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EXERCISE/EXERCICE

NEW HORIZONS

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The Sleep of a labouring man is sweet.

Ecclesiastes ch.7, v. 6

Sleep, sleep has often been considered a luxury and at times a self-indulgence within the military culture. How often has it been heard from the young officer or NCO, " Sleep, hah! I'll sleep when the job is done". In history we have seen where an apparent immunity to fatigue and sleepiness have been considered stoic virtues in a military man. An example of this was the praise Socrates received from Alcibiades following the battle of Potidaea. Further, to this sleep has been at times been interpreted as self-indulgent. This is illustrated in the New Testament, book of Matthew, when Jesus is arrested in the garden of Gethsemane while his Disciples where to maintain a lookout. There is a hint in this passage that Jesus' betrayal was somehow due to the self-indulgent sleep of the Disciples. Science today has a much more realistic and practical view about sleep or the lack of it. Sleep is an essential and vital biological function. An individual's physical and emotional well being are solidly linked to this activity. Research has shown that without enough sleep, an individual's ability to perform even simple tasks declines dramatically. In today's military operating environment, the effect of sustained work in continuous operations can result in significant sleep deprivation upon our servicemen. It has been observed that failure to incorporate an appropriate sleep management plan into small unit operations can have an adverse effect upon results. This paper will demonstrate the potential for operational limitations due to sleep deprivation; additionally

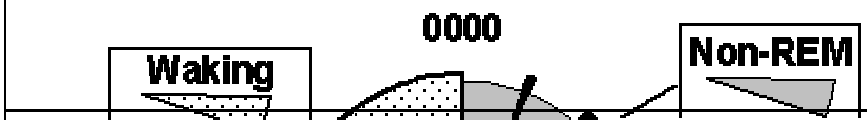
by examining small unit experience offer potential solutions to avoid less than optimum results due to sleep deprivation.

This paper will first examine what is sleep and why it is crucial. Following this a review of some previous research into sleep deprivation supported by historical examples of the consequences of sleep deprivation with be viewed. Subsequently, following this study, some different approaches to sleep management and sleep deprivation avoidance will be offered.

Sleep as defined in the Canadian Oxford dictionary is "the naturally recurring condition of rest and inactivity assumed by people and most higher animals, in which consciousness, response to external stimuli, and voluntary muscular action are largely suspended".[1] Sleep is characterized by a general decrease in breathing rate, blood pressure and body temperature. Of note however, is that the human brain never decreases activity, the brain is as active during sleep as it is when awake. During an eight hour sleep cycle an individual alternates between both REM (Rapid Eye Movement) and non-REM sleep (Figure 1).

[1] The Canadian Oxford Dictionary

Figure 1. The 24-Hour Sleep/Wake Cycle



progressively deeper, an individual enters into stage 3 and becomes difficult to arouse. An individual will spend approximately 12% on non-REM sleep in this stage. In stage 4 an individual experiences very deep sleep. Personnel who wake during this stage will feel groggy and disoriented for a short period. 13% of non-REM sleep occurs in this stage. REM sleep occurs during stage 5 of the sleep cycle. Indicators of this stage include heart rate, blood pressure, breathing, eyelid fluttering and muscle paralysis. A unique feature of this stage is that the brain activity is similar to an awakened state and it is during this stage that dreaming occurs. During this stage the brain blocks signals to the muscles to remain immobile so dreams will not be acted out. Approximately 20-25% of the sleep cycle is spent in this stage.[3]

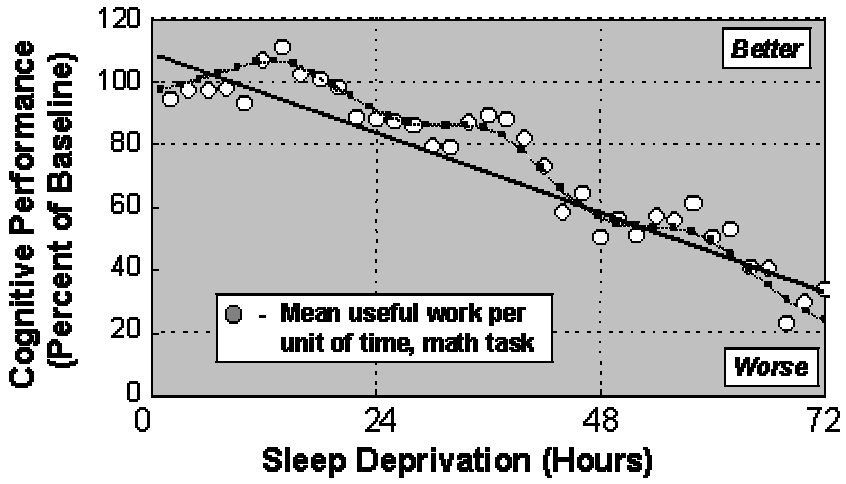
Circadian rhythms are the main reason why humans sleep. Any cycle that lasts for 24 hours is termed circadian; this period is also known as the biological clock. Humans have a natural cycle of approximately 24 hours. Sleep is a vital and essential biological function. Sleep provides an essential restorative function, in so far as it allows the body and mind to reenergize. While an individual sleeps the brain performs vital functions, "such as organizing long-term memory, integrating new information, and repairing and renewing tissue, nerve cells and other bio-chemicals. Sleep allows the body to rest and the mind to sort out past, present and future activities and feelings."[4]

[3] Marshall Brain, "How Sleep Works," available from http://www.howstuffworks.com/sleep.htm . Accessed 3 April 2004

[4] Online article, no author. Available from http://www.talkaboutsleep.com Internet accessed 3 April 2004

Having discussed the basics of what sleep is and its various cycles, the issue of sleep deprivation will now be examined. Sleep deprivation can occur in essentially three forms. Firstly there is total sleep deprivation; total sleep deprivation has significant negative effect upon cognitive performance. Cognitive performance is essential in order to complete tasks requiring short-term memory, mathematical processing and decision making. Figure 2 illustrates a decline in cognitive performance of approximately 25% following 24 hours of wakefulness. It can be extrapolated that after 72 hours of total sleep deprivation, this cognitive performance ability will be reduced by 75%.[5]

Figure 2. Effect of 72 Hours of Total Sleep Deprivation on Cognitive Performance



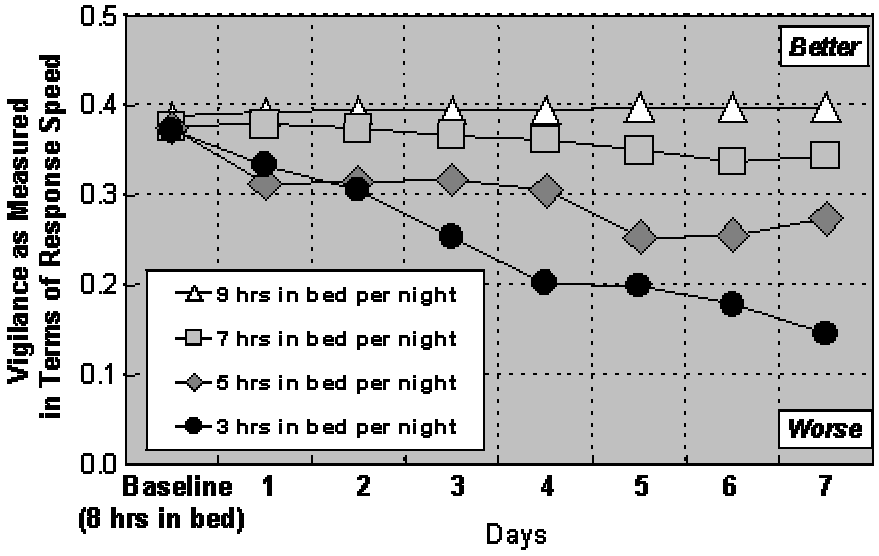
NOTE: General trend for performance over time is downward (solid line), but in an undulating pattern that continues to reflect the daily performance rhythm (small squares).

Accessed at http://carlisle-www.army.mil/apfri/chapter_6.htm

[5] Nancy Wesensten, "The Role of Sleep in Sustaining Individual and Organizational Effectiveness" Available from http://carlisle-www.army.mil/apfri/chapter_6.htm Internet accessed 3 April 2004

Partial sleep deprivation, or restricted sleep, occurs when some sleep is obtained during a given day however, not the full required amount to ensure effective restoration. On average an individual ideally requires 8 hours of sleep daily in order to maintain maximum mental performance. Any amount of sleep less than the optimum although useful will over a period of time result in performance deficits. An example of this is seen over a period of a week where one person receives 9 hours of sleep per day and another only 3. the person who only receives 3 hours of sleep per day over the period of a week incurs a 70% reduction in performance as compared to an individual who receives 9 hours of sleep. Finally, there is the individual who manages to spend 8-9 hours in bed

Figure 3. Seven Days of Restricted Sleep: Effects on Vigilance



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However during this period is disrupted by noise or is attempting to sleep during daytime hours. In this instance alertness and mental performance is found to reduce. The more

frequent the disruptions the lower the levels of alertness and mental performance the next day. Disrupted sleep increases the time that a person spends in stage 1 sleep, a stage where little recuperative sleep is gained. Disrupted sleep can over time have the same effect as total or restricted sleep deprivation.[6]

Sleep deprivation is seen to present two significant behavioral effects. In a high tempo or stimulating environment where a person is less seduced to fall asleep, sleep deprivation directly results in negative effect upon higher order mental operations. In a mundane or less stimulating environment a person will be much more susceptible to falling asleep.

In the military environment sleep is frequently regarded as a luxury instead of a necessity. Sleep loss is cumulative and creates what is termed as sleep debt. The greater the sleep debt, the more restorative sleep is required to return the mind and body to normal, rested levels. We have seen that people who sleep only four to five hours per night for a week will need approximately two full nights of sleep to recover to normal levels of performance and mood. Sleep deprivation affects an individuals intellectual abilities and mental processes. Memory and decision making ability is reduced as well as there is reduced performance on mentally demanding tasks and negatively affects psychomotor skills. Communication, productivity and mood all suffer. Extended periods without sleep may cause paranoia and hallucinations. Sleep deprivation can lead to

[6] Nancy Wesensten, "The Role of Sleep in Sustaining Individual and Organizational Effectiveness" Available from *http://carlisle-www.army.mil/apfri/chapter_6.htm* Internet accessed 3 April 2004

depression and mood swings, increased use of drugs and alcohol and personality changes particularly loss of humor and increased ill temper.

There have been numerous studies with respect to sleep deprivation and its effect within the military operational environment. In one study the selected members of a crew aboard a US Coast Guard cutter where followed during a routine 30-day patrol from Tokyo, Japan to Pearl Harbor, Hawaii. In this study the individuals where examined utilizing electroencephalography (EEG) techniques which permitted the measurement of individual alertness. Tests were conducted within three hours of waking up and every four to five days. Over the period of the 30 day test period individuals where examined between five and seven times. It was observed over the period that sleep deprivation can aggregate over a period thus incurring sleep debt. Some of the findings are as follows:

i. approximately 70% of the individuals exhibited signs of significantly degraded alertness;
ii. evidence of sleep debt, as indicated by disruptions on the sleep/wake cycle, was detected in 62% of all sleep/wake cycles analyzed;
iii. crew endurance levels in the low tempo patrol were characterized as less than optimal; and
iv. operational situations involving increased tempo, deteriorating weather conditions, and reduced crewing is certain to exacerbate fatigue symptoms.[7]

[7] Carlos A. Comperatore, "The Cost of Doing Business at Sea: A Tale of Fatigue and Endurance" Available at http://www.uscg.mil/d1/units/msoprov/Fatigue.html Internet accessed 3 April 2004

In another study conducted by the University of Loughborough, the impact of Sleep deprivation on Decision Making was specifically examined. Initially it was considered that under motivating and demanding circumstances, sleep deprivation would have little effect upon high-level decision-making or complex skills. This assumption was based on a few previous studies. An example of these were IQ tests, critical reasoning and logical well-practiced tasks were found to be resilient to 36 hours or more of sleep deprivation. To valid these assumptions scientists developed two decision-making tasks which involved military type activities and participants were trained naval personnel. The first task involved a tracking and interception task. This test showed no signs of impairment, despite being of a long duration. This result supported previous sleep deprivation studies which showed that interesting tracking tasks show little negative impact due to short term sleep deprivation. In the second task individuals where required to plan ahead and conduct a cost benefit analysis of actions taken. Following 30 hours of sleep deprivation substantial impairment was observed, this was attributed in the most part to loss of focus and interest on behalf of the individuals. It can be seen that the principle difference between the two tasks and the subsequent outcomes were the levels of interest.

It is important to also view sleep deprivation and decision making within an operational construct. Decision-making requires skills of critical, logical and deductive reasoning and can also involve unfamiliar and unique circumstances. These divergent skills can be significantly affected by sleep deprivation. Another skill important for high-

level decision-making is the ability to grasp complex scenarios while avoiding distractions. This ability will demand at times the assimilation of volumes of information and often within a limited time frame. As seen earlier the level of complexity may not be an issue however following a period of sleep deprivation there a lack of attention to detail often pervades. This lack of focus is likely to impact on the higher decision making process which require the grasping of rapidly changing information. Sleep deprivation does lead to higher levels of auditory and visual distraction. Sleep deprived individuals have been seen to be less confident, less discriminating more open to suggestion and likely to modify memories of witnessed events. This last point was largely evident when the individual encountered negative feedback following the first detailing of events. Even after only 24 hours of sleep deprivation individuals where seen to be less knowledgeable of the big picture and often applied strong effort to the more minor areas of their decision making which in fact had no, or very little, impact on the outcome.

Sleep deprivation also has a marked effect on a person's ability to keep track of events and develop and update strategies. In a simulated military operation, soldiers worked in team based operations through a period of approximately 80 hours of continuous work. At around 36 hours individuals lost track of critical tasks, deferred important tasks and failed to keep plots updated with incoming information. This exercise drew parallels to a tragic real life friendly fire incident during Operation Desert Storm, in which American military vehicles on the ground were fired at and destroyed by fighter pilots from the same unit who had become confused and spatially disorientated

after failing to update positional references. The persons involved had recently experienced a 48-hour period of reduced sleep.[8]

When it comes to assessing risk and anticipating consequences it has been seen That when faced with sleep deprivation individuals will be less concerned with negative consequences when faced with higher risk activities. A decrease in motivation and maintenance of interest also occurs following periods of sleep deprivation.

The effect on a person's mood during periods of sleep deprivation can be quite noticeable. Indeed it has been observed that the strongest outcome due to sleep deprivation was with mood changes rather than with cognitive or motor performance. Impatience, childish humor, inappropriate personal behavior and irritability have all been witnessed in cases involving sleep deprivation. These uninhibited behaviors often occurred more as outbursts since during much of a sleep deprivation period individuals tend to remain quiet and withdrawn. During military exercises it has been observed for some junior officers to concentrate more on self-centered concerns than acting as leaders. At time the willingness to engage in planning reduced and during periods of high tension these individuals demonstrated somewhat inappropriate behavior all of which seemed to be exacerbated by sleep deprivation.

Temporal memory (memory for when events occur) degrades during periods of sleep deprivation. It has been observed that during periods of sleep deprivation individuals were able to recognize events but were often unable to recall the timing for

[8] Kenneth K. Steinweg, "Dealing Realistically with Fratricide," *Parameters*, Spring 1995, p 4-29

recent events. The potential impact on real world operations is that sleep deprivation may lead to confusion or difficulty in remembering the ordering of events, facts, instructions or interactions with other personnel. This communication with others will undergo subtle changes during periods of sleep deprivation due to alterations in language processing. Noticeable differences in the articulation of speech can be observed in as little as 24 hours of sleep deprivation. "Sleep deprivation affects language by reducing verbal spontaneity and word retrieval and alters articulation and other vocal characteristics."[9] Also, "sleep deprived participants may be less willing to volunteer factual details, may appreciate less the importance of doing so, or may have less empathy with colleagues' ignorance of vital information. All this can impair conversational flow."[10]

Sleep deprivation is something that commanders must be wary of in themselves as well as their subordinates. Being able to recognize the onset of sleep deprivation in ones' self is essential to avoiding errors, as well as being an indicator for the need for sleep. Decision makers will often overvalue their own self-denial of the need for sleep. While a commander will often accord his subordinates with the need for sleep the concept of self-care is often overlooked. The lack of respect for self-maintenance can have very destructive outcomes, most of which will contribute to degrees of psychological injury. Some of the results arising from the lack of self-sleep maintenance are:

[9] Yvonne Harrison and James Horne, "The impact of Sleep Deprivation on Decision Making: A Review," *Journal of Experimental Psychology*, Vol. 6, No. 3., p. 236-249

[10] ibid

i. impaired ethical perception, making the difference between crucial self-maintenance and self-indulgence nearly impossible. The two will begin to seem the same;

ii. a cover-up mentality and solidarity, resulting in the failure to criticize another's self-indulgence;

iii. burnout, with eventual self-destruction; and

iv. needlessly compromised integrity.

Sleep deprivation, in particular, promotes:

i. catastrophic operational failure;

ii. fratricide and other accidental deaths;

iii. preventable noncombatant casualties;

iv. loss of emotional control and failure of complex social judgment; and

v. blind obedience to militarily irrational or illegal orders.[11]

Having now discussed sleep and the degraded effects of sleep deprivation, it will Prove useful to discuss the various methods to manage the problem within a military operational context. Firstly, some of the signs of sleep deprivation are as follows:

i. increased sleepiness and fatigue;

ii. weariness;

iii. poor attention and motivation span;

iv. memory lapses

[11] Jonathan Shay, "Ethical Standing for Commander Self-Care: The Need for Sleep", *Parameters*, Summer 1998, p. 93-105

v. decreased initiative, judgment and decision making ability;

vi. increased irritability; and

vii. decrease communication effectiveness.

There are various methods and theories, which can be applied when combating Sleep deprivation effects. Education, stimulants, napping and effective employment routines or watch schedules are some of the effective tools, which can be used within a military environment. When discussing education it may seem self-evident that people know about sleep deprivation. While this may be true not all people truly understand its effects or how to deals with them. Ideally, as with most problems of this nature, prevention is the ideal method. A brief aide-memoir, which has recently been provided to crewmembers aboard a Canadian submarine to assist individuals in combating sleep deprivation, is as follows:

i. allow at least 4 hours of uninterrupted sleep each day during sustained operations to maintain minimal performance;

ii. take frequent naps (when off watch!), 20 or 90 minutes in length. A 60-minute cycle causes waking during the REM (dreaming) cycle of sleep. An individual can wake up feeling more irritable less refreshed and disorientated;

iii. plan naps before watches to enhance performance. Sleep can be cumulative as well, like storing it in a sleep bank;

iv. endeavor to plan a 4 hour block of uninterrupted sleep after midnight;

v. use stimulants, like coffee, sparingly;

vi. avoid use of alcohol, antihistamines, tranquilizers, motion sickness medications or any drugs that will sedate;

vii. while on watch, have frequent small snacks of high carbohydrate foods. Avoid large amounts of protein. The carbohydrates will provide energy to fuel body function and prevent drowsiness. A large amount of protein will exacerbate drowsiness because the body must break down and digest the protein; and

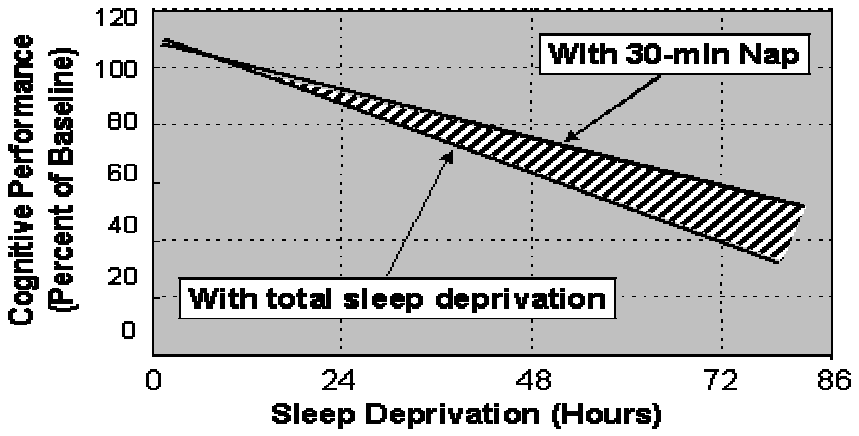
viii. after your watch and about 20 minutes before you plan to sleep, have a snack of high protein. This will help sustain your hunger longer and you will have a more uninterrupted sleep.[12]

Among the few means of extending an individuals effectiveness and ward off the Onset of sleep deprivation, napping offers the most natural approach. A nap is viewed as having recuperative power, reducing fatigue and sleepiness. Afternoon napping has been proven to improve performance and mood within a 1.5 to 2 hour period after being awakened from napping. Morning naps (0930 – 1130hrs) or late evening naps (2130 – 2330hrs) have shown to be nearly as beneficial as afternoon naps. Naps may assist in maintaining performance levels over long periods however, performance immediately post nap map indicate no improvement. Indeed performance may be even worse than pre-nap levels. This situation is due to what is called sleep inertia. Sleep inertia is usually short lasting and is followed by the recuperative effect of the nap. Sleep inertia

[12] Fernanda Morley, "*Sleep Deprivation*", Available at http://www.searoom.com Internet accessed 3 April 2004

can last for about 15 minutes after awakening or may disappear as soon as 1 to 5 minutes after awaking from a nap. Under most circumstances the pro of the recuperative power of a nap, outweighs the con of the short-term risk of impaired post-nap performance. Napping provides an excellent method for raising the overall amount of total daily sleep, provided the individual sleeps during the napping period. Figure 4 indicates that after 72 hours of sleep deprivation where a person was permitted only 30 minutes per day to nap,

Figure 6. Cognitive Performance during Total Sleep Deprivation vs. with Daily 30-minute Nap



Accessed at http://carlisle-www.army.mil/apfri/chapter_6.htm

that they performed nearly 25% better than person's whole received no sleep at all. Thus it can be seen that even small amounts of sleep will improve performance. It must be understood however that a nap must contain stage 2-5 sleep of the sleep cycle. Overall it is ideal that individuals nap as long and as often as required to obtain a daily amount of 8 hours sleep overall.

It is considered that sleep is the best means to combat sleep deprivation, however operational necessity may not permit timely sleep. It is during these occasions that other methods for augmenting mental performance can be utilized. The most common means for improving mental performance during periods of sleep deprivation is through the use of central nervous system stimulants. Common stimulants used include caffeine (non-prescription) and dexotroamphetamine (prescription). The use of caffeine following a period of 48 hours of sleep deprivation (600mg dose) can restore complex mental operations. Caffeine in the 600mg dose will permit restored performance for at least 4 hours. Additionally the 600mg dose will increase an individual's ability to remain awake in a non-stimulating environment. Of note caffeine in 150 or 300mg doses is equally effective for 1 hour after ingestion. Caffeine will interfere with normal sleep for up to 12 hours after ingestion. Caffeine is readily available over the counter and in differing dosages. The use of caffeine may cause nervousness, nausea, jitteriness and anxiety; additionally caffeine may interfere with sleep should an opportunity arise after ingestion. Some individuals will develop a tolerance for caffeine following repeated use. Dexotroamphetamine in the 20mg dose has the same effects as caffeine in the 600mg dosage size. One additional precaution with dexotroamphetamine is that there does exist some potential for abuse.

Another method, which has proven to be quite effective in addressing the sleep deprivation issue, is the work routine or watch rotation within a military unit. For the purposes of this paper experience is drawn from an example aboard a Canadian submarine. At sea a submarine is a beehive of activity 24/7, with personnel always on

watch, working, eating, socializing or sleeping. The submarine operates in a typical one watch in three rotation with the traditional rotation being represented at table 1. This

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0400	Red	White	Blue	Red	White	Blue	Red
0400-0800	White	Blue	Red	White	Blue	Red	White
0800-1200	Blue	Red	White	Blue	Red	White	Blue
1200-1600	Red	White	Blue	Red	White	Blue	Red
1600-1800	White	Blue	Red	White	Blue	Red	White
1800-2000	Blue	Red	White	Blue	Red	White	Blue
2000-0000	Red	White	Blue	Red	White	Blue	Red

Table 1

rotation provides for more watch turnover during a given day thus in theory providing fresh watch-keepers and personnel for off-watch maintenance requirements. This watch rotation does provide the crewmember the opportunity to achieve an aggregate overall daily sleep rate of approximately 5-6 hours. However, this rotation does not provide the opportunity for a solid 6-8 block of time during night hours for recuperative sleep. As we have seen earlier in this paper the overall effect of restricted sleep can eventually create the same diminished operational level of performance as total sleep deprivation. In order to attempt to provide crewmembers a better opportunity for full sleep during the traditional night period the watch rotation at table 2 was trailed. This rotation calls for

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0100-0700	Red	White	Blue	Red	White	Blue	Red
0700-1300	White	Blue	Red	White	Blue	Red	White
1300-1900	Blue	Red	White	Blue	Red	White	Blue
1900-0100	Red	White	Blue	Red	White	Blue	Red

Table 2

six hours shifts or watch-on, followed by 12 hours off-watch. The increased on-watch period from 4 hours to 6 had no apparent negative effect upon watch-keeper performance. Additionally this rotation allowed crewmembers a full 12 hour down period during the night hours, which permitted for a continuous 6-8 hour sleep period with the subsequent positive recuperative effects.

This paper has examined the basics of sleep. How there exists a sleep cycle and that within that cycle there occurs periods of what can be truly termed recuperative sleep. This recuperative sleep is essential in that it allows for the re-energization of both the body and mind. It is also known that the reality of military operations often precludes the ideal nights sleep, and that without proper knowledge and prevention potentially disastrous sleep deprivation can occur. Even after 72 hours of sleep deprivation it has been determined that the cognitive performance ability of our servicemen can reduce by 75%, a potentially lethal level given the complexities of modern warfare. Through the

appropriate applications of sleep management techniques this potentially deadly side effect of military operations may be mitigated. Through the proper use of naps, stimulants and a creative approach to crew employment watch rotations an appropriate middle ground can be achieved which ensures the health of our servicemen while maintaining optimum operational efficiency.

The utilization of the crew watch rotation schedule as presented in the paper at table 2 will allow for appropriate on-watch alertness and sufficient off-watch down time to ensure that over time sleep deprivation levels are not allowed to reach operationally unacceptable levels. It is also evident that through education and understanding of the sleep cycle crewmembers can see the benefits of the quick afternoon nap with respect to the overall effectiveness of the unit. Caffeine has proven effective at restoring cognitive ability after periods of sleep deprivation and although this stimulant is available as a tablet form medication the ever-present cup of "Joe" fulfills this function. Therefore it is recommended that the watch rotation as proposed in this paper coupled with proactive education about sleep and the sleep cycle be instituted by small units. The adherence to these recommendations will ensure a more operationally effective military unit.

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