ALERTNESS *management* GUIDE

Delta

Alertness Management Guide

OVERVIEW

This *Alertness Management Guide* provides individuals with an introduction to managing alertness in aviation operations. The guide is divided into two sections. The first section provides basic information on the physiological factors that underlie fatigue. The second section presents information on personal alertness strategies, including both preventive and operational fatigue countermeasures.

It is important to acknowledge that managing fatigue in aviation operations is a complex task, and any industry-wide initiative to address these issues requires participation from all areas, including individuals, companies, industry organizations and federal agencies. The information contained in this document merely introduces the topic, focusing on personal strategies for individuals. Additional sources are available that provide more in-depth discussion of these issues, outline in detail the challenges to aviation operations, and describe comprehensive, scientifically-based approaches to alertness management.

THE ISSUE

Maintaining aviation safety is a complex endeavor. Despite sophisticated technological equipment, human operators (pilots, controllers, maintenance personnel and others) are central to safe, efficient flight operations. Human-related error accounts for approximately 70 percent of all transportation accidents, including aviation. Fatigue has been identified as a significant factor that contributes to human error in the industry. In one study, about 20 percent of incident reports to NASA's Aviation Safety Reporting System (ASRS) refer to fatigue. The National Transportation Safety Board has cited fatigue as a probable cause in the aircraft accident involving a DC-8 in Guantanamo Bay, Cuba, and as a contributing factor in several other aircraft accidents.

Flight operations can lead to fatigue, disruption of sleep and circadian rhythms, and degradation of alertness and performance. Clearly, these factors could affect operational safety. Acknowledging and managing these physiological challenges promotes safety and performance in flight operations, while ignoring them can increase the potential for errors, incidents and accidents. Fortunately, a wide range of strategies is currently available to effectively manage fatigue in flight operations.

The first step in any effort to manage fatigue must be education, because even the most effective strategies cannot be used optimally without a basic informational foundation. Since the task of managing fatigue is a shared responsibility among individuals, companies, industry organizations and federal agencies, education should occur in each of these groups. The ultimate goal is to maintain—and wherever possible—enhance safety and performance in aviation operations. By developing effective, personalized approaches to managing fatigue, individuals in the aviation industry benefit themselves and contribute to that overall goal. This guide is only one element of any comprehensive effort to successfully address fatigue in aviation operations.

BASIC HUMAN PHYSIOLOGY: SLEEP AND THE CIRCADIAN CLOCK

Sleep Basics

1. *Sleep is a Vital Physical Need*. Like food, water and air, sleep is required by the body for survival. Further, sleep is a critical requirement for alertness and performance. Data collected during actual flight operations demonstrate that, with sleep loss, alertness and performance degrade; conversely, with sleep, alertness and performance can be optimized.

2. *Sleep is a Complex Physiological Process*. Sleep is comprised of two distinct components: NREM (non-REM) sleep generally involves restoring the body, while REM (rapid eye movement) sleep generally involves restoring the mind. NREM sleep is divided into four stages, with Stages 3 and 4 being the deepest sleep.

3. *Average Sleep Requirement is Eight Hours*. An individual requires the amount of sleep necessary to achieve full alertness and an effortless level of functioning during waking hours. Most adults require about eight hours of sleep, though there is a range of individual sleep-needs (e.g., about six to 10 hours).

4. *Sleep Debt: Lost Sleep Accumulates*. An individual who requires eight hours of sleep and obtains only six hours is sleep-deprived by two hours. If that individual sleeps only six hours each night over four nights, then the sleep loss accumulates into an eight-hour sleep debt. Estimates suggest that in the U.S. today, most adults obtain one to one and a half hours less sleep per night than they actually need. Generally, recovery from a sleep debt involves obtaining deeper sleep and sufficient amounts over one to two nights.

5. *Sleep Changes with Age, Alcohol and Disorders*. Some of the most significant changes to sleep occur as a natural function of age. While younger people sleep more and deeper, as people age, they get less sleep during the night (although they still need the same amount), get less deep sleep, and have more awakenings. Sleep also changes with alcohol consumption. Although many people use alcohol to "wind down" and foster sleep, it can actually reduce sleep quality and quantity overall. Alcohol can reduce REM sleep in the first half of night, then disturb sleep in the second half of night.

   A range of physiological sleep disorders also can disturb the quantity and quality of sleep, and subsequently can degrade waking performance and alertness. In any given year, about one-third of American adults report a sleep disturbance. This figure is conservative, considering that sleepers often are unaware of these disturbances. One example of a common disorder is *sleep apnea*, characterized by breathing pauses during sleep that causes the sleeper to awaken repeatedly to resume breathing. A cardinal symptom of sleep apnea is snoring (although there are other causes for snoring besides sleep apnea). Sleep apnea is an example of a sleep disorder that is a well-documented health risk and can significantly reduce waking alertness and performance. Evaluation and treatment for sleep disorders are available at accredited sleep disorders clinics.

6. *Physiological vs. Subjective Sleepiness.* Two aspects of sleepiness can be considered: physiological and subjective. Physiological sleepiness is the result of sleep loss: lose sleep, get sleepy. Sleep loss will be accompanied by increased physiological sleepiness that will drive an individual to sleep in order to meet the physiological need for sleep. Subjective sleepiness is an individual's introspective self-report of how sleepy they feel. Subjective reports of sleepiness can be affected by many factors, such as physical activity or a particularly stimulating environment (e.g., an interesting conversation), which tend to mask or conceal physiological sleepiness and lead people to overestimate their own level of alertness. Subjective reports of sleepiness often differ significantly from physiological measurements; individuals will generally report greater alertness than indicated by physiological state. Applying this fact to operations means that a flight crewmember who reports being alert, in fact, may be close to falling asleep.

7. *Daily Maximum Sleepiness.* Humans are hard-wired to experience two periods of physiological sleepiness each day. These are at about 3–5 a.m. and 3–5 p.m., and are dictated by the circadian system controlled by the brain.

Circadian Basics

1. *The Circadian Clock.* Humans, like other mammals, have an internal circadian (circa = around; dies = day) clock that regulates physiological and behavioral functions on a 24-hour basis. Located in the brain, this body clock is set by external time cues, especially bright light.

2. *Control of 24-Hour Rhythms.* The clock coordinates daily cycles of sleep/wake, performance, physiology, mood and other functions. It programs us to sleep at night, to be awake during the day, and to have daily peaks and troughs in different functions at specific times. Between 3-5 a.m., physiological sleepiness peaks, and virtually all aspects of alertness and performance slow and can be reduced. Less dramatically, an afternoon dip between 3-5 p.m. also affects sleepiness, alertness and performance.

3. *Circadian Disruption.* The circadian clock cannot adjust immediately when a person suddenly changes schedule (e.g., by flying to a new time

zone or changing to a new work/rest schedule). This is the basis for the circadian disruption associated with jet lag and shiftwork patterns. To shift schedules (e.g., from day to night shift), the body must override the circadian signals to sleep at night and be awake during the day. Also, the clock will receive conflicting time cues from the environment.

Jet lag, resulting from flying to a new time zone, produces a different challenge to the circadian clock. The time cues in the new time zone provide consistent information to the clock, but it can take several days or weeks for the clock to get into step with the new local time. In addition, circadian rhythms in different body functions do not all adjust at the same rate and therefore may be out of step with each other for an extended period of time.

ALERTNESS MANAGEMENT: PERSONAL STRATEGIES

For the individual facing the challenges of managing alertness in flight operations, a variety of well-tested countermeasure strategies can help maintain alertness and on-the-job performance. However, there is no simple, universal solution to fatigue in the workplace. Both operational requirements and human physiology are complex, and each individual is different. It is important to use multiple strategies, and tailor the strategies to individual needs. As new strategies become available, individuals should test them and evolve their approach to managing alertness.

Fatigue countermeasures can be divided into two categories: *1) Preventive strategies* are those used before work and during rest periods, and *2) Operational strategies* are those used on-the-job (in flight, at a computer terminal, etc.). Preventive strategies are designed to minimize the sleep loss and circadian disruption caused by work demands. They are aimed at the physiological causes of fatigue. Operational countermeasures are designed to minimize the impact of sleep loss and circadian disruption on alertness and on-the-job performance. They can temporarily relieve the symptoms of fatigue, to help get the job done as safely and efficiently as possible.

1. Preventive Strategies

a. *Minimizing Sleep Loss*. A number of preventive strategies can be used to minimize sleep loss. The effective use of days off and rest periods to catch up on sleep is critical. Field studies in flight operations indicate that sleep loss is common. Since the effects of sleep loss are cumulative, it is important not to begin a new work schedule or trip pattern with an existing sleep debt. Therefore, try to get at least two nights of sufficient sleep before a trip.

On nights before or between duty days, try to get at least as much sleep as you get on normal off-duty nights. If your duty schedule prevents you from getting that much sleep in a single sleep period, try to sleep more than once (e.g., morning and evening) or to take naps. Take advantage of times in the circadian cycle when it is easy to fall asleep. Conversely, because it is impossible to force sleep, don’t depend on getting sleep during peaks in the circadian cycle when you would usually be awake.

b. *Naps*. Naps can acutely improve alertness and performance, and even short naps can provide benefits. However, the duration of a nap is important because if you enter deep NREM sleep you may experience sleep inertia, a feeling of grogginess, sleepiness and disorientation that can last for 10 to 15 minutes. Therefore, if you have a short nap opportunity just before work, or if you are likely to be interrupted by a duty call, then limit the nap to about 45 minutes or less. At other times, longer naps can be beneficial, and two hours will normally allow for a complete cycle through the different states and stages of sleep. Generally, performance improves, even when people do not report feeling refreshed on awakening.

A nap reduces the duration of continuous wakefulness before a work period, and can be particularly beneficial before a period of night work, when the challenge of working through the circadian low point is also a factor. Getting some sleep is always better than none.

c. *Good Sleep Habits*. Good sleep habits can help improve sleep quality on a regular basis, at home and while on trips. By practicing a regular pre-sleep routine, you can teach your body and mind that certain activities mean that it is time to sleep. It separates the psychological stressors of the day from the sleep period. Once this pattern of cues is established, it can be used anywhere and anytime. It may include such things as checking door locks and turning off lights, or reading something relaxing and entertaining (not work-related). Also, various physical and mental relaxation techniques can be learned and used in this way, such as meditation, autogenic training, yoga and progressive muscle relaxation. These skills must be developed and practiced before they can be expected to provide benefit. It is also important that the bedroom remain an environment conducive to relaxation and sleep, and does not become associated with stressful activities, such as work or worry. Sleep time needs to be given priority and kept as free as possible from other commitments and activities.

d. *Sleep Environment*. Physical aspects of the environment can also affect sleep. A dark, quiet room is preferable. Eye shades are a simple and portable solution to the problem of intrusive light. Earplugs can help by reducing noise, but they must be used such that they do not interfere with a required wake-up signal (such as an alarm clock or call for duty). Sudden sounds can disturb sleep, and continuous background “white” noise can help mask such noises. One suggestion is to set the radio between two stations for this purpose. In general, sleep quality is better if the environment is cooler rather than warmer. A comfortable sleep surface also can be important.

e. *Effects of Food, Alcohol and Exercise*. Food, alcohol and exercise shortly before sleep can affect the quantity and quality of the sleep that you obtain. The discomfort associated with being hungry or, conversely, with having eaten too much, may interfere with falling asleep. If you are hungry or thirsty at bedtime, have a light snack or a small drink. In general, evidence that common foods significantly affect sleep is not yet conclusive. However, both caffeine and alcohol have well-documented disruptive effects on sleep. Caffeine stimulates the nervous system, generally taking effect 15–30 minutes after ingestion and remaining active for 3–4 hours (up to 10 hours in some individuals). The effects of caffeine depend on a number of factors, including habitual usage, body mass and previous food intake. However, regardless of how much caffeine someone habitually takes, caffeine before sleep can lead to lighter sleep with more awakenings and reduced total sleep time. Consider eliminating or minimizing caffeine intake at least three hours before bedtime. Individuals sensitive to caffeine effects should consider avoiding caffeine as much as six hours before bedtime.

Nicotine has much the same effects as caffeine on nocturnal sleep and subsequent daytime sleepiness and performance. As with caffeine, avoid nicotine (e.g., tobacco, gum or patch) for several hours before the time you want to fall asleep.

Alcohol is reported as the most commonly used sleep aid in the U.S. It can promote relaxation and thereby help a person to fall asleep. However, with moderate to excessive alcohol intake, sleep is easily disrupted. Alcohol suppresses REM sleep in the first half of the night, leading to REM rebound and withdrawal effects in the second half. Therefore, avoid drinking even moderate amounts of alcohol 2–3 hours before sleeping. Also, individuals with breathing disorders during sleep, for example apnea, should keep in mind that alcohol worsens these conditions and reduces oxygen levels during sleep. FAA regulations govern alcohol consumption in proximity to duty periods.

There is evidence that regular exercise may enhance deep sleep, which has been shown to be physically restorative. However, strenuous exercise results in physiological activation, which may interfere with sleep. Therefore, avoid strenuous exercise within several hours of going to bed.

f. *Circadian Strategies*. Currently, there are more practical, well-tested preventive strategies for minimizing sleep loss than there are for speeding circadian adaptation to different schedules. Resetting the circadian clock in an operational setting is complex for several reasons. First, unless a technique is applied correctly, interventions that reset the circadian clock can shift the clock in the wrong direction, depending on when in the circadian cycle they are administered. At this time, there is no simple, practical way of measuring precisely where a person is in the circadian cycle, particularly in an operational setting. Without this information, an intervention intended to move the circadian clock "eastward" may end up sending it "westward." Further, for such a treatment to be successful, it is necessary to control exposure to the natural time cues in the environment, such as sunlight and darkness. In practice, this can be very difficult to achieve, especially on a trip.

In some situations, it may not be possible or even desirable to adapt the clock fully to rapidly changing schedules. For example, during long-haul flight operations, crewmembers usually spend each consecutive rest period (layover) in a different time zone, so it may not be preferable to adapt to the destination time zone. The known clock-shifting interventions (e.g., melatonin and bright light) need more testing to determine their feasibility and effectiveness in improving alertness and performance in operational settings, including aviation environments.

2. Operational Countermeasures

Once on the job, the range of available strategies to combat fatigue is more restricted. In most commercial aviation operations, there is an additional constraint that crewmembers must remain in their cockpit seats from take-off through landing, except for "biological need," which currently does not include sleep. In general, operational countermeasures do not address the underlying physiological causes of fatigue. Instead, they are meant to temporarily enhance alertness and performance by masking fatigue, so that operational safety and efficiency are maintained.

a. *Social Interaction and Conversation*. Interacting with others can be a useful operational strategy. To maintain alertness, it is necessary to be actively involved in the conversation, not just listening and nodding. In fact, a lack of conversation can be associated with declining physiological alertness.

b. *Physical Activity*. Physical activity is one of the most effective ways of combating sleepiness. Some stretching and isometric exercises can be done in the cockpit seat. Even writing or chewing gum may help. Almost any physical activity is preferable to passivity.

c. *Caffeine*. Use the alerting effects of caffeine to help you stay awake during circadian low points or other times during operations when you struggle to maintain wakefulness (remember: on average, about 15–30 minutes to take effect, lasting three to four hours). To optimize caffeine as an operational strategy, avoid or minimize its use when you are already alert, such as at the beginning of a daytime work period or just after a nap. Start consuming caffeine about an hour before expected times of decreased alertness (e.g., 3–5 a.m.). However, consider your planned bedtime, and try to stop caffeine consumption at least three hours before to avoid its disruptive effects on sleep. In some situations, these requirements may be conflicting. For example, using caffeine to help work through the circadian low point at the end of a night flight could result in problems trying to fall asleep after coming off duty in the morning. In that case, consider the benefits and drawbacks in light of overall operational demands.

Caffeine is a diuretic, which can cause further dehydration for flight crews, who are already vulnerable due to low humidity in the cockpit. Another consideration when using caffeine is that, in high doses, caffeine can lead to anxiety, irritability, “shakiness” and insomnia.

d. *Diet*. Currently, there is no compelling evidence that specific types of food directly affect alertness and performance. Candy or other “energy boosters” can produce a transient increase in alertness (e.g., “sugar highs”), but this is frequently followed by a decrease in alertness (sometimes suddenly) as blood glucose levels fall. Stomach (gastrointestinal) upsets can be disruptive to sleep, and maintaining a balanced diet is important. Duty schedules can make it difficult to maintain a regular pattern of well-balanced meals, so plan ahead and bring nutritious snack foods with you on long flights or shifts.

e. *Naps*. The goal of all operational countermeasures is to improve on-the-job performance and alertness when compared to the no-countermeasure condition. Napping is one countermeasure that has been tested in a real-world operational setting. A NASA/FAA study examined the effectiveness of a planned cockpit rest period to improve subsequent performance and alertness in commercial long-haul flight operations. Crewmembers who were allowed to take planned naps showed better performance (34 percent) and higher physiological alertness (54 percent) during the last 90 minutes of flight than the control group crewmembers who had not napped. This practice is not currently sanctioned by the FAA, but research is ongoing.

The significant results of this NASA/FAA study and other scientific research have demonstrated that naps can be extremely beneficial. Strategic naps should be used as a high-priority countermeasure in appropriate circumstances. For example, there are many opportunities outside the cockpit environment when a short strategic nap can be an effective countermeasure, such as between flight legs when other duties are completed. Napping is the only operational countermeasure that addresses one of the major physiological causes of fatigue—the need for sleep—and reverses it. While other operational countermeasures primarily mask fatigue, naps actually reduce it.

CONCLUSION

Clearly, there is no single approach or countermeasure that will eliminate fatigue from flight operations. Operational demands, human physiology and individual differences are too complex for a simple mechanistic approach. Since there is no simple answer, the challenge is to effectively manage alertness. Education is a crucial first step in any effort to manage fatigue. The information in this guide is provided as one element in this educational process. By learning about the issues involved, by maintaining and spreading awareness of these issues, by developing and using personal strategies to maximize alertness and performance during operations, everyone in the aviation industry can support efforts to reduce fatigue related risks and can contribute to safer flight operations.

ACKNOWLEDGEMENT

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