ALERTNESS MANAGEMENT IN 24/7 SETTINGS, LESSONS FROM AVIATION

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> *My mind clicks on and off . . . I try letting one eyelid close at a time while I prop the other open with my will. My whole body argues dully that nothing, nothing life can attain, is quite so desirable as sleep. My mind is losing resolution and control.*
>
> ~Charles Lindbergh,
> The Spirit of St. Louis, 1950

THE ISSUE: SOCIETAL SAFETY AND RISKS

It has been more than 74 years since Charles Lindbergh's historic transoceanic flight to Paris, during which he completed 33.5 hours of solo flying. His comments in *The Spirit of St. Louis* clearly demonstrate that fatigue has been a longstanding safety issue in aviation operations. The history of aviation offers but one example of how our society has evolved to its current state of "24 hours a day/ 7 days a week" global activities and continual technological changes. The demand for 24/7 operations was an outgrowth of the Industrial Revolution and the round-the-clock capability provided by the invention of the light bulb. Initially, many of these activities were safety related so that, for example, healthcare, police, and fire services could be available any time they were needed—day or night. Today, it is difficult to identify an activity that is not available or operating 24/7: consider the fields of transportation, manufacturing, power, technology, health care, public safety, military, and finance. Even "convenience" activities, such as shopping or getting gasoline, can be done at 24-hour facilities.

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While societal demand and technology have evolved significantly, human physiology has remained unchanged. As humans, we have vital physiological requirements for sleep and a stable internal biological clock. If you lose sleep or disrupt the internal clock, there are significant effects on waking performance, alertness, and safety. This is a basic challenge of our modern society: humans were not designed to operate 24/7. The scientific data are clear that there are risks associated with presuming that human operators can function round-the-clock with the same efficiency, safety, and consistency now expected of our technology. Just as the machines have certain capabilities and operating limitations, so do the humans who design, implement, and operate them.

The societal risks associated with human fatigue engendered by 24/7 operations have been observed in a variety of ways. Fatigue has been identified as causal or contributory in multiple high-profile accidents. For example, official accident investigations have identified fatigue as causal or contributory in the Exxon Valdez grounding, the Three Mile Island and Chernobyl nuclear accidents, and the Space Shuttle Challenger explosion.[22,19,38,26] Fatigue-related accidents have been identified in every mode of transportation. These risks touch us personally as well. The most recent National Sleep Foundation poll found that 51% of respondents reported having driven drowsy during the previous year, and 17% reported "nodding off" while driving.[35] There are an estimated 100,000 fatigue-related auto accidents each year in the United States, which are associated with 76,000 injuries and 1500 fatalities.[37] In a recent consensus statement, scientists estimated that 15–20% of all transportation accidents are fatigue related; that official statistics generally underestimate the role of fatigue; and that the contribution of fatigue to accidents surpasses that of alcohol and drugs.[1]

This chapter provides a brief introduction to the physiological factors that underlie these fatigue-related safety risks. Examples from the aviation environment, especially NASA research, are used to demonstrate how these physiological factors translate into real-world operations. Finally, a comprehensive approach to addressing this important safety issue is outlined, with examples of successful implementation activities. The information and approaches provided can be generalized to any 24/7 operational setting.

PHYSIOLOGICAL FACTORS UNDERLIE FATIGUE*

There are two principal physiological factors that account for about 85–90% of the phenomenon generally described as "fatigue": sleep and the circadian clock. A brief introduction to these factors will provide a foundation for subsequent discussions of scientific findings from the aviation environment. A variety of resources are available that provide more information about these and related topics.[4,8,18]

Sleep

Sleep is a vital physiological function, now known to be as critical to human survival as food, water, and air. Generally, adult humans require about 8 hours of sleep each day, though there is a range of 6 to 10 hours for sleep need.[5,40] This sleep amount is required for optimal health, alertness, and performance. The amount of sleep that an individual requires is probably genetically determined and cannot be significantly altered through "training." Estimates indicate that most adults obtain 1–1.5 hours less sleep than is physiologically required each day.[20] This "lost" sleep accumulates into

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*In this chapter, the word fatigue is used as the summary or synthesis descriptor for the varied effects and labels used to describe the cognitive, behavioral, and physiological outcomes of sleep loss and circadian disruption.

what is termed a "sleep debt." Consider this sleep debt equivalent to a financial debt, as if a bank account were in the red. For example, if an individual obtains 1.5 hrs less sleep than needed over a 5-day workweek, then that individual enters the weekend with 7.5 hrs of sleep debt. Over the week, the individual would have accumulated a sleep debt equal to about one full night of sleep loss.

While many factors can significantly affect sleep quantity and quality, three deserve particular attention: age, alcohol, and sleep disorders. Perhaps the most dramatic changes in sleep occur as a normal function of the aging process.[2] When approaching age 50 and older, four sleep-related changes typically occur. First, there is a significant reduction in deep sleep, with some data suggesting that non-rapid-eye-movement (NREM) sleep stages 3 and 4 decreases or possibly disappears in the elderly. Second, there are more frequent awakenings during sleep, so that sleep is disrupted and quality is reduced. Third, sleep becomes less consolidated, and it becomes increasingly difficult to obtain the same quantity and quality of sleep that was enjoyed when younger. Fourth, most sleep disorders increase in prevalence and severity with age.

The most widely used sleep aid in America is **alcohol,** yet it can disrupt both the quantity and quality of sleep.[41] The specific amount of alcohol needed to disrupt sleep is dependent on a variety of factors, such as body mass and tolerance. However, the general effect is due to alcohol's potent suppression of REM (dreaming) sleep in the first half of a night's sleep. As the alcohol is metabolized, an REM rebound occurs in the second half of the night, and awakenings occur more often—both of which disrupt sleep continuity. Therefore, alcohol consumed with the intention of promoting good sleep can instead reduce both the quantity and quality of sleep.

Almost 90 different sleep disorders exist that can affect sleep and waking function.[17] In any given year, at least a third of the adult U.S. population will complain about a sleep disturbance. There are a variety of physiological and psychological causes for these disorders. Often the sleeper is unaware of the disorder, and complaints may focus on disturbed nocturnal sleep or decreased waking function (e.g., sleepiness or performance problems). Many sleep disorders can be effectively diagnosed and treated at specialized sleep disorder centers by board-certified sleep experts.

One sleep disorder receiving particular attention in operational settings is sleep apnea. This disorder involves the repetitive cessation of breathing during sleep. To begin breathing again, the sleeper must wake up. In severe cases, breathing pauses can occur hundreds of times a night and last up to a couple of minutes. The primary presenting complaint of sleep apnea patients is excessive daytime sleepiness. Studies have demonstrated that individuals with sleep apnea have a two to seven times increased risk for car crashes. A recent study has shown that mild to moderate sleep apnea can cause the performance decrement equivalent to that of a .05 to .08 blood alcohol content.[25]

Circadian Clock

The internal circadian clock is the other principal physiological determinant of waking alertness and performance.[39] Located in the **suprachiasmatic nucleus** of the hypothalamus, the circadian clock controls the 24-hour rhythm for a wide range of functions, including performance, alertness, behavior, and mood. For example, a prominent circadian pattern is exhibited by the sleep/wake cycle, with biological programming for a consolidated period of daytime wakefulness and nighttime sleep, reoccurring in a regular 24-hour pattern. Every 24 hours, humans are programmed for two approximate windows of physiological sleepiness and two windows of alertness. Generally, maximal sleepiness occurs at the lowest point of the circadian cycle, typically from about 3 to 5 AM. This is the period when the lowest levels in many functions is observed, such as temperature, mood, and performance. A second window of sleepiness occurs at about 3 to 5 PM. The two windows of programmed alertness occur at approximately 9 to 11 AM and 9 to 11 PM. A variety of factors affect the specific timing of these windows of alertness and sleepiness and the degree of change observed during these times.

Recent research has demonstrated that the intrinsic period of the circadian clock is slightly longer than 24 hours, approximating 24.2 hours.[7] Perhaps the most powerful cue that sets the circadian clock is light. Light (and dark) exposure at times of clock sensitivity can be used to manipulate the clock and "move it" to a new time zone or shift schedule. However, abruptly transitioning the clock to a new schedule or time zone can result in both internal and external **desynchronization**. *External* desynchronization involves the internal clock being out of sync with external time cues. *Internal* desynchronization involves the internal rhythms (e.g., temperature, sleep/wake, hormone secretion) being out of sync with one another. It can take anywhere from a few days to weeks for full circadian resynchronization. This timeframe is dependent on factors such as direction flown, number of time zones crossed, and light exposure. It can take 48 to 72 hours with expert application of light/dark cues to readjust the internal circadian clock. Therefore, there will not be significant circadian adaptation during trips of less than approximately 72 hours, no matter what adaptation strategies are employed.

Subjective vs. Objective Discrepancy

Another well-documented phenomenon with important operational implications is the discrepancy between subjective reports of alertness and objective, physiological measures.[34] Generally, individuals can report being alert when physiological measures indicate that they could be asleep within a few minutes. This discrepancy is operationally relevant for two reasons. First, an individual—especially when already tired—may not be a reliable source for determining whether he or she is alert enough for an operation. Second, if an individual does not subjectively perceive a level of sleepiness considered operationally relevant, the individual is unlikely to engage a strategy to improve alertness and performance.

Effects of Sleep Loss and Circadian Disruption

Basically, every aspect of human capability and performance can be reduced with sleep loss and circadian disruption.[3,9,11,12,24] Studies have shown that decision-making, reaction time, memory, communication skills, mood, vigilance, alertness, and more can be degraded by sleep loss and circadian disruption. Operationally, it is important to note that these reductions may not occur as a smooth function. Performance becomes more variable when humans fatigue, and the onset of significant performance decrements can occur quickly. So, while performance may be at an acceptable and consistent level at one point, it is possible that only moments later, it will become irregular and significantly degraded. The ultimate performance failure would involve an actual episode of falling asleep, whether a momentary microsleep or an extended sleep episode. However, performance can be reduced and can represent a safety risk well before or in the absence of a spontaneous, unplanned sleep episode.

FATIGUE FACTORS IN REAL-WORLD OPERATIONS: AVIATION EXAMPLES

The following examples demonstrate how the physiological factors that underlie fatigue are translated into real-world operations. Specific NASA research studies are used to show how sleep and circadian factors are affected by aviation operations. The NASA Fatigue/Jetlag Program was initiated in 1980 in response to a Congressional inquiry about whether fatigue was a safety issue in flight operations. In 1990, the Program evolved into the NASA Fatigue Countermeasures Program to emphasize strategies that would address the issue.

Over the years, the NASA Program has employed a broad range of research methodologies and measures. Research projects have included studies in controlled laboratory situations, high-fidelity full-motion simulators, and field studies during actual flight operations. The range of measures includes subjective surveys and diaries, physiological measures of brain activity and core body temperature, and performance variables. A number of scientists and groups have conducted research on these aviation issues, and the NASA activities are intended as illustrative of the data and progress in this area.

The last example discusses the role of fatigue as a probable cause in a DC-8 crash. We briefly describe how to examine fatigue factors in an accident investigation.

Short-Haul Flight Operations

A field study was conducted with 74 commercial pilots from two different airlines flying short-haul (flight legs less than 8 hrs) operations.[15] A sleep/wake diary was completed for 3 days before the trip schedule, throughout the trip, and for 3 days after returning home. Core body temperature was monitored to examine circadian variables, and wake/rest activity patterns were assessed with an actigraph (a wrist-worn movement device). A NASA researcher accompanied the crews on the flight-deck during the trips.

Overall, the trips averaged 10.6 duty hours and involved 4.5 hours of flight time and 5.5 flight legs per trip day. About one-third of the duty periods were longer than 12 hours, and the average rest period (i.e., off-duty) was 12 hours long. The logbook data revealed that during the trip schedule, pilots reported that they slept less; awoke earlier; had more difficulty falling asleep; had lighter, less restful sleep; and poorer overall sleep quality. Overall, 67% of crewmembers had at least 1 hour less sleep per 24 hours during the trip (compared to pre-trip amounts), and 30% averaged 2 hours of sleep loss. Pilots reported consuming increased amounts of caffeine, snacks, and alcohol during the trip schedule and experiencing more physical symptoms, including headaches, congested noses, and back pain.

Long-Haul Flight Operations

This field study involved 32 commercial pilots flying long-haul (> 8 hrs) trips that crossed up to 8 time zones per 24 hours.[16] Overall, the average duty period was 9.8 hours long with an average layover of 24.8 hours. On two-thirds of the layovers, crewmembers slept twice, though they still averaged 49 minutes less than their pre-trip amount. Circadian consequences of time zone crossings were evident in a variety of measures. For example, the circadian cycle moved to a 25.6 hr period, and about 20% of crewmembers had no discernable circadian temperature pattern. Overall, the circadian cycle did not synchronize to the continual time zone shifting. Also, there was more sleep loss associated with night flights compared to day flights. Pilots reported consuming more caffeine and snacks, though they ate fewer meals during the trip schedule. Pilots reported an increase of physical symptoms, including headaches, congested noses, and back pain during trips. Logbook data and observer notes suggested that 11% of flight crewmembers took a nap on the flight deck when conditions permitted.

Overnight Cargo Flight Operations

This NASA study involved 34 B-727 commercial pilots flying an 8-day overnight cargo schedule.[14] The trip schedules involved crossing no more than one time zone per 24 hours. Total sleep on duty days averaged 1.2 hours less than pre-trip amounts, and the day sleeps were rated as poorer compared to nighttime sleep episodes. This resulted in 54% of crewmembers averaging more than 1 hour of sleep loss per 24 hours, and 29% of crewmembers lost more than 2 hours per 24 hours, across the 8-day schedule. The all-night flight schedules did not result in a significant circadian shift (e.g., a shift toward alertness at night and sleep during the day), as there was only about a 3-hour phase delay (i.e., rather than a circadian nadir at 4 AM, it moved to about 7 AM). Pilots reported consuming more snacks and experiencing more physical symptoms, such as congested noses, headaches, and burning eyes during trips. There was a significant influence of the circadian timing system observed. For example, the length of morning sleep periods following an all-night duty period coincided with the underlying circadian wake-up time.

Augmented Long-Haul Survey

On certain long-haul flights, extra crewmembers (i.e., augments) are available to allow pilot rest periods in onboard crew rest facilities (i.e., bunks) on a rotating basis. A survey was completed by 1404 flight crew at three different commercial airlines flying several types of long-haul aircraft.[32] Overall, flight crew reported taking about 39.4 minutes to fall asleep in the rest facility and averaging a total of 2.2 hours of sleep. The crews also rated 25 factors for whether they interfered or promoted good sleep in the bunk facility. The three factors that most promoted good sleep were physiological readiness for sleep, physical environment (e.g., bunk size, privacy), and personal comfort (e.g., blankets, pillows). There were five factors that most interfered with good sleep: environmental disturbance (e.g., background noise, turbulence), luminosity (e.g., lighting), personal disturbances (e.g., bathroom trips, random thoughts), environmental discomfort (e.g., low humidity, cold), and interpersonal disturbances (e.g., bunk partner).

Survey of Regional Flight Operations

Regional airline operations represent a growing segment of commercial aviation with different operational considerations. A survey completed by 1424 pilots from 26 regional carriers examined fatigue issues.[6] Overall, 89% of flight crewmembers rated fatigue as a moderate or serious concern in regional operations. Also, 88% reported that fatigue was a common occurrence, with 92% indicating it was a moderate or serious concern when it did occur. Pilots identified a variety of fatigue factors in regional operations, including multiple flight segments, scheduling, and varying regulations. Overall, scheduling factors represented nine of the ten most common issues that pilots believed could reduce fatigue in regional operations. Survey results indicated that 86% of respondents received no formal training regarding fatigue. When asked directly, 80% of respondents reported that they had "nodded off" in the cockpit during flight.

Survey of Corporate Aviation Operations

Corporate/executive operations represent another unique component of the aviation industry. Corporate aviation operations can involve unscheduled flights, quickly changing schedules, long duty days, and extended periods of "on-call." Corporate pilots also can be asked to support non-flight–related activities such as baggage handling and refueling.

A survey examining fatigue factors was completed by 1488 corporate flight crews.[27] On average, the flight crews reported flying 13.8 days/month for an average of 35.2 flight hours/month. The average duty day was 9.9 hours and involved 3.2 flight segments. Many corporate flight departments set their own flight and duty time limitations because the Federal Aviation Regulations (under Part 91) provide minimal guidance. About one-third of respondents had no established duty limit; over half had no specified flight time limit; and 40% had no minimum rest policy. About 85% of respondents identified fatigue as a moderate or serious safety issue, with approach as the most often cited flight phase affected by fatigue (48%). Almost 71% reported having "nodded off" during a flight. Seventy-nine percent reported that they had received no formal training about fatigue.

Activity Breaks as a Fatigue Countermeasure

Activity breaks were evaluated to determine their effectiveness in promoting alertness and performance during flight operations.[23] Twenty-eight pilots participated in a B747–400 simulator study that involved a 6-hour uneventful night flight. Pilots were provided either five regularly scheduled 7-minute breaks (Treatment) or a single, mid-flight break (Control) that involved getting out of their cockpit seat, walking, and interacting socially. Pilots in the Treatment condition showed improved subjective sleepiness ratings up to 25 minutes after the break compared to Controls. However, the objective performance test did not show improved results for the Treatment vs. Control conditions and therefore, did not parallel the subjective findings that the pilots reported feeling less sleepy.

Effects of a Planned Cockpit Rest Period

Laboratory-based studies have clearly demonstrated that naps can improve performance and alertness. Previous NASA data had indicated that pilots reported spontaneous, uncontrolled sleep episodes occurring in flight. Therefore, a field study was conducted to examine the effectiveness of a planned cockpit rest period to improve pilot alertness and performance during actual flight operations. [30]

Twenty-one B747–200 flight crew participated in the study that involved a 12-day trans-Pacific trip schedule with eight flight segments of about 9 hours each, with approximately 24 hours layover between flights. One group was allowed a 40-minute planned in-flight cockpit nap opportunity during a single flight segment, one crewmember at a time on a predetermined rotation (Nap Group). One group had a 40-minute control condition identified, but were not allowed to nap during that time (Control Group). Both groups had the same measures collected, including subjective sleep/wake diaries, physiological measures of brain and eye movement activity (i.e., EEG, EOG), and vigilance performance using a sustained attention task.

On average, using standard EEG criteria, the Nap Group fell asleep in 5.6 minutes and slept for 25.6 minutes. Overall, there was a 34% improvement in performance for the Nap Group compared to the controls (Fig. 1) and a 54% improvement in physiological measures of alertness during the last 90 minutes of flight (Fig. 2). Overall, the Control Group had 120 "microsleeps" of 5 seconds or longer during that time, including 22 during the final 30 minutes of flight that involves touchdown. The Nap Group had a total of 34 microsleeps, with none occurring during the final descent and landing phase of flight. It is important to note that there were no differences in the subjective ratings of alertness between groups, though the objective performance and physiological alertness measures showed significant improvements in the Nap Group.

Examining Fatigue Factors in an Aviation Accident Investigation

In 1993, the National Transportation Safety Board (NTSB) investigated the crash of a DC-8 cargo plane in Guantanamo Bay, Cuba. At the request of the NTSB Human Performance Investigator, scientists at NASA examined fatigue factors to de-

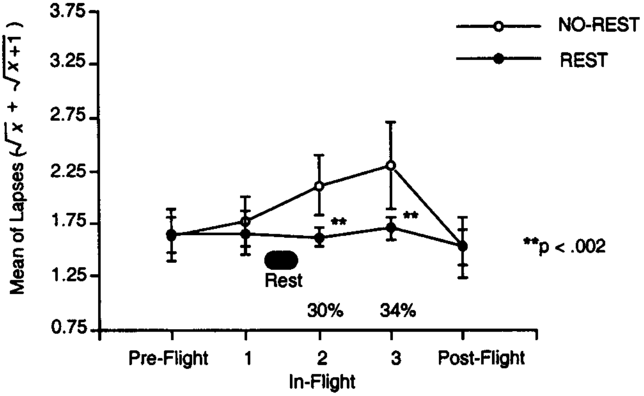

FIGURE 1. Results of performance on reaction time test by no-rest and rest groups during NASA Planned Cockpit Rest Study.

termine whether fatigue had been a causal or contributory factor in the accident.[31] The NASA scientists identified three specific fatigue factors to be examined: (1) sleep, both acute and cumulative, (2) continuous hours of wakefulness, and (3) circadian or time-of-day effects. Subsequent to this evaluation, a fourth factor—sleep disorders—has been added to this list of factors. The first task was to determine whether these fatigue factors were present at the time of the accident and to what extent. The second task was to determine whether fatigue-related performance changes were causal or contributory to the accident.

Two of the three crewmembers had an acute sleep loss (Fig. 3). All three crewmembers accumulated a sleep debt. Examining the hours of continuous wakefulness indicated that crewmembers had been awake ranging from 19 to 23.5 hours prior to the accident.

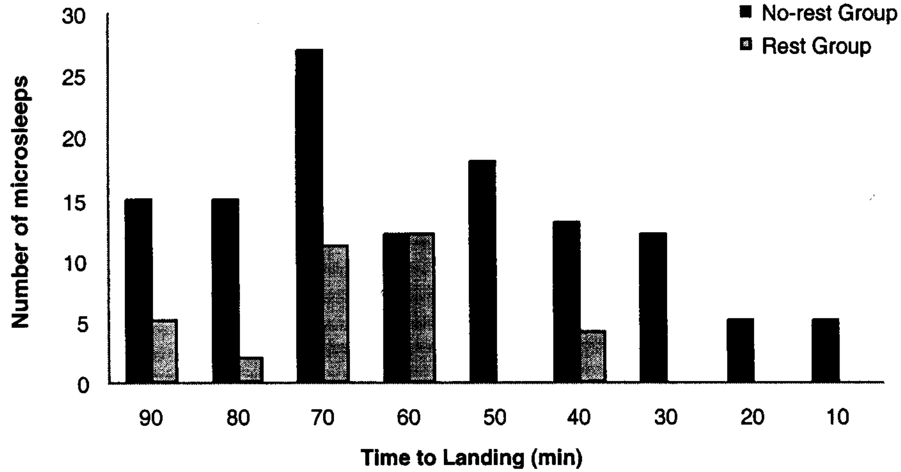

FIGURE 2. Number of "microsleeps" (i.e., EEG and EOG indicators of sleep) by no-rest and rest groups for the final 90 minutes of flight—from an hour before top of descent, through descent and landing—during the NASA Planned Cockpit Rest Study.

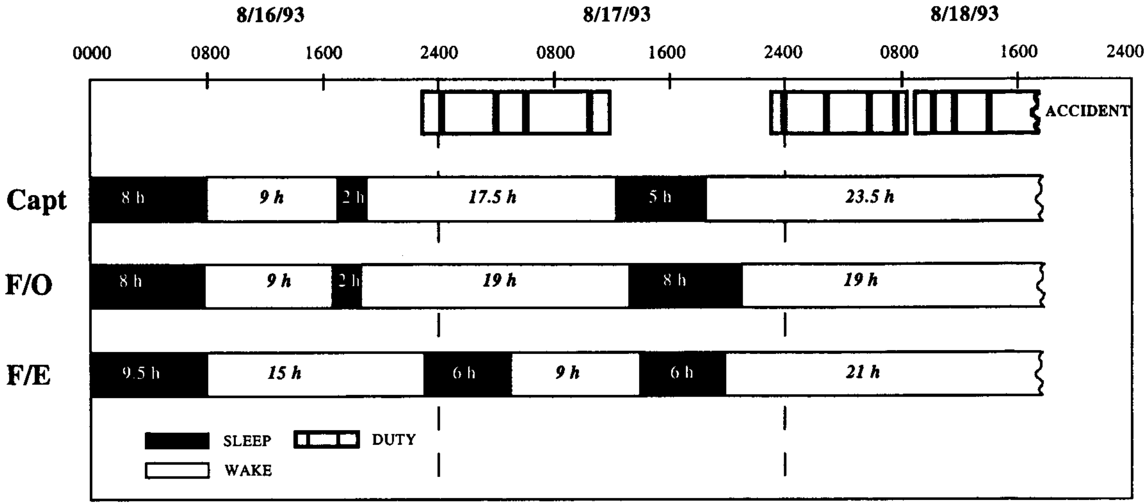

FIGURE 3. The 72-hr sleep/wake history of flight crew prior to accident at Guantanamo Bay, Cuba.

Also, the accident occurred during the afternoon window of sleepiness (about 3 to 5 PM home body time). Therefore, all three physiological fatigue factors were present at the time of the accident and, generally, to a significant extent.

The next task was to relate fatigue-related performance changes to actions that may have caused or contributed to the accident. In this case, four specific performance problems were identified: (1) poor decision-making, (2) cognitive fixation, (3) poor communication/coordination, and (4) slowed reaction time.

Based on all of these findings, the NTSB found that "the probable causes of this accident were the impaired judgment, decision-making, and flying abilities of the captain and flight crew due to the effects of fatigue."[21] This was the first time in a major U.S. aviation accident that the NTSB had identified fatigue as a probable cause. Furthermore, the Board recommended that flight crew be trained on the effects of fatigue and strategies to mitigate its effects, and that the Federal Aviation Regulations be updated to reflect the current state of scientific knowledge related to fatigue.

The approach outlined in the NTSB report can be used for examining fatigue factors in an incident or accident investigation in any setting. Also, it can be used to evaluate proposed schedules or operations to determine relative risk prior to implementation.

Some Conclusions from Research

In aviation operations, it is often assumed that "jet lag" and fatigue are only concerns in long-haul flights that involve significant time zone changes. The studies summarized clearly demonstrate that fatigue is an issue across all segments of the aviation industry. In fact, the data show that different flight operations create different physiological disruptions and, hence, somewhat different outcomes. However, there are some conclusions that are common to the different flight settings.

There are four **core operational factors** that emerge related to the physiological factors previously discussed:

- Duty period length is related to the continuous hours of wakefulness, though a subset. Flight time is a subset of the duty period.
- Rest or off-duty periods are related to sleep opportunity and can affect both acute sleep loss and the creation of a cumulative sleep debt.
- Circadian factors can affect both alertness and performance during operations as well as the quantity and quality of sleep obtained during rest periods.
- Cumulative effects can be relevant for continuous and consecutive duty periods and for the creation of a sleep debt.

Any consideration of schedules, policies, or regulations should, at the very least, acknowledge these four core operational factors and their physiological consequences.

NO MAGIC BULLET: THE NEED FOR A COMPREHENSIVE APPROACH

Once acknowledging that fatigue represents a safety risk in operational settings, there is a natural tendency to want to "fix" the situation. Unfortunately, there is no simple or single solution, or one-size-fits-all approach, that will eliminate fatigue from 24/7 operations. Currently, this complex issue presents at least **five significant challenges to effective interventions:**

1. Operational requirements are diverse. As illustrated by the previous examples, even within one transportation mode such as aviation, there are tremendous differences between short-haul, long-haul, overnight cargo, regional, and corporate flight operations.

2. There are individual differences among the operators, such as age, sleep need, experience, and other relevant factors.

3. Sleep and circadian physiology are complex, and their interaction in real-world operations continues to be researched.

4. History can be a significant barrier to change when longtime practices are questioned or changes proposed (i.e., "that's the way it's always been done").

5. There are core economic challenges that affect all participants attempting to address fatigue issues. The economic aspects include costs of meeting potential regulatory requirements, staffing levels, shift pay differentials, salaries, injuries and accidents, legal liabilities, and cost vs. benefits analyses.

Given these complex and potentially contentious aspects of effectively managing fatigue, a comprehensive alertness management approach offers the greatest opportunity for effecting change. Alertness management is employed for two reasons. It is questionable whether fatigue can ever be "eliminated" from 24/7 operations given that humans are not physiologically designed for this round-the-clock requirement. However, there is an opportunity to more effectively manage this situation and reduce fatigue-related risks while improving alertness and performance during operations. Also, an approach focused on alertness can transition and expand this issue into a more constructive context. This effort is similar to the expanded focus in health care from disease processes and illnesses to prevention, health, and well-being. The alertness management approach also can be used to progress beyond longstanding societal attitudes and behaviors related to fatigue that may interfere with constructive change.

The core components of a comprehensive Alertness Management Program (AMP) include: education, alertness strategies, scheduling, policy, and healthy sleep.[29] Education is a critical foundation for any successful program dealing with this issue. A National Sleep Foundation true/false quiz composed of basic sleep knowledge questions was failed by 86% of participants, with an average score of 46% (guessing at answers would have been as effective).[36] A survey of medical schools found that, on average, in 4 years of curriculum students received less than 1 hour of information on sleep and sleep disorders prior to receiving their M.D.[33]

To address this issue, NASA developed an education and training module for use within aviation and other operational environments.[28] This module has been used at 30 workshops by 660 participants from 234 organizations. A survey of these participants (professionals in safety, operations, health, human resources, OM, and others) indicated that they have used the module to provide approximately 6300 classes for about 117,000 individuals. Also, 58% reported that the educational activity had been the basis for some organizational change related to alertness management. The module can be downloaded from the NASA website at **http://human-factors.arc.nasa.gov/zteam/**.

The alertness strategies component involves the identification and implementation, both at a personal level and through organizational support, of scientifically validated countermeasures. These strategies could include strategic naps, caffeine use, good sleep habits, exercise, and light levels. The scheduling component can be the most complex, and contentious, aspect of addressing fatigue issues. As a starting point, schedules can be examined according to their effects on the physiological fatigue factors previously identified. Policies should be broadly considered, ranging from policies that support implementation of specific strategies to potential federal regulatory issues. There are examples of operational policy documents intended to provide guidelines, not regulatory frameworks, to address these issues in aviation.[10,13]

It is important that any comprehensive AMP include information on healthy sleep, especially the identification and treatment of sleep disorders. This can take the form of information, providing tools for individuals to identify if they are at risk, or an actual screening program for individuals in safety-sensitive positions. It is critical that policies be developed to address the specific healthy sleep program that is developed.

THE NEED FOR CHANGE

Effectively managing alertness in operational settings confronts core attitudes, behaviors, and practices in our society. There is a well-established bravado associated with going for days without sleep and still accomplishing one's task. Yet, there is now an extensive amount of scientific data that clearly demonstrate the many significant risks associated with sleep loss and circadian disruption. And every individual with a story of prolonged wakefulness that ends successfully has another one with a poor outcome or a "near-miss." Therefore, a critical step toward progress will involve cultural change to support different attitudes, practices, and behaviors that can effectively reduce known fatigue-related risks and improve alertness and performance during operations.

There are many situations in which this approach to safety and health issues has been effective (consider seat belts, drunk driving, smoking, diet, and exercise). It is now time for a societal and individual focus on the substantial costs and risks associated with 24/7 operations. We have the opportunity, offered by scientific knowledge, to avail ourselves of the significant benefits improved safety, performance, and alertness can provide.

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