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**Using Controlled Daylight Exposure
and Sleep Timing in the Prevention
of Shift Lag During Night Operations**

By

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Biomedical Applications Research Division



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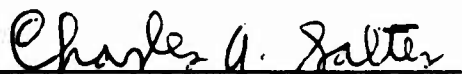
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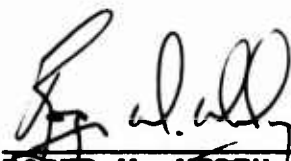


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In the Army aviation community, a significant component of combat and training missions is night operations. Mission requirements often necessitate an initial shift from daytime to nighttime duty hours within 24 to 48 hours. Rapid shifts from daytime to nighttime work, and nighttime to daytime sleep usually result in loss of sleep, degradation of alertness, increased fatigue, and reduced work effectiveness. These symptoms are referred to as "shift-lag" because the body's physiological adjustment lags behind the rapid shift to the new work schedule. Research on shiftwork provides a variety of approaches to avoid the deterioration of performance and health of shiftworkers. Shift-lag prevention plans may consider the speed of shiftwork rotation, the duration of each shift, age of workers, physical strength associated with work demands, diet, timing of sleep, and in some cases, the use of drugs to induce sleep and attempt to resynchronize the body's internal biological clock. However, the use of controlled timing of daylight exposure and of sleep schedules are of overriding importance. In the Army aviation context, consequences of shifts to

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nocturnal work schedules without the implementation of a shift-lag prevention plan have been recently documented. This work reviews the mechanism of biological timing in humans, the role of environmental lighting, and specifically identifies methods of preventing sleep loss and fatigue during the transition from daytime to nighttime duty hours. This detailed treatment of shift-lag countermeasures is presented with the purpose of providing unit commanders, flight surgeons, safety personnel, pilots, air crew, and maintenance personnel with enough information to design general or individual strategies relevant to specific demands imposed by mission objectives and environmental conditions.

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Introduction

In the Army aviation community, a significant component of combat and training missions is night operations. Missions often require an initial shift from daytime to nighttime duty hours within 24 to 48 hours. Experimental and clinical evidence indicates that shifting to nocturnal work schedules without sufficient adaptation time has a detrimental impact on health and psychological well-being (Scott and Ladou, 1990; Smolensky and Reinberg, 1990). Rapid shifts from daytime to nighttime work, and nighttime to daytime sleep usually result in loss of sleep, degradation of alertness, increased fatigue, and reduced work effectiveness (U.S. Congress OTA report, 1991; Monk, 1990). These symptoms are referred to as "shift lag" because physiological adjustment lags behind the rapid shift to the new work schedule (Kogi, 1985).

Research on shiftwork, particularly of work schedules used in industry, provides a variety of approaches to avoid the deterioration of performance and health of shiftworkers. General strategies consider the speed of shiftwork rotation, the duration of each shift, age of workers, physical strength associated with work demands, diet, timing of sleep, and in some cases, the use of drugs to induce sleep and attempt to resynchronize the body's internal biological clock (U.S. Congress OTA report, 1991).

In the Army aviation context, consequences of shifts to nocturnal work schedules without the implementation of a shift-lag prevention plan have been recently documented (Comperatore et al., 1993). A study conducted at the Eastern Army National Guard Training Site at Fort Indiantown Gap, Pennsylvania, examined the effect of shift-lag countermeasures on estimated sleep time during a instructor pilot course involving night flights. Student aviators using a consistent schedule of bedtimes (approximately 0000-0200), rise times (approximately 0800-1000), and daylight exposure (between 1100 and 2000) exhibited a predictable daily pattern of rest and activity which resulted in the protection of the sleep period and the conservation of sleep duration after night flights. In contrast, instructor pilots living at home exhibited a variable pattern of bedtime and rise times resulting in a significant reduction in daily estimated sleep time, particularly after night flights. Student pilots implemented shift-lag countermeasures throughout the entire training period, even when night flights were not carried out due to weather intrusions. In these cases, students maintained the same work/rest schedule and did not consistently disrupt the sleep/wake cycle by retiring and rising earlier after night flight cancellations.

The Eastern AATS facility provided the appropriate environmental conditions for students to implement shift-lag countermeasures. Bedrooms could be darkened completely by using available blackout curtains. The sleep environment was further protected by the implementation of quiet hours until 1000. Students were encouraged to sleep until at least 0900 since they were not required to report to duty until afternoon hours. In contrast, conditions at the homes of instructor pilots were not expected to be as ideal as in the facility dormitories.

In a follow-up study, instructor pilots were asked to implement a shift-lag prevention strategy at their private dwellings. Primarily, they were instructed to delay rise time and daylight exposure time until 0900 throughout 2 consecutive weeks of training. In order to mimic the environmental conditions in bedrooms at the Eastern AATS, daylight light levels in the bedrooms of IPs were reduced to a minimum by using blackout material on windows. To reduce the impact of environmental noise, IPs used a compact disk in their bedrooms featuring the rushing sound of ocean waves. The compact disk was played continuously from bedtime to rise time at low intensity. As a result, sleep duration did not change significantly after night flights throughout the entire NVG training course.

In both studies, Eastern AATS personnel controlled daylight exposure by maintaining bedrooms completely dark during the sleep period and by delaying daylight exposure from early morning (0600) until approximately 0900. Also in both cases, the maintenance of consistent daily sleep duration depended on consistent bedtimes and rise times. Delaying daylight exposure until 0900 mimicked a 2-hour westward trip to a location in the southern hemisphere characterized by 11 hours of light and 13 hours of darkness (approximate daylight exposure time extended from 0900 to 2000). Thus, delaying rise times permitted the delay of daylight exposure and subsequent delay of bedtimes. This schedule facilitated work in the evening and night (2000-0200). The consistent timing of daylight exposure, of bedtimes, and rise times served as an effective anchor for the readjustment of the sleep/wake cycle to the new work schedule.

Although, the strategy used at the Eastern AATS cannot be generalized to all operational environments, its success provides evidence that the use of nonpharmacological countermeasures may facilitate adaptation to night shift without the use of drugs, complicated diet plans, or long-term preadaptation procedures.

The following discussion has two objectives: 1) to describe the fundamental physiological timing in humans which mediates the efficacy of the eastern AATS countermeasures, and 2) to describe

general shift-lag countermeasures and the design of coping strategies to provide the Army aviation community with a format for the design of unit-specific shift-lag prevention plans.

Background

The mechanism of physiological timing

The human body uses consistent exposure to environmental rhythms of daylight and darkness to synchronize the internal organization of physiological and cognitive functions. In general, maximum availability of physiological and cognitive resources occurs during daylight hours. The mechanism which mediates the interdependence of human physiology with natural environmental cycles of light and dark (LD) has been formally referred to as the circadian timing system (CTS) (Moore-Ede, Sulzman, and Fuller, 1982) and is commonly known as the "internal biological clock." It is generally accepted that the human biological clock synchronizes physiological and behavioral rhythms to a period of approximately 24 hours (circadian), and that daylight or sufficiently bright artificial light (above 1,000 lux) regulates these rhythms. Other rhythmic cues such as social interaction and meal timing also serve to synchronize the internal clock, but the LD cycle is of overriding importance.

Shiftwork induced desynchronization

Under consistent work schedules (e.g., day shift), significant daily life events such as sleep, awakening, meals, work, exercise and leisure occur at similar clock times from day to day. Under these conditions, physiological and behavioral rhythms maintain a relative synchronization with each other (internal synchronization) and with the environmental LD cycle (external synchronization). That is, in steady state conditions, physiological rhythms exhibit stable peaks and troughs at approximately the same time of day or night. Consistent timing of bedtime, rise time, meal time, exercise time, and exposure to daylight promotes a stable internal synchronization and maximizes the availability of physiological and cognitive resources.

Shift lag results from the desynchronization of physiological and behavioral rhythms. This condition is referred to as internal dissociation, or by some authors as circadian rhythm desynchronization. Shiftworkers experience a shift in the timing of work and rest periods, but no concurrent shift in the environmental rhythm of daylight and darkness. Thus, night shift

personnel work during the dark hours of the day and sleep during most or part of daylight hours. This readjustment in the timing of sleep and work usually conflicts with family and social schedules. Night shiftworkers often exacerbate the body's adjustment needs by reversing to daytime activity schedules on off-duty days (e.g., on weekends) in an attempt to maintain a normal social life.

Shift-lag related impairments persist until the internal clock resynchronizes to the new duty-rest schedule. This process is disrupted during shifts to nighttime duty hours when workers are exposed to early morning daylight after night work (e.g., while driving home), prior to retiring to bed, or even during the sleep period due to improper blocking of daylight in sleeping quarters. The daily exposure to daylight prior to the onset of sleep entrains the biological clock to a day-active/night-rest circadian rhythm, thus retarding the process of resynchronization to nocturnal duty hours.

Shift lag: Consequences

Effects on health

Long term health risks associated with the use of rotating shiftwork schedules are becoming better known (Kogi, 1971, 1985; Wojtczak-Jaroszowa, 1977; Menzel, 1962; Rutenfranz, Colquhoun, and Knauth, 1976; Rutenfranz et al., 1981). Several studies have documented that biological rhythms of nightworkers, such as core body temperature, do not easily readjust to nocturnal work schedules (Knauth and Rutenfranz, 1981; Knauth et al., 1981; Van Loon, 1963). This resilience to readjustment may be caused by the lack of synchronization of the work period with daylight hours. Czeisler et al. (1990) showed that synchronizing artificial bright light exposure (above 7,000 lux) with the nocturnal work period can resynchronize successfully core body temperature to peak during nighttime duty hours.

A number of studies indicate that long exposure to shiftwork may adversely affect the ability of the body's immune system to fight disease (Nakano et al., 1982). Gastrointestinal diseases such as gastric or duodenal ulcers also have been found more frequently among shiftworkers (Aanonsen, 1964; Angersbach et al., 1980). As a group, shiftworkers generally experience degraded sleep quality, increased fatigue levels, and lapses in performance associated with transitioning from one shift to another (for review see OTA report, 1991).

Reduced sleep duration and work efficiency

In general, shiftworkers experience alterations of sleep, wake up, and meal times during shift transitions. The consequence of changing work schedules, particularly from day to night or night to day, is the reduction in the total duration of the sleep period. Internal factors such as the desynchronization of the biological clock and external factors such as daylight, environmental noise, as well as family and societal demands, contribute to the degradation in the quality and duration of sleep (OTA report, 1991).

Degradation of cognitive performance accompanies rapid changes in shiftwork schedules since the performance rhythm becomes desynchronized relative to the new activity-rest rhythm (Folkard, 1980; Folkard, 1981; Folkard et al., 1976). The synchronization of body core temperature with the activity-rest rhythm is critical for the availability of cognitive resources during the work period. This synchronization is disrupted easily since temperature rhythms adapt very slowly to new schedules (Colquhoun, Blake, and Edwards, 1968a, 1968b; Van Loon, 1963; Wojtczak-Joroszowa and Pawlowska, 1964, 1965; Wojtczak-Joroszowa, 1977) and activity-rest rhythms are altered immediately by changing sleep and wake-up times. Resynchronization of cognitive resources may be delayed if the worker does not observe consistent bedtimes, wake up times, and exposure to daylight after awakening. Studies on the performance of night shift workers indicate a consistent reduction in work efficiency, and in some cases, safety. The following list summarizes a few of the work related variables reviewed by the Congressional Office of Technology Assessment in the report to Congress on the impact of shiftwork on worker's health and safety:

- 1) increased time required to complete work-related tasks during night shift (Folkard, Monk, and Lobban, 1978);
- 2) increased number of errors during nightshift (Hildebrandt, Rohmert, and Rutenfranz, 1974);
- 3) increased probability of missing warning signals and nodding off while driving during the night (locomotive drivers) (Hildebrandt, Rohmert, and Rutenfranz, 1974);
- 4) lower overall performance of nurses during rotating shifts (Coffey, Skipper, and Jung, 1988);
- 5) increased frequency (double the day average) of accidents involving truck drivers between midnight and 0200 (Hamelin, 1987);

6) decreased manual dexterity of factory workers during night shift (Wojtczak-Jaroszowa et al., 1978);

7) degraded performance in vigilance tasks of night shift workers tested in the laboratory when compared to day shift and rotating shift workers (Tepas, Walsh, and Armstrong, 1981; Tepas et al., 1981); and

8) degraded reaction times of night shift workers in simple and complex tasks tested during the work period (Tilley et al., 1982).

Shift lag prevention using artificial lighting

In many nocturnal work environments in which artificial lighting can be used, shift-lag symptoms may be avoided by observing the following specific countermeasures:

1) Use bright artificial light (above 1000 lux, if possible above 7000 lux) in the work environment during the night shift to synchronize the circadian timing system to the nocturnal schedule (Czeisler et al., 1990).

2) Maintain complete darkness in daytime sleeping quarters (Czeisler et al., 1990).

3) Follow a consistent sleep/wake schedule from day to day.

4) Reduce environmental noise to a minimum (e.g., traffic noise). Wear ear plugs while sleeping or use a sound-masking device (e.g., sound of ocean waves, wind, rain, etc.) to reduce the impact of noise on sleep.

5) Follow a consistent meal-timing schedule from day to day.

6) Eat light meals prior to retiring and schedule the heaviest meal in the middle of the day approximately between 1400-1800.

7) Maintain the same schedule of sleep, wake-up, and meal times on work days and days off.

This coping strategy uses artificial light to couple the night work period with the light phase of the light-dark cycle and promotes regular meals, sleep and wake-up times. Shiftworkers have been shown to readjust to a nocturnal work schedule within 4 days when implementing countermeasures 1, 2, and 3 (Czeisler et al., 1990).

Shift lag prevention for aviators and aircrew during night operations

The case of Army helicopter pilots

The above set of countermeasures can be reasonably applied within a variety of working conditions. However, there are settings in which at least some of these countermeasures are impractical. Specifically, in the case of Army helicopter pilots involved in NVG training or night operations, bright light exposure during or prior to night operations may interfere with the process of dark adaptation (DA FM 1-301 pp 7-6, 1987). In this case, the approach to shift-lag prevention must be modified to account for the demand to fly at night using NVGs. A modified version of the above prevention scheme must include the implementation of all of the general recommendations described above, except for the use of bright lights, to facilitate readjustment to the new work/rest schedule.

To adapt shift lag countermeasures to circumstances associated with night missions, the control of daylight exposure is of utmost importance. Several studies provide evidence that the internal clock adjusts rapidly to a delay in the daily exposure to sunlight similar to that experienced by westward travelers (Smolensky and Reinberg, 1990; Winget et al., 1984). For instance, in a transmeridian flight from Germany to the U.S., travelers experience a 6-hour delay in sunrise upon arrival, and consequently, a relatively similar delay in sleep onset and wake-up times. Table 1 illustrates the changes in the cycle of daylight and darkness, daylight exposure upon awakening, and sleep associated with a westward translocation. Table 1 also illustrates the use of a jet lag prevention scheme which uses the delay of sleep, wake-up time, and daylight exposure by 6 hours to compensate for the westward shift. This strategy of delaying sleep, wake-up time, and daylight exposure also can be incorporated in the design of a work/rest schedule to facilitate the adaptation to nocturnal duty hours.

For instance, in the design of a shift lag prevention schedule to be used in the transition to nocturnal duty hours (e.g., from 2000 to 0500), sleep, wake-up times, and daylight exposure times should be systematically delayed until there is about 6 hours difference with the daytime schedule, see Table 2. Theoretically, this approach would result in a sleep period beginning at approximately 0400 and rise time occurring at approximately 1200. If the schedule is followed diligently, exposure to daylight can occur only during the afternoon hours (after 1300) and would mimic a 6-hour delay in sunrise time. The biological clock then will experience a short daylight period lasting approximately 8 hours and a long darkness period of 16

hours in duration. Work hours will occur almost entirely during the night, while sleep will begin prior to sunrise and will extend well into daylight hours. The biological clock will receive a consistent daylight signal beginning at approximately 1300-1400 each day. This signal can be used as an anchor for resynchronization. Establishment of this process in actual practice can be accomplished only if the delay of sleep, wake-up time, and daylight exposure is implemented consistently from the first day of transition to the night schedule.

Napping before and after work

The recently published review of biological rhythms and shiftwork by the Congressional Office of Technology Assessment provides a comprehensive review of literature on the use of naps in the transition to nocturnal duty hours (OTA report, 1991). The following discussion includes the recommendations offered in the OTA report. The reader is encouraged to complement the information given here with Chapter 5 of the OTA report.

Naps are recommended for workers rotating from day to night shift if they can not sleep more than four to five hours during the daytime sleep period as long as the next night is going to be another work period. Naps are not recommended for workers whose next sleep period will take place during the night. In this case, naps taken during the day may interfere with the onset and duration of that night's sleep.

Similarly, daily naps are not recommended to be taken regularly if workers will be working during the night for several consecutive work days (e.g. 3 or more days). A nap consistently taken at the same time of the day may act as a reference point for circadian rhythms, retard the speed of resynchronization to the new work/rest schedule, and ultimately reduce total sleep time during the daily sleep period (Tepas, Popkin, and Dekker, 1990).

Slowing resynchronization of circadian rhythms is beneficial to workers who rotate from day to night and back to days within a few days (2 to 3 days). Slowing down the process of resynchronization to the nocturnal work schedule will maintain circadian rhythms in synchronization with the daytime work schedule. Workers in rapidly rotating shifts (day-night-night-day) may experience fatigue during nighttime duty hours, but are unlikely to experience shift lag symptoms upon the return to daytime duty hours.

Frequent use of rapidly rotating schedules is not recommended because of the inevitable loss of sleep. This may ultimately compromise safety during the work period and may have an adverse impact on the health of the worker. Ultimately, when

rapid shift rotations are used, workers should be encouraged to use naps during off time to compensate for sleep loss incurred during the transition to nighttime duty hours.

The time of day in which the nap is taken will affect its restorative effectiveness. When workers transition from daytime to nighttime duty hours, opportunities for naps may occur during the afternoon (e.g., 1500-1700) or in the evening prior to reporting (e.g., 1600-1900) for the duty period (e.g. work 2100-0500). Research on the effects of the restorative value of naps indicate that a 2-hour nap taken in midafternoon (e.g., 1500) contained more deep sleep (stages 3 and 4) time and resulted in greater efficiency in the restoration of alertness than a 2-hour nap taken in the evening (e.g., 1900) (Lavie and Weler, 1989). In addition, naps taken during the mid-afternoon (1500) have also been shown to contain more total dreaming time (REM sleep) than naps taken at 0300 (Dinges, 1986).

In summary, when Army aviation personnel transition from daytime to nighttime duty hours, a nap at 1500 may well compensate for sleep loss incurred during the assigned sleep period. This will apply particularly to personnel who will sleep soon after the end of the work period and whose work period ends between 0100 and 0600. If the shift to nighttime duty hours extends for at least 1 week, naps should be taken only if necessary (total sleep period less than 5 hours) during the first 2 days but should be discontinued thereafter to allow for the undisturbed resynchronization of the sleep/wake rhythm to the new work/rest schedule. Naps taken in the afternoon may be more restorative than naps taken in the evening, prior to reporting for duty. However, naps taken during the work period after midnight may not only be less restorative than earlier naps, but also may induce sleepiness upon awakening and performance degradation for up to 1 hour (Akerstedt, Torsvall, and Gillberg, 1989). This consideration limits the value of a nap after midnight, particularly in the context of Army aviation where safety of aircrews depends directly on job performance.

Caffeine

One dietary component that has been shown to alter human alertness and sleep is caffeine. When this compound is consumed in beverages such as coffee, tea, and cola, it enhances certain types of performance, especially vigilance, and increases self-reported alertness (Lieberman, in press). Caffeine has been shown to maintain performance in laboratory simulations of sustained operations (SUSOPS) (Penetar et al., 1992), and, at least in high doses (4mg/kg), can interfere with sleep (Walsh et al., 1990).

Given its widespread use and stimulant-like properties, the amount and timing of caffeine consumption should be carefully considered when adaptation to night operations is necessary. Consumption of caffeine in the first part of the new night duty cycle should probably be encouraged while consumption before bedtime should be discouraged.

Because caffeine acts as a stimulant, its consumption during the first portion of the new duty schedule is likely to be beneficial. There appear to be considerable differences in individual sensitivity to caffeine's effects on sleep and other parameters. Therefore, if caffeine is consumed within a few hours before bedtime, it may interfere with sleep. This inter-individual variability may, at least in part, be attributable to tolerance for caffeine by individuals who normally consume large quantities. Sudden withdrawal of caffeine from the diet of individuals who are heavy caffeine users (those consuming more than four or five cups of coffee per day or eight 12-oz. servings of cola beverages) can produce adverse effects on performance and mood and often results in headaches and other undesirable physical symptoms (Griffiths and Woodson, 1988). Caffeine withdrawal as part of a phase shift may, therefore, produce the adverse effects of desynchronization on mental performance, mood state, and alertness.

Design and application of coping strategies

During night operations, fast rotations of work schedules from day to night within 24 hours can be expected to adversely affect the ability to obtain adequate rest. The biological clock, thus the sleep/wake rhythm, must be resynchronized to the new work/rest schedule to avoid performance degradation throughout the entire duty cycle. The rate of resynchronization will depend upon the consistency of timing signals that the individual provides to the biological clock, namely daylight exposure time, bedtime, and wake-up time. In general, the body's slow physiological adaptation always will lag behind the sudden change in the work schedule, but the rate of readaptation will depend upon the individual's ability to adhere to a specific shift lag prevention plan. To derive maximum benefits from any shift lag prevention strategy, shiftworkers must consistently implement countermeasures throughout the entire duty reversal period, including during days off (e.g., weekend days).

Shift lag prevention plans are best designed by first determining mission demands, applicable work/rest schedules, and environmental conditions. These parameters should be defined prior to the selection of countermeasures that will constitute the shift lag prevention plan. Parameters of paramount importance are those mission requirements that will define the

beginning of the work and rest periods and environmental conditions. The following questions will yield necessary information to design a shift lag prevention plan:

a) Will mission objectives require flying throughout the night into the morning hours after sunrise? Work schedules which permit personnel to retire prior to sunrise will facilitate implementation of nonpharmacological countermeasures. Mission demands which require nighttime personnel to work into the morning hours (after sunrise) may result in sleep loss. In this case, emphasizing the proper use of naps may compensate for sleep loss incurred during the scheduled sleep period. If flying will take place after 0400, personnel can be expected to experience increased sleepiness and fatigue during flight. Briefing pilots and aircrew prior to departure to enhance crew coordination during these flights may help to maintain alertness.

b) Can duty hours be reduced during the first 3 days of the transition to night operations? Reduced work periods during the first 3 days of night operations will provide the opportunity for a more gradual transition to the new work/rest schedule. Sleep loss can be expected when mission demands do not permit gradual transitions.

Once the work/rest cycles are established, the next consideration is environmental conditions. Information may be derived by answering the following questions:

1) Will night shift personnel have access to sleeping quarters away from work-related noise produced by day shift personnel?

2) Is hot weather expected to interfere with the ability to sleep during daytime?

3) Will environmental conditions permit the control of daylight and noise intrusions in sleeping quarters?

In training situations in which individual rooms are available, noise and daylight intrusions can be controlled, thus enhancing the efficiency of nonpharmacological strategies. However, in field conditions it will be necessary to brief personnel on the use of cloth sleep masks, sound masking devices (white noise), or ear plugs in order to minimize the interruption of the sleep period. Disruptions of the sleep period will reduce the efficiency of nonpharmacologic strategies. When the sleep period cannot be protected regularly from noise and daylight intrusions, controlled timing of daylight exposure, bedtimes, and rise times, are likely to fail in completely preventing sleep loss and fatigue during the work period.

These considerations determine the constraints within which the shift lag prevention plan must be designed. Planners can select countermeasures which are practical and applicable to specific missions. Countermeasures can be selected from the following exhaustive list:

1. Avoid working after 0400-0500 to prevent the adverse effects of nightshift-related fatigue on performance and the pronounced tendency to fall asleep from approximately 0400 to 0700 (Akerstedt, 1988). This countermeasure applies particularly to NVG training periods, night flights, and night work schedules ending between 0400 and 0700. Observance of this countermeasure will encourage pilots and aircrew to retire well before sunlight illuminance exceeds 1000 lux (illuminance levels greater than 1000 lux occur after dawn), thus avoiding exposure to the synchronizing influence of daylight at the wrong time of the day (relative to the work period).

2. If possible, avoid prolonged exposure to daylight in the early hours of the morning after flying a night mission even if sleep occurs after sunrise (e.g., 0800). Exposure to bright daylight (above 1000 lux) may retard the adaptation to nightshift and may result in the reduction and disruption of daytime sleep. Optimally, sleep should begin between 0400 and 0500 depending upon sunrise time and should end between 1200 and 1300. Upon awakening, one should engage in outdoor activities as much as possible to ensure an extended period of daylight exposure (1 or more hours).

3. When possible, sleep in complete darkness and avoid momentary exposure to daylight during the sleep period. To facilitate proper rest, sleeping quarters should comply with the following restrictions: a) nightshift personnel should be isolated from the activity of day shifters, b) environmental noise should be reduced to a minimum or masked, and c) sunlight illuminance should be reduced as much as possible.

4. A nap at 1500 may compensate for sleep loss incurred during the assigned sleep period, particularly for personnel who will sleep soon after the end of the work period and whose work period ends between 0100 and 0400. If the shift to nighttime duty hours will extend for more than 3 days, naps should be taken only if necessary (total sleep period less than 5 hours) during the first 2 days, but should be discontinued thereafter to allow for the undisturbed resynchronization of the biological clock.

5. Avoid consumption of caffeine near bedtime as well as sudden withdrawal of caffeine during a shiftwork transition.

6. Avoid sudden changes in eating habits in order to minimize gastrointestinal disturbances.

7. If mission requirements result in variable bedtimes, attempt to maintain consistent wake-up times and daylight exposure times as long as the sleep period is not reduced to less than 5 hours. Afternoon naps may compensate for lost sleep time as long as these occur infrequently.

Of these seven countermeasures, control of meals (6) can be expected to be the least critical. However, sleep/wake schedules (1), daylight exposure schedules (2), and environmental control (3) are central to any effective shift lag prevention plan. Planners are encouraged to adjust duty schedules as much as possible to meet the requirements of countermeasures 1-3. In general, when these countermeasures (1-3) are successfully implemented, sleep loss can be expected to occur on the first day of the transition, but only moderately thereafter. Again, conscientious use of afternoon naps may help to compensate for sleep loss during the first days of the transition or throughout the mission if needed.

Implementation of a shift lag prevention strategy that includes most of the recommendations mentioned above may result in the following work/rest schedule:

Sleep

The sleep period begins prior to sunrise no later than 0500 (depending on local sunrise times) and end at approximately 1200 to 1300.

Daylight exposure

Daylight exposure begins soon after awakening between 1300 and 1400. Exposure should last at least 1 hour and preferably extend throughout the afternoon as much as possible.

Exercise

Outdoor activities such as walking, running, and bicycling coincide with the first daylight exposure (e.g., activities occur after 1300).

Meals

The first meal of the day is scheduled between 1330 and 1400; and a more substantial meal is scheduled no later than 3 to 4 hours prior to actual take-off time.

Gradual delay of sleep onset

Mission permitting, 3 days of transition are allowed resulting in a gradual adaptation period. Using 3 transition days, sleep may be delayed 2 to 3 hours on the first day (e.g., from 2200 to 0100), 2 more hours on the second day (e.g., from 0100 to 0300), and only 1 to 2 hours on the third day (e.g., from 0300 to 0500). Shortened work periods (6 hours) are implemented during the transition, promoting work efficiency and safety. Normal 8-hour work periods begin on the fourth day of the night work schedule once sleep onset has been fully delayed to 0500.

Work period

After the first 3 days of the transition to nighttime duty hours, the work period can be changed to an 8-hour duty day beginning at 1900 and ending at 0400.

Compliance: A critical issue

The seven recommendations listed can facilitate physiological adjustment to nightshift and reduce the impact of fatigue on performance. Although all seven components of the strategy are important, the isolation of sleeping quarters (countermeasure 3) may be critical. For instance, in field exercises, night crews may sleep near the air field in canvas tents, on the ground, or even in the back of helicopters and may be exposed to the noise associated with normal daytime activities (land vehicles and aircraft). This constitutes a critical problem because restorative sleep (sufficient amount of deep sleep) cannot be obtained unless environmental noise is sufficiently controlled.

Controlling environmental variables such as daylight and noise intrusions in sleeping quarters may be difficult to implement and may require a considerable coordination effort within units. Field experimentation could be conducted by individual units to isolate night shift from day shift personnel. Air-conditioning (AC) could be fielded to buildings or shelters used for sleeping quarters during hot summer days. AC units will regulate not only temperature within sleeping quarters, but may also reduce the impact of sudden loud sounds by providing a continuous source of masking noise (fan and compressor motors). A more desirable approach is the use of commercially available sound masking devices. In the absence of any type of sound masking, ear plugs may be used to attenuate unwanted noise. Blocking daylight intrusions in sleeping quarters can be accomplished by providing sunlight blocking blinds in bedrooms or individual cloth sunlight blocking sleep masks in tents.

Compliance with the above recommendations requires the allocation of time to plan and coordinate activities with safety officers, line unit commanders, unit flight surgeons, supply officers, maintenance personnel, individual pilots, and aircrew. However, the time spent planning and coordinating can result in significant returns in the form of shift lag prevention and increased safety throughout night missions and training exercises.

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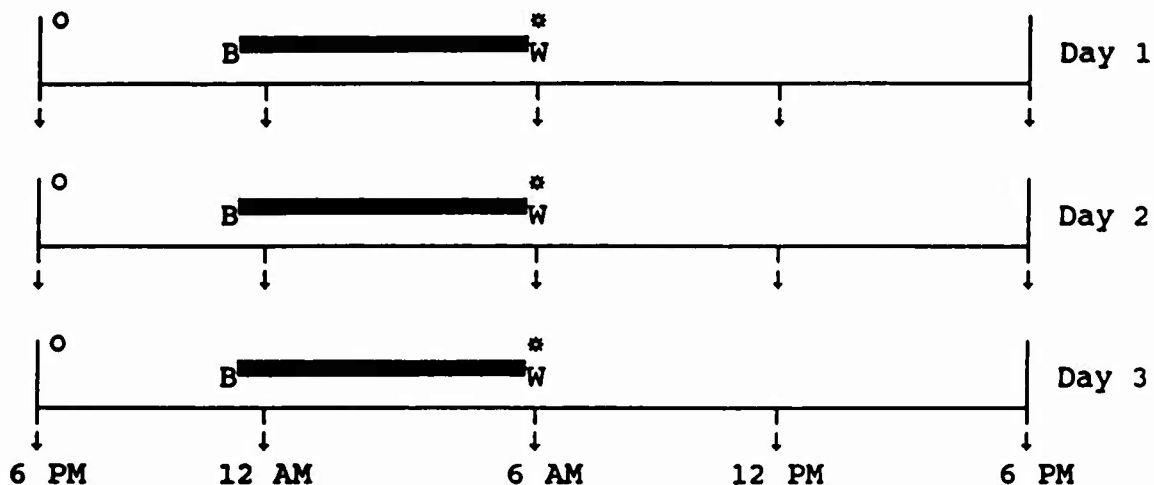
Appendix A.

Tables.

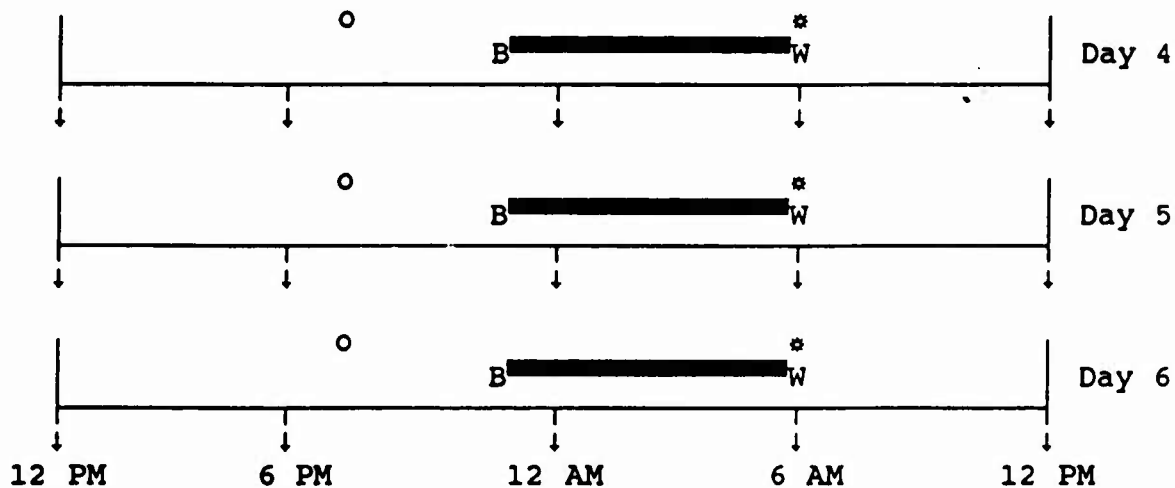
Table 1.

Transmeridian translocation from east to west.

Germany



United States

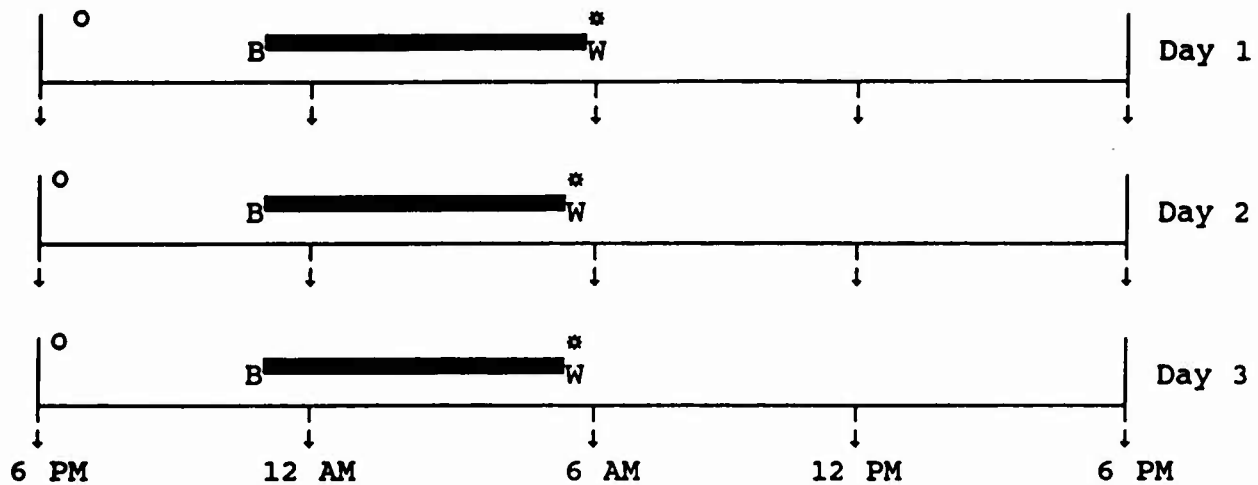


LEGEND

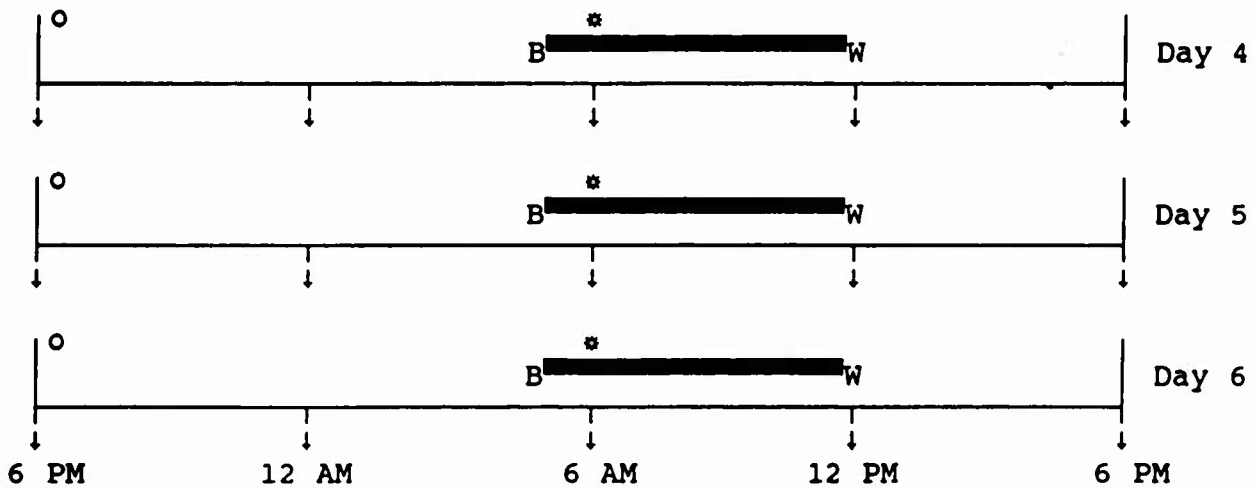
- B = Bedtime
- W = Wake-up time
- o = Sunset
- * = Sunrise
- = Sleep

Table 2.
Transition to night shift.

Day Shift



Night Shift



LEGEND:

B = Bedtime
W = Wake-up time
O = Sunset
* = Sunrise
■ = Sleep

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