. These actions averted an accident and normal safety mechanisms were restored. No major damage occurred and no radiation was released into the

environment. A news report said that the U.S. Nuclear Regulatory Commission found the underlying cause to be "lack of attention to detail in the care of plant equipment." (Source: Weisskopf, Michael. "Ohio Nuclear Plant Mishap Raises Questions on U.S. Safety." *The Washington Post*, May 24, 1986, 1A.)

20. In the Chernobyl nuclear power plant accident, 30 technicians and firefighters died from high doses of radiation after the nuclear reactor and part of a building were destroyed by a steam explosion and fires. Radioactive materials were released into the environment, the plant was encased in a shelter, and many residents of the region were permanently relocated. Causal factors included problems in the reactor's control and protection system, an unstable operational mode and violations of operational safety rules. [Source: Kurchatov Institute Russian Research Center. "Chernobyl and Its Consequences (Project Polyn): The Causes of the Accident and Its Progress." http://polyn.net.kiae.su/polyn/history.html]

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