

Fatigue Resource Packet for Aviation  
 Naval Safety Center  
 Updated 8/6/13  
 Ms. Kelsey Leo

**Table of Contents**

**Pages**

□ "Fatigue-A Root Cause" (Source: <i>Approach</i> , September-October, 2007)	1
□ "Assessing How Fatigue Causes Mishaps" (Source: <i>Approach</i> , September-October 2007)	3
□ "More Fatigue! (Yawn)" (Source: <i>Approach</i> , May-June 2009)	7
□ "Wake-Up Call in the Desert" (Source: <i>Approach</i> , May-June 2009)	11
□ "Shifting Time Zones=Increased Risk" (Source: <i>Approach</i> , July-August 2011)	14
□ Larkins, A. (2009). Aircrew Member Fatigue And Crew Rest. <i>Mobility Forum: The Journal Of The Air Mobility Command's Magazine</i> , 18(4), 4-7.	17
□ Cunha, B. (2012). Medscape Reference: Chronic Fatigue Syndrome. Retrieved 8/6/2013, from <a href="http://emedicine.medscape.com/article/235980-overview">http://emedicine.medscape.com/article/235980-overview</a>	21
□ From The Merck Manual Diagnosis and Therapy: The Merck Manual Home Handbook for Patients and Caregivers: Fatigue, edited by Michael Wasserman 2013 by Merck Sharp & Dohme Corp., a subsidiary of Merck & Co, Inc, Whitehouse Station, NJ. Available at <a href="http://www.merckmanuals.com/professional/">http://www.merckmanuals.com/professional/</a> . Accessed 8/6/2013, from <a href="http://www.merckmanuals.com/home/special_subjects/nonspecific_symptoms/fatigue.html">http://www.merckmanuals.com/home/special_subjects/nonspecific_symptoms/fatigue.html</a>	26
□ Federal Aviation Administration. (2010). <i>Fact Sheet – Pilot Flight Time, Rest, and Fatigue</i> . Retrieved from <a href="http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=6762">http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=6762</a>	33
□ Davenport, N. "Fatigue in Naval Aviation" (Source: Naval Aviation Schools Command, taken from <a href="http://www.netc.navy.mil/nascweb/sas/files/fatigue_in_naval_aviation.pdf">http://www.netc.navy.mil/nascweb/sas/files/fatigue_in_naval_aviation.pdf</a> , Printed on 8/6/2013)	38
□ Caldwell, John A. (2004). Aircrew Fatigue: Combating The Problem. <i>Flying Safety</i> , 60(11), 20-24.	52
□ Curry, Justin. (2005). SLEEP MANAGEMENT AND SOLDIER READINESS: A Guide for Leaders and Soldiers. <i>Infantry</i> , 94(3), 26-26.	57
□ Fleming-Michael, Karen. (2003). The Sleep Factor. <i>Soldiers</i> , 58(10), 38.	58
□ Graybiel, A., Horwitz, O. Gates, D. (1944). The Problem of Fatigue Among Student Pilots at the Naval Air Training Center, Pensacola, Florida. <i>Aviation Medicine</i> , 9-25.	62
□ Miller, N.L., Shattuck, L.G., and Matsangas, P. "Sleep and Fatigue Issues in Continuous Operations: A Survey of U.S. Army Officers", <i>Behavioral Sleep Medicine</i> , Volume 9, Issues 1, pp. 53-65, January 2011.	79
□ NAVMED P-6410: Performance Maintenance During Continuous Flight Operations	
○ Sleep: More is Better...Up to a Point	92
○ Circadian Rhythms: Early Morning is the Hardest Time	93
○ Fatigue: Easy to Understand but Difficult to Define	94
○ Performance: For the Military Aviator Performance is the Bottom Line	95
○ Strategies and Ideas: Suggestions for the Air Wing, Squadron, Individual and Flight Surgeon	
□ OPNAV 3710.7U Ch. 8	96
	98

# Fatigue—A Root Cause

By Capt. Nick Davenport, MC

**T**he mission of naval forces is to train continually in preparation for war, if not already so engaged. Technological advances and the ever-increasing capability of our machines and missions dictate more complex training scenarios and more highly educated and trained professionals in our service. We own the technology of the night, and strike when least expected. The modern Sailor, aviator, and commander must be energetic, intelligent, innovative, highly motivated, highly trained, and resourceful.

We spend unlimited hours and resources training, drilling and molding the minds of warriors. And yet, these minds do not always perform satisfactorily. Training mishaps and loss of assets take a much higher toll on our capabilities and readiness than enemy action ever did. We are our own worst enemy.

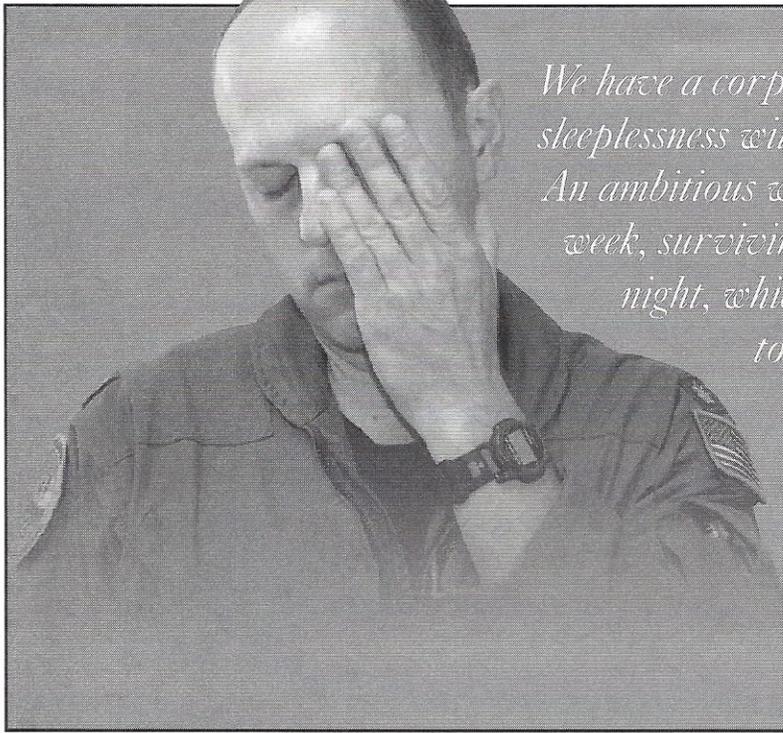
The mind of the successful warrior is simply the product of the human brain. As an organ of incredible complexity and wonder, it is only now beginning to yield its secrets to modern science. The brain is the most complex system in the known universe; yet, in its simplest description, it is nothing more than an electrochemical digital computer. The brain is another weapon system the war fighter must understand in sufficient detail for proficiency; yet, it's so familiar to us that we rarely consider it in such terms.

While awake, the healthy, well-nourished and rested human brain is capable of prodigious feats of sensory perception, symbol manipulation, logic, analytic thought, language, and problem-solving. However, because of its biologic nature, the brain cannot run continuously in the awake conscious mode, but requires scheduled maintenance and recharge cycles for efficient function. The awake functioning brain seems to deplete neurons and biochemical capability, build up toxins and metabolic by-products, and starts to run down. This "running down" is manifest as declines in mental performance, judgment, and complex decision-making, and is associated with a variety of symptoms we commonly experience as "fatigue."

We refer to the regular maintenance and recharge cycles that the brain engages in as "sleep." All animals studied show sleep behavior, cycling around a 24-hour interval. This condition is simply a product of our evolution and the orbital motion of this planet, and is inseparable from the fabric of our existence. Sleep is as necessary for survival as oxygen, water, and nutrition. Animals that cannot enjoy the luxury of unconsciousness during sleep, but must remain continually vigilant, such as porpoises, can switch their brains into sleep mode half-a-brain at a time, while still functioning sufficiently to avoid drowning.

Sleep activity consists of periods of deep, slow electrical activity known as "non-REM" sleep, alternating with periods of fast electrical activity during which the eyes are seen to move beneath the eyelids, hence the term "rapid eye movement," or REM, sleep. Dreams occur during REM sleep, but, in this phase, the brain, in essence, disconnects itself from the rest of the body, and with the exception of respiratory muscle activity, no signals are sent to the muscles of action, so dreams are not translated into body activity. The majority of non-REM sleep is obtained in the first half of the night's sleep, whereas REM predominates in the latter half of the sleep period. Depriving the brain of REM sleep by shortening the nightly sleep period from eight to six hours may significantly affect learning and retention. It is apparent that both are necessary for brain health and function, and if the human brain is deprived of either type of sleep, it actively will seek that type in greater amount. Inefficient or fragmented sleep will result in increased fatigue levels and, again, declining performance.

All this fatigue and sleep physiology would be of mere academic interest to the war fighter were it not for the simple fact the sleep-deprived and fatigued brain suffers increasing performance deterioration as sleep deficits accrue. The signs and symptoms evident in individuals in a fatigued state include deterioration in mood, impairment in complex reasoning and decision-making,



*We have a corporate culture that still confuses sleeplessness with vitality and high performances. An ambitious worker logs 80 hours or more each week, surviving on four to five hours of sleep per night, which induces an impairment equivalent to a blood alcohol content of .1. The analogy of sleep deprivation and drunkenness is a fair comparison because, like a drunk, a person who is sleep deprived has difficulty assessing how functionally impaired they truly are.*

increased tolerance for error and risk, task fixation, reduced communication, reduced vigilance and motivation, and increased reaction times.

As the pressure for sleep increases, the brain will unpredictably try to insert snatches of sleep: lapses or microsleeps. These typically last five to 15 seconds or longer, during which the individual even may appear awake with eyes open but actually is asleep. The brain has switched to sleep mode and is not processing external stimuli. Performance deteriorates because of fatigue, but during these lapses, performance drops to **zero**. These lapses become more frequent as fatigue accumulates. What's most dangerous is that individuals are often unaware of them. External events, such as radio calls, warning lights, sudden threats, or mandatory responses aren't processed during lapses. Fatigue produces predictable declines in performance, interspersed with sudden lapses, an especially dangerous combination of deficits where vigilance is required.

It would be understandable for the war fighter to respond, "So what? We have to train and fight wars in a fatigued state, and we manage to deal with it. We can't eliminate fatigue. Crews must be vigilant and capable 24 hours a day. Wars are fought at 0400. The luxury of eight hours of sleep a night can't be afforded in the military. If the problem is so serious, where's the evidence?"

Our culture, especially in the military, holds that somehow training, habit, motivation or attitude can overcome fatigue. Mishap statistics suggest otherwise.

As part of many mishap investigations, particularly aviation mishaps, we routinely measure for glucose, alcohol, drugs, carbon monoxide, lactic acid, cyanide, and a variety of other biological markers and agents, both in the living and the dead. But, we have no good measure for fatigue, so we've historically missed it as a causal factor.

It's time to change the culture in the Navy regarding sleep deprivation and fatigue. We never would tolerate the profound deterioration in performance that would result if a large number of our personnel routinely were intoxicated on duty; yet, we accept the same levels of impairment in performance from fatigue without recognition. In fact, our military culture often rewards sleeplessness as a badge of honor. Fatigue is so prevalent and such a part of our culture we scarcely see or recognize it. It's the big gray elephant we muscle out of the cockpit when we fly, step around when we enter the bridge, and push aside when we peer into the periscope.

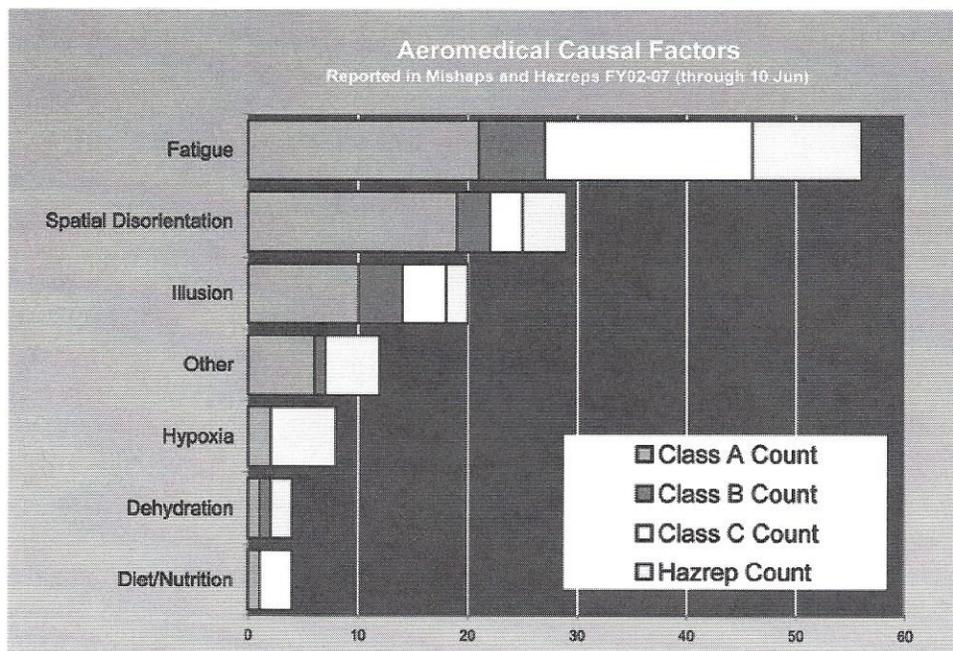
The war fighter is right: We cannot eliminate fatigue. But, we increasingly have sophisticated tools and scientific evidence to recognize the true cost of fatigue on naval operations. We can provide the commander with better risk-assessment strategies and countermeasures. Perhaps, we don't need more training, more discipline, more regulation, more safeguards, or bigger instructions. Perhaps, we just need more sleep. ✈

Capt. Davenport is the command flight surgeon, School of Aviation Safety, Naval Aviation Schools Command.

# Assessing How Fatigue Causes Mishaps

By Capt. Nick Davenport, MC and Capt. John Lee, MC

**F**atigue resulting from sleep deprivation, disrupted circadian rhythm, and/or associated conditions is the most frequently cited aeromedical causal factor in naval-aviation mishaps. Fatigue is four times more likely to contribute to workplace impairment than drugs or alcohol.



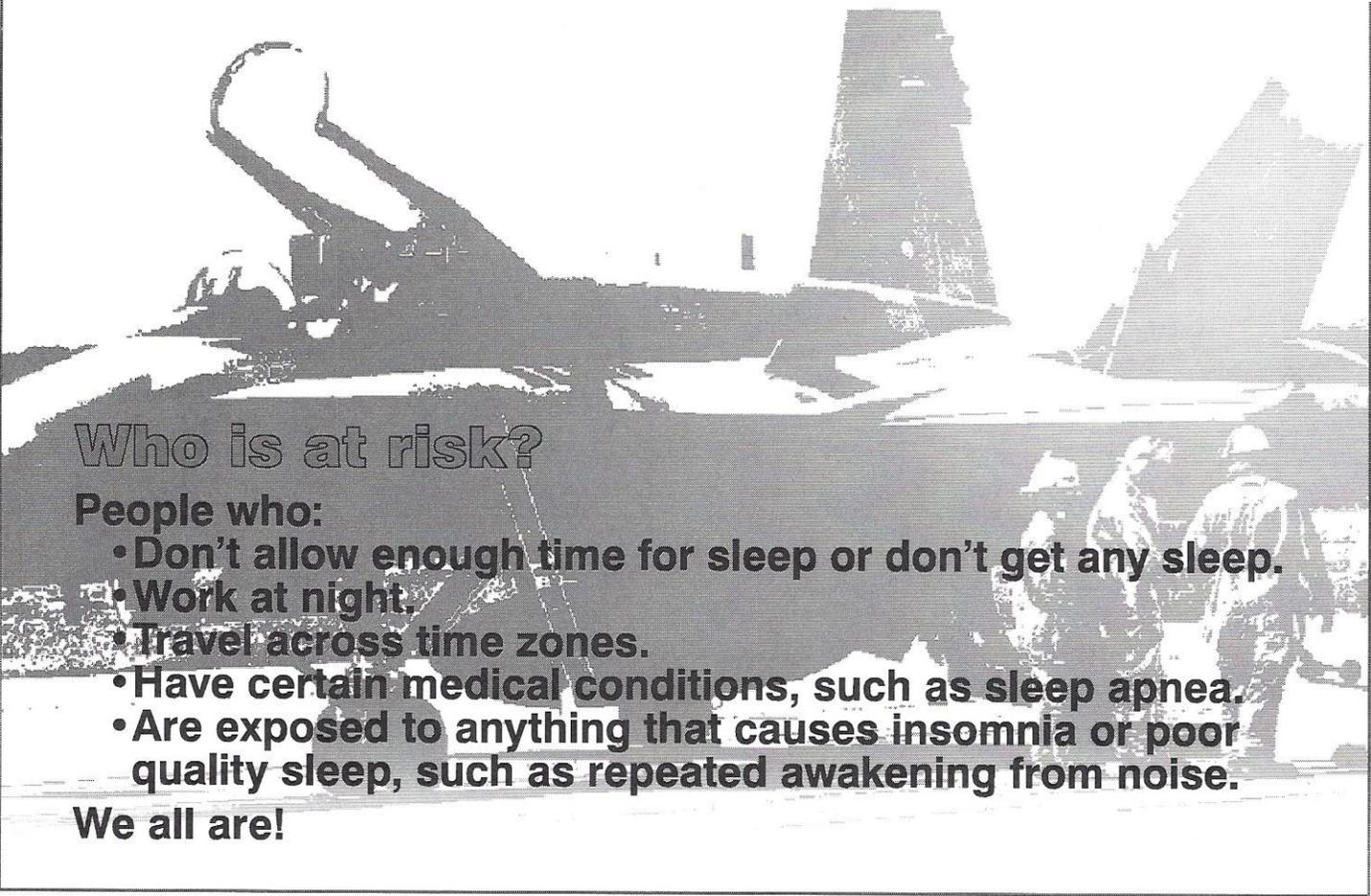
The term “fatigue” describes the constellation of signs and symptoms that result from sleep deprivation and circadian desynchrony. These problems lead to impaired performance and increased susceptibility to such conditions as spatial disorientation, visual illusions, and a variety of conditions that can increase mishap potential. Flight surgeons must look for fatigue as a root causal factor in all naval-aviation mishaps.

Identifying fatigue is difficult, because there are no simple measures. Drugs, alcohol, carbon monoxide, cyanide, and other toxins can be identified from post-mortem tissue and body-fluid testing; however, no similar lab measurement identifies fatigue levels in a deceased aircrew member. Measuring vigilance and cognitive performance in a survivor immediately after a mishap isn’t possible or practical. And an aircrew’s self-assessment of fatigue has been shown to be poor: The greater the level of fatigue, the poorer the awareness of degraded performance.

Fatigue can be predicted if good information is available on a crew member’s sleep habits, timing and quality of sleep, and duty periods before the mishap. Computer modeling of fatigue physiology and prediction of expected aircrew performance at the time of the mishap is feasible.

We now have a software tool that can assist in investigating and monitoring fatigue; it’s called the Fatigue Avoidance Scheduling Tool (FAST).

Almost all adults require 8 to 8.25 hours of quality sleep per night at the nightly circadian trough to retain full alertness and cognitive effectiveness. However, in many military operations and training, members get less than optimal sleep; therefore, performance and vigilance suffer. Also, travel across multiple time zones causes shifts of circadian rhythms, which can take from just a few days to more than two weeks for full recovery.



## Who is at risk?

### People who:

- Don't allow enough time for sleep or don't get any sleep.
- Work at night.
- Travel across time zones.
- Have certain medical conditions, such as sleep apnea.
- Are exposed to anything that causes insomnia or poor quality sleep, such as repeated awakening from noise.

**We all are!**

FAST is one such computer program. It accepts information on date and location coordinates, an individual's sleep habits, duty times, sleep time, and sleep quality before a mishap. FAST will project expected cognitive performance, based on these variables. It also will accept the times and locations of all transmeridian travel (waypoints) and will calculate the effects of circadian shifts. FAST has been validated against a variety of test subject data from sleep-deprivation studies and has been shown to have up to 95-to-98-percent predictive ability in certain data sets.

The Naval Safety Center requires flight surgeons to analyze all 72-hour histories obtained in mishap investigations, using the FAST analysis software. In any mishap where aircrew traveled over multiple time zones in the two weeks before a mishap, a full 14-day history

is required and should be analyzed in FAST. A 14-day history also should be considered if there are any other factors where circadian shifting would be expected, such as in rotating shift work.

The following fatigue-related information should be collected by the aviation mishap board on all aircrew involved in a mishap:

1. Usual habits of the member regarding sleep. For example, what are the normal times the member goes to sleep and wakes up, both on weekday (or duty-day) and weekend (or off-day) nights? This information helps establish the times of normal circadian variation of each individual and allows some estimation of existing sleep debt.
2. The member's usual sleep quality. For example, how well does he or she usually sleep: excellent, good,

**Mishap-Free  
Milestones**

VAQ-130

26 years

42,987.6 hours

Most people sleep in the dark and are awake in daylight. When that cycle is interrupted by work schedules or the need to travel, the results are fatigue and impaired performance. Our brain requires sleep to recharge and reorganize. You cannot overcome lack of sleep or train to defeat sleep deprivation. It is not a matter of lack of motivation or training. If you don't make up for lost sleep, one way or another, the loss will take its toll.

fair, poor? (Excellent would be considered restful sleep with no nightly awakenings; fair includes up to two arousals per hour; poor is six or more arousals or awakenings per hour).

3. Any evidence for sleep pathology, such as sleep apnea, restless-leg syndrome, narcolepsy, or other medical conditions that may interfere with good quality sleep.

4. Sleep and wake times in the three days before a mishap and estimates as to the quality of each of these sleep periods. This documentation requires a detailed 72-hour history, including a record of times and quality of any nap periods during the day or night.

5. Use of any sleep or performance aids and when. For example, how many caffeinated beverages, sleeping pills, or performance-maintenance drugs were taken?

6. Times and location coordinates in latitude and longitude when beginning and ending any travel over time zones.

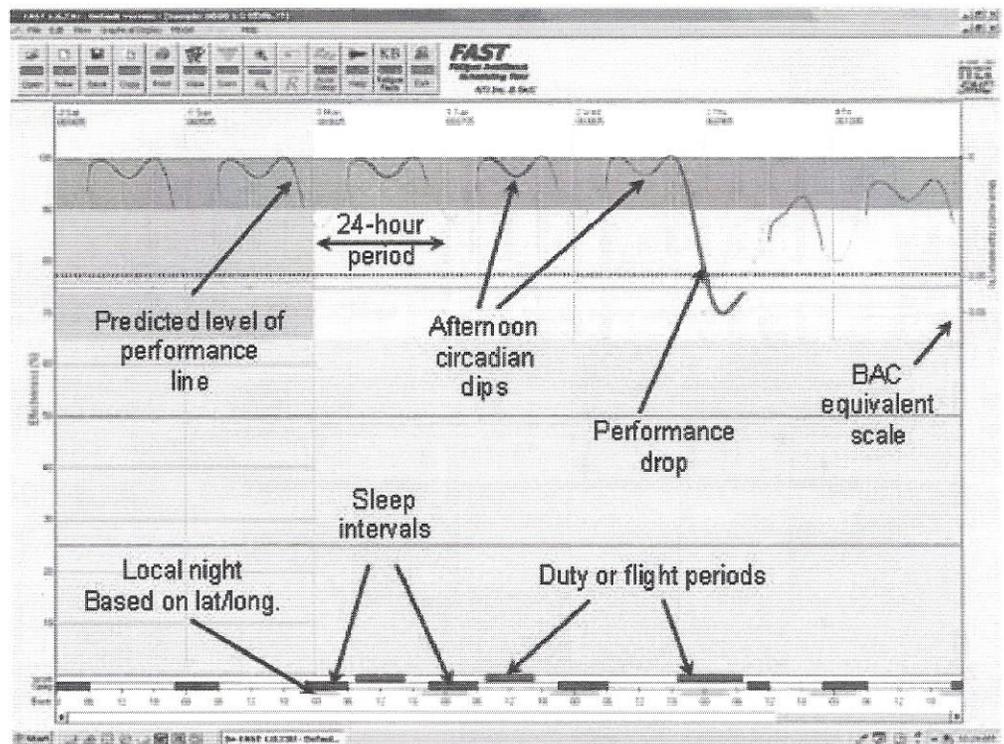
7. Time and location of the mishap.

The FAST program will accept all the above information (except medication effects) and produce plots of expected levels of cognitive performance, including a numerical assessment of the predicted effectiveness of the mishap member and propensity for lapses or microsleeps at the time of the mishap. Include the FAST plots as enclosures to the aeromedical analysis, and comment as to the likely accuracy or limitations in the data. Recognize that any FAST plots and results, if they are based on

72-hour or 14-day histories, can be obtained from privileged information and also are privileged.

Clearly, the validity of the prediction depends heavily on the accuracy and completeness of the input information, so the best possible attempt should be made to verify times and conditions of sleep in the 72- and 14-day histories. This data collection can be difficult, especially with deceased aircrew members. Try to validate times as much as possible from witness statements, family members, phone records, email transcripts, and any other sources which may help reconstruct the sleep and wake data.

Information on the FAST program can be downloaded from the Nova Scientific Corporation website at: [www.NovaSci.com](http://www.NovaSci.com); just click on the FAST icon. The program must be installed in a legacy computer because it has not gone through NMCI certification. Instructions come with the download on unzipping and installing the



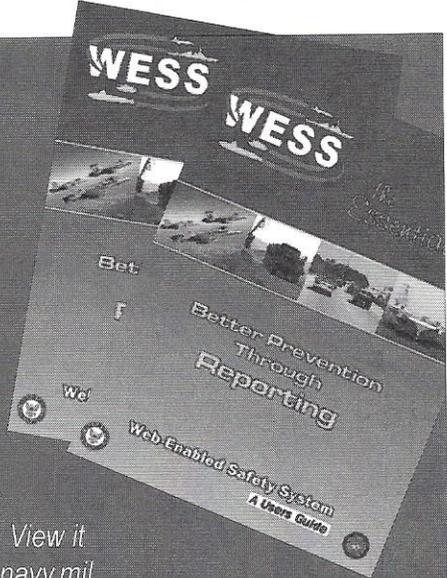
*An example of a FAST plot is shown above.*

program on a computer on which you have administrative privileges, and on obtaining an activating license. The program is licensed to official DoD users only. Technical assistance in using the FAST program can be obtained by contacting the Aeromedical Division of the Naval Safety Center, (757) 444-3520, ext. 7228 or 7268, or the Command Flight Surgeon at the Naval School of Aviation Safety, at (850) 452-5140. Additional aeromedical information is available on the Naval Safety Center's website at [www.safetycenter.navy.mil/aviation/aeromedical](http://www.safetycenter.navy.mil/aviation/aeromedical). 

Capt. Davenport is the command flight surgeon, School of Aviation Safety, Naval Aviation Schools Command, and Capt. Lee is the head, Aeromedical Division, Naval Safety Center.

## How do we deal with fatigue?

- Recognize we are all at risk, and make sure you get enough sleep, at least six hours (but preferably eight hours) per night.**
- Maintain a consistent bedtime and wake-up schedule, even on weekends.**
- Exercise on a regular basis, but not within three hours of bedtime.**
- Avoid caffeine products within four hours of going to sleep.**
- Avoid alcohol within three hours of bedtime.**
- Avoid tobacco products within one hour of bedtime.**



A special issue WESS users guide is now available in your squadron. For additional copies contact: April Phillips, Naval Safety Center at [april.phillips@navy.mil](mailto:april.phillips@navy.mil). View it online at: [safetycenter.navy.mil](http://safetycenter.navy.mil)

## WESS Update

### Training

The Naval Safety Center offers WESS training at your unit that is tailored to your specific needs. The training can range from a one-hour lecture to multiday, hands-on system operation, and includes the latest functions, changes, and improvements to WESS.

Online WESS tutorials can be found at:  
<http://www.safetycenter.navy.mil/wess/tutorial/aviation/>

### New Items

- WESS search function—This brief will show you how to use the JReport function to find a HAZREP, even if you do not have the date of the event.  
[http://www.safetycenter.navy.mil/wess/tutorial/aviation/WESS\\_Search\\_Info.ppt](http://www.safetycenter.navy.mil/wess/tutorial/aviation/WESS_Search_Info.ppt)
- Safety authority procedures—Required for all units in order to receive WESS accounts.  
<http://www.safetycenter.navy.mil/wess/tutorial/aviation/Pt8QuesSafetyAuth.ppt>

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**MORE FATIGUE!  
MORE FATIGUE!  
MORE FATIGUE!  
MORE FATIGUE!**

**(yawn)**

By Capt. Nick Davenport, MC

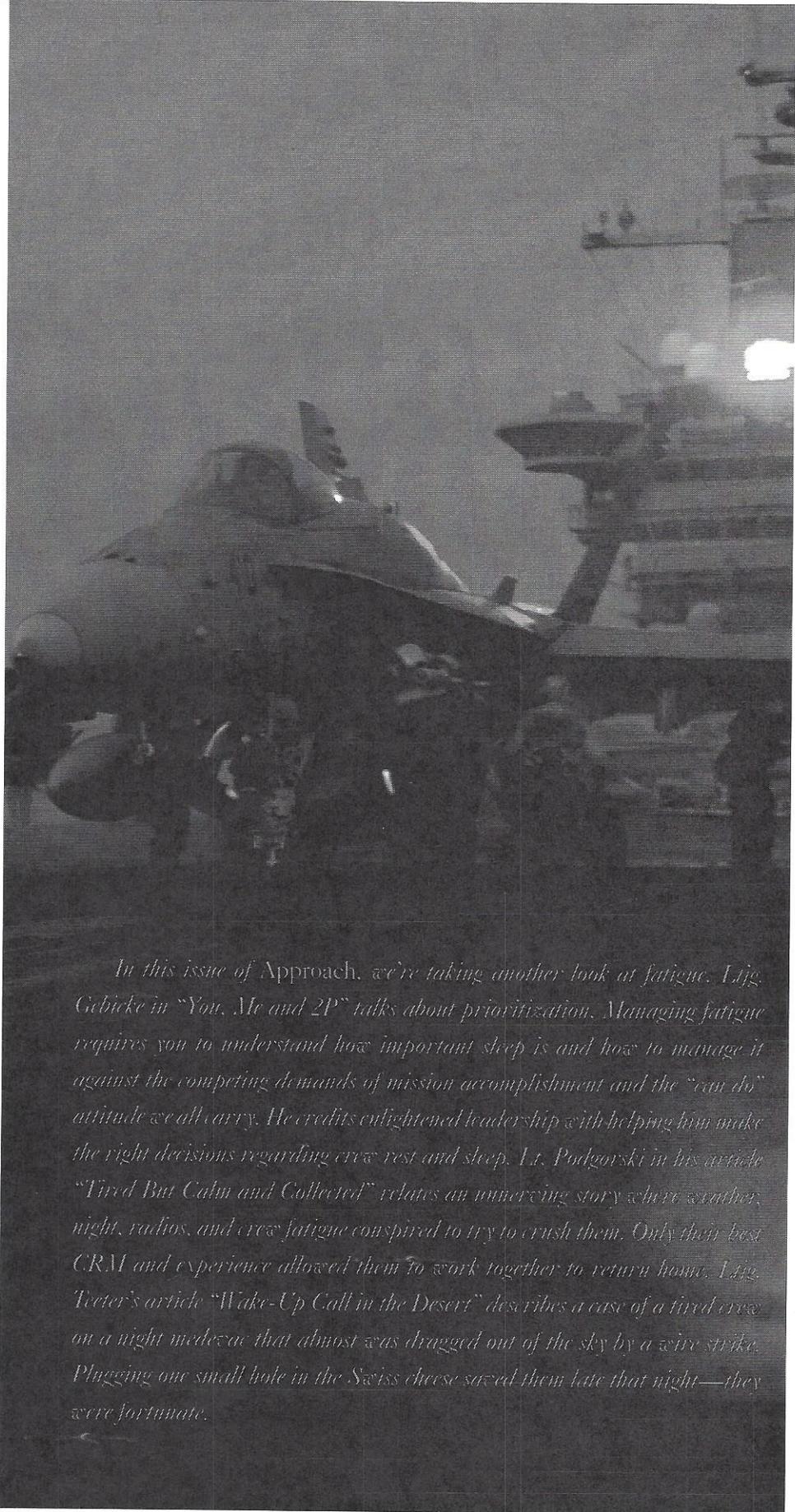
**Y**eah, we're at war and OPTEMPO is up; we're mission-oriented folks accustomed to continually doing more with less.

We just gut it out and get the job done, right? You're probably thinking, "We're fatigued, and there ain't much we can do about it."

What control do we have over fatigue? Let's look at some key points.

## FIRST, HOW SLEEP DEPRIVED ARE YOU?

Most adults need about eight hours of sleep per night to perform at their peak. If you're getting that much every 24 hours, you're probably doing fine. Or you might be one of those individuals who only need six and a half or seven hours of sleep to function normally (but don't bet on it, those folks are few in number). If you wake up before the alarm goes off each morning, leaping out of bed feeling well-rested and energetic, good for you. If you're the only one still awake during a boring afternoon lecture, watching those around you nod



*In this issue of Approach, we're taking another look at fatigue. Ljig Gabicke in "You, Me and 2P" talks about prioritization. Managing fatigue requires you to understand how important sleep is and how to manage it against the competing demands of mission accomplishment and the "can do" attitude we all carry. He credits enlightened leadership with helping him make the right decisions regarding crew rest and sleep. Lt. Podgorski in his article "Tired But Calm and Collected" relates an interesting story where weather, night, radios, and crew fatigue conspired to try to crush them. Only their best CRM and experience allowed them to work together to return home. Ljig Teeter's article "Wake-Up Call in the Desert" describes a case of a tired crew on a night medevac that almost was dragged out of the sky by a wire strike. Plugging one small hole in the Swiss cheese saved them late that night—they were fortunate.*

*As the sleep debt gets bigger, the pressure to sleep becomes overwhelming.*

off, you're in good shape. If it takes you about 15 to 20 minutes each night to fall asleep after your head hits the pillow, you're normal.

Then, of course, there are the rest of us. Late nights, deadlines, night-shift work, early briefs, time-zone travel, deployments, combat stress, and anxiety all compete for limited sleep time. Dr. William Dement, one of the world's premier sleep researchers, estimates most Americans in our 24-hour society have a 25-to-50-hour sleep deficit. For many in the military, we're probably worse. As the sleep debt gets bigger, the pressure to sleep becomes overwhelming. We're not just nodding off at briefings, traffic lights, and general-quarters drills, we're snoring and drooling, as well. No wonder we nap in passageways and sleep like we're in a coma, even next to the arresting gear and the catapults below the flight deck. Getting rid of that sleep debt takes days to weeks, because you have to add that recovery sleep to your normal eight hours per day. You'll notice improvement after a long leave or vacation where you've been getting full-recovery sleep. After two or three weeks, you'll start feeling more alert, energetic and creative.

## TOO LITTLE SLEEP, SO WHAT?

"All that may be true," you say, "but I'm still able to do the job; if things get tough, I'll just gut it out."

Well, maybe not. If you look at the graph, we've still

got a long way to go. Fatigue from sleep deprivation, acute and chronic fatigue, and circadian-rhythm disruption exceeds all other aeromedical causal factors in Class-A flight mishaps, and hazard reports, combined.

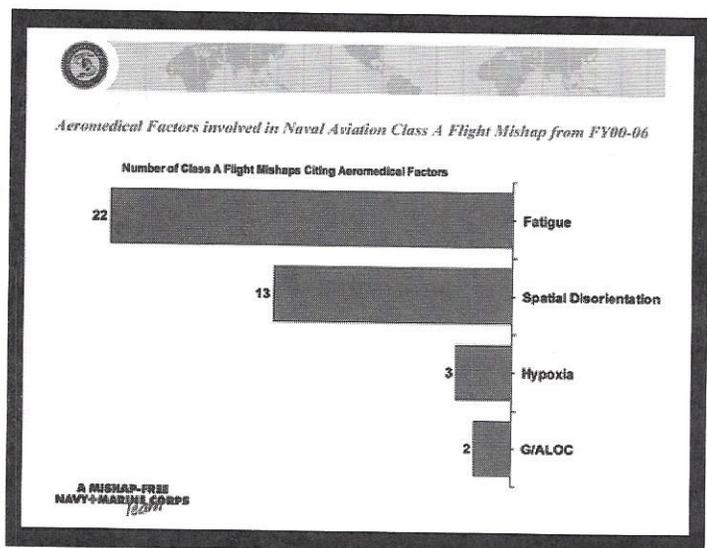
Safety Center analysis of Class-A flight mishaps for FY00 to FY06 has found the percentages of the following fatigue-related HFACS nanocodes: fatigue-physiological/mental, circadian rhythm desynchrony, and inadequate rest, in the aviation communities listed in the table.

These results are influenced by accuracy of reporting and type of aircraft and mission.

### Fatigue-associated HFACS nanocodes in Class A flight mishaps, by aircraft type.

- USMC H-53 57%
- USMC H-46 29%
- USMC H-1 23%
- USN FA-18 21%
- USN H-60 20%
- USMC FA-18 10%
- USMC AV-8B 05%

Provided by Cdr. Don Delorey and LCdr. Jeff Alton



Fatigued people are not very aware of how impaired they are, and as the fatigue mounts, that lack of awareness gets even worse. Just like the drunk at the party, they may think they're doing well when fatigued but not be in condition to handle anomalies, emergencies or unexpected changes in plans. Functioning at 75 percent of baseline capacity might be good enough if the mission isn't very challenging, and there are no surprises. But, if a flight suddenly demands high-level decision-making and performance, you may not have the reserves to function successfully. Many mishaps begin with a minor distraction, which starts to consume limited brain resources, while the bigger picture gets lost.

What about the adrenalin rush (that "fight or flight" response) that comes with surprises and emergencies?

Doesn't that restore alertness and brain function? That huge jolt of adrenalin restores alertness for only a short while, maybe five to 10 minutes. Then fatigue comes right back, and we're just as degraded as before. This scenario is typical of the late-night driver, who is jolted awake by the sound of rumble strips on the tires. While he makes it another five miles down the highway, he then falls asleep and crashes. Often times, we get that first shot of adrenalin after the mishap has occurred. Also, although that adrenaline rush might wake us up, it doesn't necessarily restore our ability to think clearly.

### THE EFFECTS OF PRACTICE.

High-level decision making, cognitive function, mood, multi-tasking, situational awareness, and vigilance are all very sensitive to inadequate sleep. Operational-risk management and crew-resource management depend on these cognitive capacities. Conversely, well-rehearsed motor skills and simple, familiar procedures are resistant to inadequate sleep. However, the kinds of thinking often required in an emergency situation such as, the ability to come up with novel solutions during rapidly evolving situations, are those that cannot, by definition, be practiced. Therefore, inadequate sleep combined with an emergency situation equals a disaster waiting to happen.

What about practicing in a fatigued state to be more resistant and familiar with how to control fatigue? Do you cope better if you train fatigued? Of the sleep deprivation experts I've asked, none know of any scientific evidence to support this belief. In fact, evidence shows that the ability to learn is degraded by inadequate sleep. So, if you train while you're obtaining adequate sleep, you learn faster and better. If you train in a sleep-deprived state, you don't learn as well; you only increase your chances of having a training mishap.

### HOW ABOUT DRUGS?

Several drugs are available to manage fatigue on a short-term basis. One of the most available is caffeine, which affects the brain, improves alertness and cognitive performance. Science shows that two to three typical, eight-ounce cups of coffee, each containing 100 to 150 mg. of caffeine, will help promote alertness for three to

four hours. Energy drinks contain twice as much, and your venti-Starbucks coffee may top out at 400 to 500 mg. of caffeine. Coffee ice cream and chocolate have some caffeine (30 mg.), which is not enough to improve performance and alertness. Caffeine is still effective even if you use it regularly, although you might need more than someone who doesn't regularly use it.

More potent drugs, such as amphetamines, do work but are restricted for use only "in extreme operational necessity or combat." They require strict prescribing and accounting of medication, and pretesting. Talk to your flight surgeon for more information when these drugs might be considered.

As with all stimulants, caffeine included, fatigue still is present, only temporarily masked by the drug. Increasing sleep debt requires increasing amounts of the drug to sustain performance. Even caffeine can have side effects, such as irregular heart beats, stomach upset, and elevated blood pressure. Until the effects of the drug wear off, getting to sleep afterward can be difficult, so planning ahead is crucial. For these reasons, managing fatigue with drugs requires a well-thought-out plan, preapproval and testing, and flight-surgeon supervision. Drugs are the last choice to maintain performance after all other counter-measures have been implemented.

### SLEEP

Nothing fully restores the brain's computational ability and performance except sleep. It doesn't matter where you get your sleep; it's just a matter of quantity. Sleep obtained in chunks still recharges the brain, and restores cognitive functioning. If you spend a night tossing and turning, and periodically waking up, you still get the benefit of the sleep time you did accrue—it all adds up.

For instance, if you have to work a night shift, take advantage of the afternoon lull in alertness and nap from 1400 to 1700 before you go on duty.

Getting to sleep can be difficult because of stress, anxiety or trying to sleep when the circadian-alerting cycle is stimulating the brain, particularly during the last three hours of the day before normal bedtime. With circadian dysrhythmias or chronic-sleeping difficulties, consult your flight surgeon for more help.

## Suggestions to maximize the effectiveness of sleep:

Try to standardize your sleep period. Get up at the same time each day, even on weekends. To add sleep, go to bed earlier at night, rather than sleep in the next morning (the latter shifts your circadian clock, which is generally undesirable).

Associate your bed with sleep only. Don't take work to your rack. If you spend 30 minutes in bed and still can't sleep, get up and do something else until you again feel sleepy.

Don't vigorously exercise within three hours of going to bed. Exercise will stimulate adrenalin and raise core temperatures; both interfere with sleep onset.

Keep your sleep spaces cool, quiet, dark, and as comfortable as possible. Consider ear plugs.

Block out as much light as possible. Lights alert and influence the circadian cycle. If necessary, duct tape aluminum foil on the windows or wear eye shades.

Stop using caffeine within six hours of your anticipated bedtime to give it time to clear your brain.

Don't drink alcohol to get to sleep. Alcohol makes you feel groggy, but does not promote sleep. Although you are not aware of it, alcohol directly disrupts your sleep.

## NAPPING STRATEGIES

In times of high operational tempo, you have to be a combat-nap expert. Use naps to get additional sleep if you don't have time for programmed sleep at night. Sleep of any duration will produce benefit in the brain. The old rules about limiting the length of the nap are outdated, and didn't account for the long-term benefit of the nap. Take as long a nap as you can.

## I FEEL GROGGY AFTER A NAP AND CAN'T SLEEP LATER THAT NIGHT.

"Sleep inertia" is that feeling of grogginess you have for about 15-to-20-minutes after awakening from a nap. Science shows that it's a direct carryover of the state of the sleeping brain into wakefulness. Cognitive performance is impaired during the first five minutes,

but this impairment dissipates rapidly over the next 15 minutes or so. Avoid any activity that requires peak performance during the first five minutes.

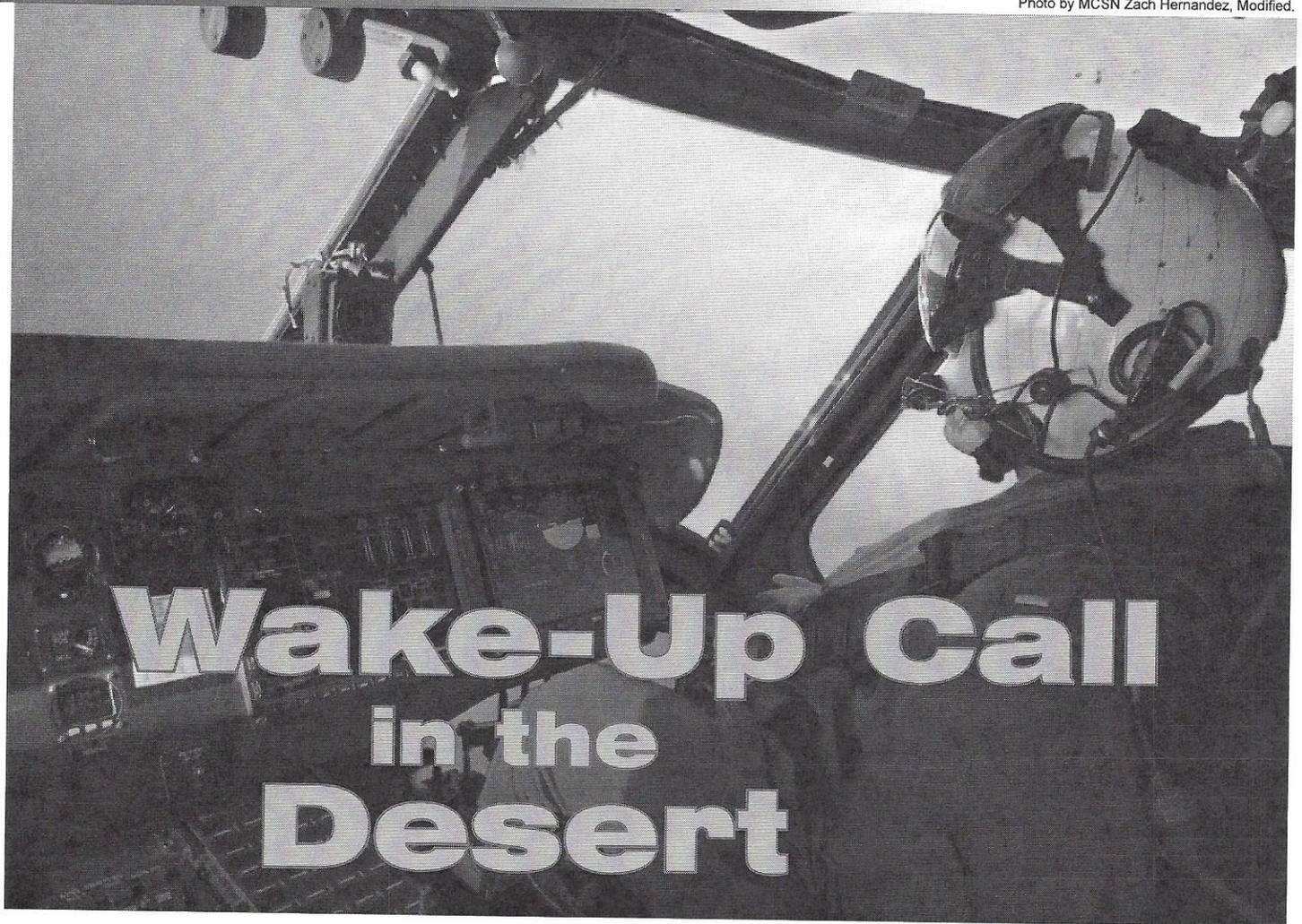
A huge amount of scientific literature on fatigue and sleep deprivation exists, and research is giving us much better tools to understand and control fatigue. Software modeling of human fatigue and performance recently has proved successful and promises to greatly improve our ability to predict when fatigue effects will occur. Such tools as FAST™ (the Fatigue-Avoidance-Scheduling Tool) are used to analyze the fatigue component of mishaps, and programs in development, such as the Air National Guard's FlyAwake, promise to revolutionize scheduling. For more info, visit the NSC website at <http://safetycenter.navy.mil/Fatigue/index.asp>.

For now, that's probably enough to put you to sleep for this issue of *Approach*.

*Capt. Nick Davenport is the head, Aeromedical Division, Naval Safety Center. Dr. Nancy Jo Wesensten, Ph.D., Task Area Manager, US Army Medical Research and Materiel Command Sleep and Fatigue Program, Walter Reed Army Institute of Research, contributed to this article.*

## FlyAwake: Fighting Fatigue

Recognizing the value of fatigue modeling, the Air National Guard Safety recently developed a user-friendly overlay on the SAFTE model, called FlyAwake. Pilots, schedulers, physiologists, and mission planners participated in developing the initial application, to ensure a product that meets warfighter needs. Thanks to a grant from the Defense Safety Oversight Council, the ANG has partnered with the Naval Safety Center, the Walter Reed Army Institute of Research and the Naval Postgraduate School to bring FlyAwake to Navy operations as one component of a comprehensive risk-management program. View it at [www.flyawake.org](http://www.flyawake.org). An enhanced version will be available later this year.—Capt. Lynn Lee, Air National Guard Safety.



# Wake-Up Call in the Desert

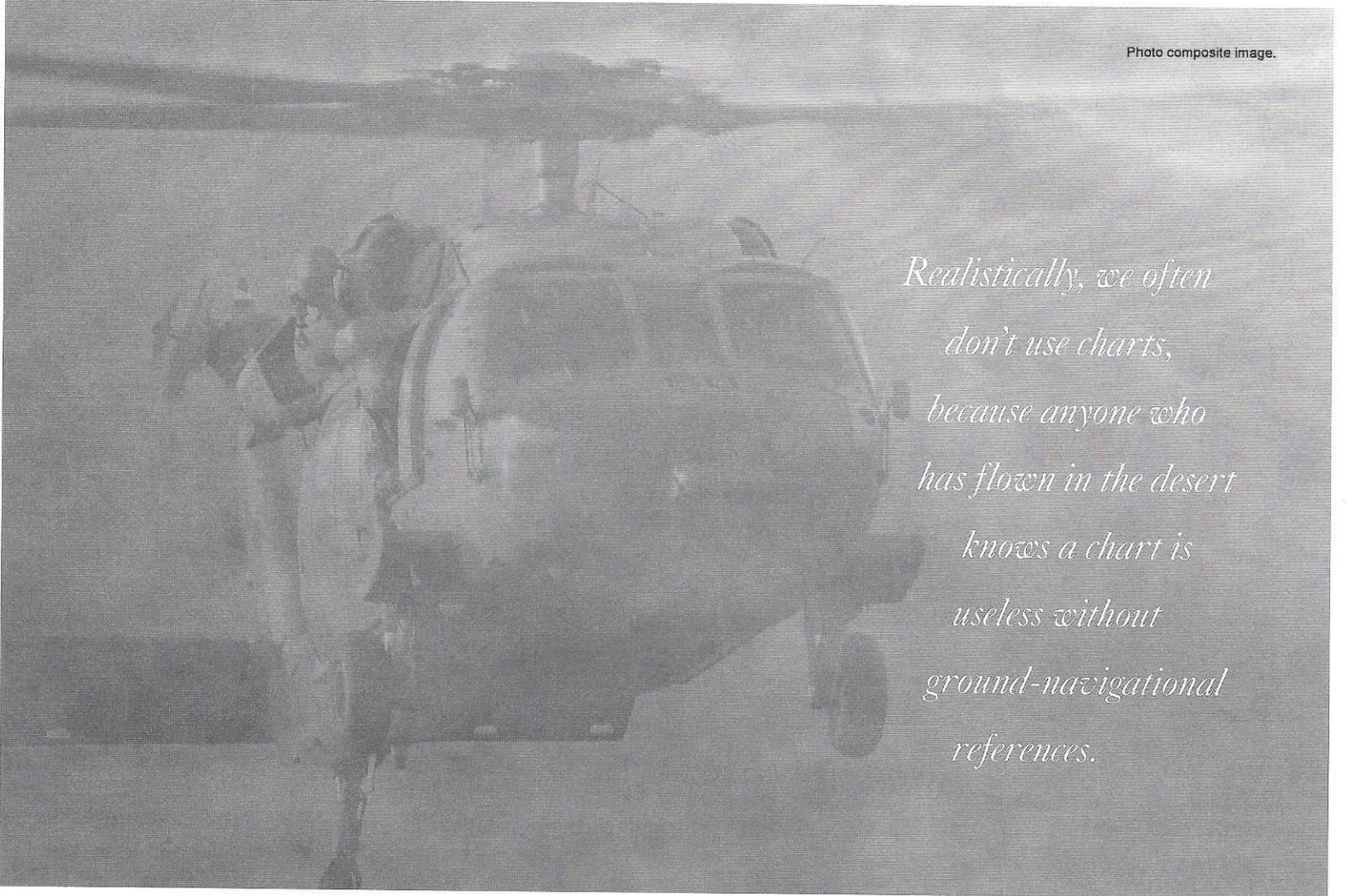
By Ltjg. Dan Teeter

I have been told Navy flying is far more dangerous than Army flying. The argument asserts that flying over land affords you terrain references and contrasts, more accessible fuel, and emergency-landing sites; all you have at sea is an infinite expanse of water. The hole in this argument never was more apparent to me than following a recent near-mishap I experienced.

Countless overland flights in Kuwait and southern Iraq have taught me the overland environment should not be taken lightly. Some of the flying is easier and even safer, but the desert quickly will remind you that overland flying can be just as dangerous as maritime flying, if not more so at times.

As with many mishaps, my near-mishap resulted from several causal factors, rather than one isolated

factor. My incident occurred in the expanse between Udairi, Kuwait, and Tallil, Iraq, which the local Army helicopter pilots not-so-endearingly call, "Davey Jones Locker." During my several months with the 2515th MedEvac Unit, I had completed countless patient transfers between Tallil and the Expeditionary Medical Facility in Arifjan, Kuwait. This medevac appeared to be no different.



*Realistically, we often  
don't use charts,  
because anyone who  
has flown in the desert  
knows a chart is  
useless without  
ground-navigational  
references.*

It started like all others, with “Medevac, medevac, medevac, 1st and 2nd up” broadcast over the squadron radios. It was 0230 in the morning, so I rushed out of bed, suited up, geared up, and ran to start the helicopter. Tallil had an Army sergeant experiencing testicular torsion (a terribly painful twisting of the testicles), and they wanted to move him to Arifjan for surgery as soon as possible. My crew was assigned wing responsibilities for the flight, and the other aircraft would pick up patient.

**WE SPUN UP AND LIFTED** without incident. As we checked out with the Kuwait air-traffic controllers and pressed toward Iraq, we anticipated the flight would be yet another routine run between the two bases. Little did we know that the “Swiss cheese” holes were lining up.

Our formation descended to 300 feet AGL, the standard night altitude in Iraq, as we crossed the border. Low-altitude-terrain flight was the first hole

in the cheese. The cultural illumination disappeared, and the zero-illumination night became extremely apparent (our second hole). We began to enter and exit dust clouds that extended well above us and obscured the horizon (our third hole). We stayed low to maintain ground reference in the absence of a horizon. Finally, we had two tired crews as we entered the flight phase—when nothing happens. Complacency rose as our crews began to drowse. I was flying, so I snuggled up within three rotor diameters of lead and established a step-down to improve my sight of lead.

The 80-mile expanse between Udairi and Tallil is an uninhabitable tract of desert. Almost nothing exists between the two bases, except vehicle and tank wreckage from the first Gulf War, distant flare pipes that bloom you out, and high-tension power lines. The power lines crossed at unpredictable intervals toward the end of our transit, and they ranged in height from about 150 to 200 feet AGL. At 300 feet at night, we try to mitigate their hazard, and we use charts to anticipate

## **No member of my crew saw the 200-foot-high power lines as we approached them.**

their proximity—at least that's the plan.

Realistically, we often don't use charts, because anyone who has flown in the desert knows a chart is useless without ground-navigational references. See-and-avoid is the common rule to clear the wires, and this practice had been effective so far.

**J**ust about the time power lines began to appear, the flight became more communication intensive. Lead had to contact Ali approach and Ali tower, while wing had to contact the Tallil medevac unit to coordinate the patient pickup. Lead seemed to have enough difficulty just maintaining good airwork. Now they, and we, had to multi-task on our radios.

We should have identified the first signs of fatigue in the other aircrew. Lead descended 50 to 75 feet at irregular intervals during the early part of our transit. The descents all were shallow and lasted only seconds before they recovered at base altitude. Still, we didn't have the wherewithal or nerve to challenge their basic airwork. We continued the flight without saying anything.

No member of my crew saw the 200-foot-high power lines as we approached them. At the same time, lead began yet another shallow descent, and I carelessly maintained my step-down without cross-checking my radalt. The next thing I heard was my low-altitude-warning system beeping. It seemed odd, so I checked my radalt, and it read 45 feet AGL for a split second—probably a transient read off of the wires we had crossed.

After a brief moment of silence, my HAC asked the crew what had happened. Our crewman confirmed my suspicions that we had passed over a set of power lines without anyone seeing or announcing them. We contacted lead on our inter-plane frequency, and they reported the same experience. We now were wide awake. We climbed another 100 feet for the remainder of the transit and arrived in Tallil unnerved.

Our lead aircraft picked up the patient at Tallil, and

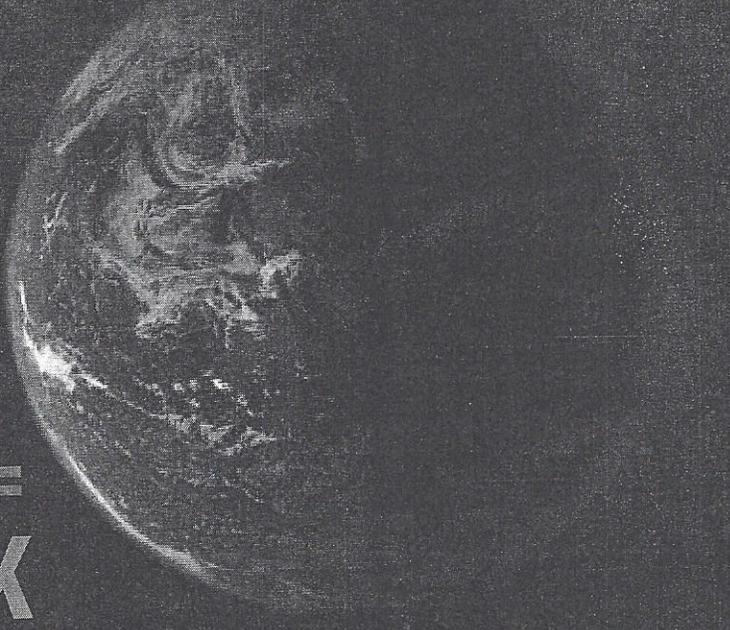
we completed the remainder of the medevac. We estimate my aircraft had crossed the wires within 50 feet, and lead had crossed just slightly above us.

Several of the flight's risks were outside our control, but how our crews mitigated the risks was not. We had briefed the possibility of doing a night flight to Tallil during our previous morning's formation brief, but a simple reiteration of the brief's sticking points may have been enough to prevent the near-mishap. In particular, fatigue-induced complacency, poor communication, and poor situational awareness were our near-fatal errors. All of these factors could have been mitigated with better crew-resource management. Responsibility rests with everyone on the crew, but the HAC and mission commander share ultimate responsibility. They set the tone for the flight, and CRM always will suffer if a crew gets the impression they are tired or disinterested in the flight.

We had little communication within my aircraft or the formation that morning. Considering the environmental conditions and time of day, my HAC and mission commander should have been extra vigilant to maintain good communication and good CRM. They were not, and none of us stepped up in their absence. Had we simply addressed the environmental risks and the importance of keeping each other engaged in the flight, we might have prevented our near-mishap. Instead, our poor CRM and complacency brought us within 50 feet of one of the overland environment's greatest hazards.

If you hear that Navy flying is more dangerous than Army flying, take the comment with a grain of salt. Weather and illumination are no more reliable on land than at sea, and the overland environment sometimes deals you hazards you never would encounter over water. If you dismiss the risks and the need to maintain sound CRM, you may find yourself in a similarly dangerous situation. 

Ltjg. Teeter flies with HSC-21.



## Shifting Time Zones = INCREASED RISK

**BY LT THOMAS BARLOW (MC) AND  
LT DREW THOMAS**

**D**eployments put unique stressors on Sailors and Marines. Emotional, relational, financial, and physiological stress affects nearly everyone who goes forward in defense of our country. One common physiological stressor, the disruption of normal sleep, is often discounted in importance, but can be dangerous to operations. Our squadron learned this lesson the hard way.

During a recent deployment to 5th Fleet AOR, VP-40 deployed from NAS Whidbey Island, Wash., and arrived in Kuwait 22 hours later, a shift of 10 time zones. For aircrew, OPNAV 3710.7U acknowledges the problem of decreased performance for those who undergo significant time-zone shifts; it suggests an accommodation period of one day for every time-zone shift over three. For maintainers, the NAVOSH Program, OPNAV 5100.23G, also discusses jet lag and gives an example of a minimum two-day accommodation for a shift of six time zones

Once the squadron arrived, we allotted several days for sleep adjustment among aircrew. However, our maintainers began work shifts only two days after arrival to begin the lengthy turnover process. There was a great amount

of information to absorb, planes to transfer, and aircraft to launch. We pushed hard, perhaps too hard, and did not take into account the full effects of our travels.

Five days after arriving at our deployment site, and a total of seven days after leaving home, our squadron had a Class B ground mishap. During a night towing operation across an active runway, an aircraft hit its tow tractor because of a failed shear pin on the tow bar connecting the nose gear to the tractor. Following the investigation, the aviation mishap board (AMB) determined fatigue of the tow crew played a role in the events leading to the mishap.

As part of our squadron's analysis of the mishap, and in an effort to better understand the extent of the impairment caused by desynchronization, commonly known as jet lag, we used the fatigue avoidance scheduling tool (FAST) software to model the sleep of three individuals in our command. The FAST software program uses an individual's 72-hour sleep history and awake periods to model their likely effectiveness and equivalent blood-alcohol level. This tool is used after a mishap in determining if an individual's sleep, or lack thereof, may be a causal factor in the event.

The first individual modeled was the “perfect traveler.” He could fall asleep at any time and sleep anywhere. He slept well during the transoceanic flights and layovers, and had no difficulty falling asleep or staying asleep after arrival in theater. The second individual was the “normal traveler.” She got some sleep on the plane, but not much quality sleep, like most of us. Upon arrival, she was so tired that she quickly fell asleep, but woke up after a few hours because her circadian rhythms were telling her that it was daytime. The third individual modeled was the “stressed traveler.” He tried to get the best sleep possible but was worried about leaving his pregnant wife. With his sleep cycle off, he woke up a lot and could not get back to sleep because of worrying; in addition, he sacrificed some sleep time to contact his wife.

Despite the differences, all three personnel were impaired because their circadian rhythms were not aligned with their new time zone. During the course of a day, our level of awareness increases and decreases according to our circadian rhythm. We begin our mornings alert and awake, but after lunch, there is a natural decrease in our level of alertness, and we soon rebound. Around our normal bedtime, alertness significantly

## Circadian Rhythm Sleep Disorders

These two types of sleep disorders affect aircrew and maintainers:

- Jet lag, which affects people who travel across several time zones.
- Shift work sleep disorder, which affects people who work nights or rotating shifts.



drops. This circadian rhythm, or internal clock, does not automatically shift to match the sun just because we have travelled to another location. After awhile, the new cues that we supply (primarily light exposure, but also mealtimes, wake-up times and bed times) will shift this internal clock to match the new time zone. Until this shift takes place, we are not functioning at full capacity.

Based on FAST analysis, even the “perfect traveler” is predicted to be functioning at 71-percent effectiveness with a representative blood alcohol content (BAC) around the legal limit of 0.08 percent. This drop-off in performance is the result of lagging circadian rhythms, despite achieving 8.5 hours of sleep per night. The “normal traveler” only got six-to-seven hours of sleep each day, and the added impact of interrupted sleep limited her effectiveness to 63 percent of normal. The “stressed traveler” suffered even more sleep deprivation, getting a total of about six hours of uninterrupted sleep over the first few days of deployment. This put his estimated effectiveness at 59 percent, much worse than legally drunk.

When the models were extended for several days beyond the mishap, they reveal that full recovery from the circadian shift takes several days beyond the Navy’s

recommended accommodation periods, even for the “perfect traveler.” This situation emphasizes that the Navy guidelines provide the threshold for the minimum reasonable period, not full recovery.

A simple internet search will yield numerous suggestions on how to reduce the effects of jet lag. However, none of these methods are scientifically proven, nor are they accepted by any U.S. government agency. NASA uses light therapy on quarantined individuals to “slam-shift” astronauts to a new launch schedule within a week before launch. This option is not available to deploying units. The flight surgeons at the Naval Safety Center and School of Aviation Safety tell us that circadian accommodation occurs in about as many days as time zones shifted: A seven hour time shift requires seven days to make full accommodation, but most of the accommodation occurs within the first three to four days. Hence the 3710 series guidance of one hour per time zone over three: a seven-zone shift would require approximately four days to accommodate. What the OPNAV 3710 does not take into account is the individual differences in each sleeper.

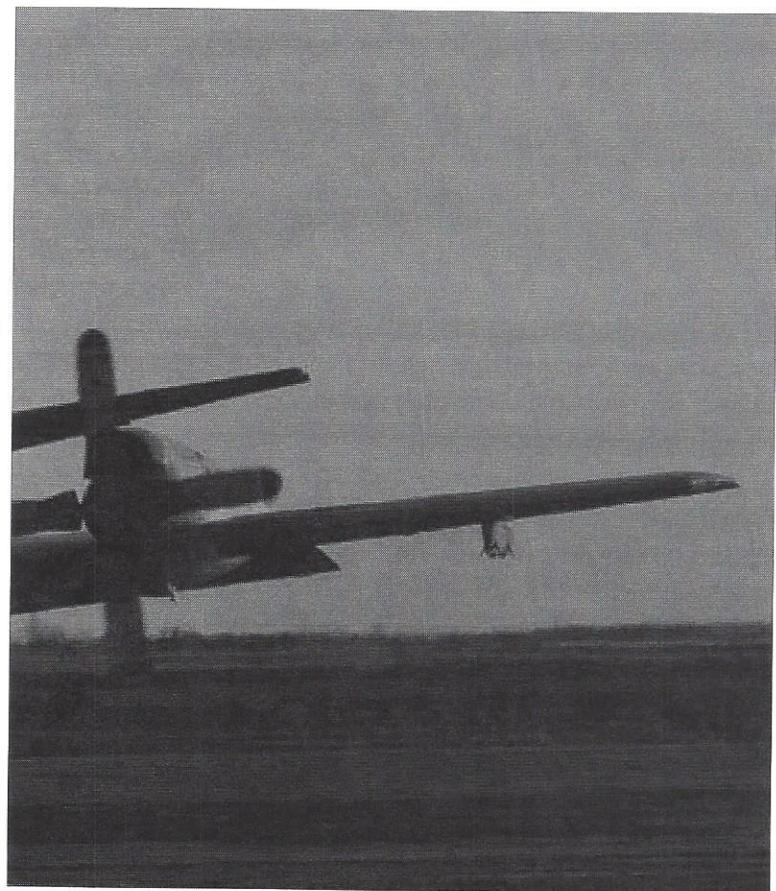
As with all safety issues, more knowledge enables better risk mitigation. Although most of the OPNAV 3710 crew-rest guidance appears to apply only to flight crew, the instruction specifically includes flight-support personnel as well (see section 8.3.2.1.1 Crew Rest for Flight Crew and Flight Support Personnel). Beyond existing NAVOSH and 3710 guidance, to better understand circadian rhythms and fatigue, we recommend you consult NAVMED P-6410 (Performance Maintenance During Continuous Flight Operations). Squadrons need to make every effort during predeployment work-ups to educate Sailors, Marines and their families to minimize external stressors.

There are no easy solutions. Operational deployment requirements will continue to make it difficult for commands to ensure complete recovery from the effects of travel. Leaders must recognize the real, tangible effects of intercontinental travel. As we do at the end of long shifts or during nighttime operations, increased vigilance and oversight of complex evolutions can mitigate the added risk brought about by fatigued personnel. 

LT BARLOW AND LT THOMAS ARE WITH VP-40.

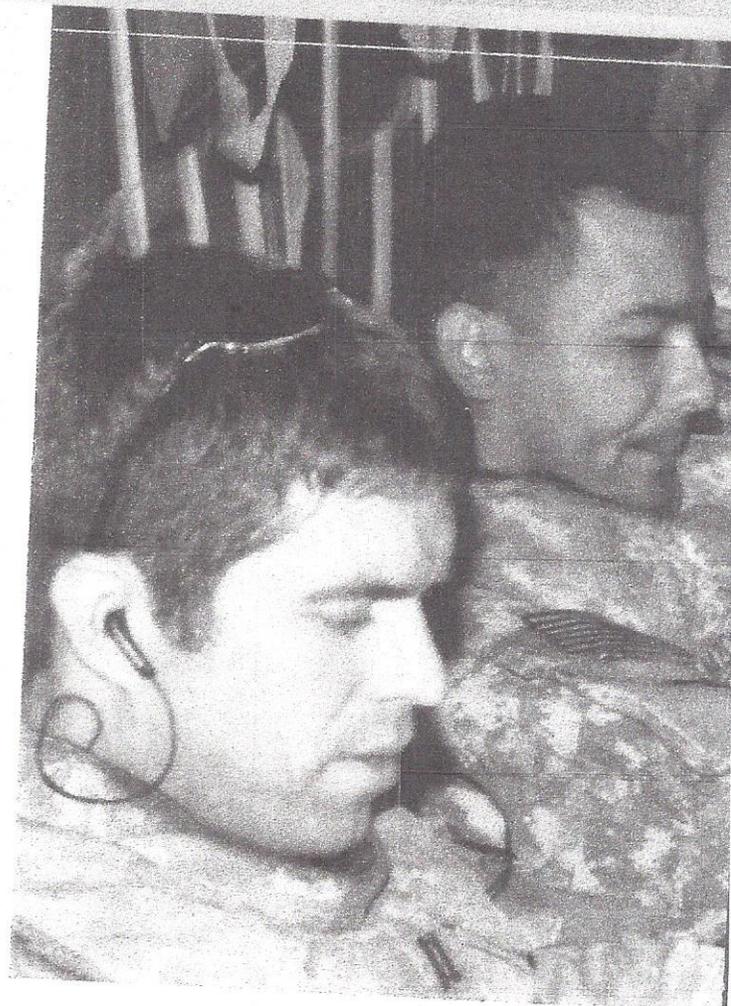
For more information on the FAST program, visit the Naval Safety Center webpage at: [http://www.public.navy.mil/navsafecen/Pages/aviation/aeromedical/FAST\\_for\\_NMCI.aspx](http://www.public.navy.mil/navsafecen/Pages/aviation/aeromedical/FAST_for_NMCI.aspx)

NAVMED P-6410 can be viewed at: <http://www.med.navy.mil/directives/Pub/6410.pdf>



# AIRCREW MEMBER FATIGUE AND CREW REST

By Lt Col Al "Jedi" Tankus, AMC/SEF



recently overheard a conversation about crew rest, and the individuals did not understand why aviators are authorized pre-mission down time. Crew rest is required in accordance with *Air Force Instruction 11-202V3, General Flight Rules*. The instruction prescribes crew rest and maximum flight duty periods (FDP) for aircrew members in U.S. Air Force aircraft, and it applies to all personnel who operate those aircraft. The crew rest period is normally a minimum 12-hour non-duty period before the FDP to ensure the aircrew member is adequately rested before performing flight or flight-related duties.

Why is this important for optimum mental and physical performance? Statistics show that fatigue and distractions generally have a detrimental impact on physical and cognitive performance regardless of the tasks involved. While all human beings experience fatigue in day-to-day activities, aircrew



Passengers rest and relax during a C-130 Hercules airlift mission over Iraq. This C-130 aircraft is with the 777th Expeditionary Airlift Squadron from Little Rock AFB, AR.

USAF PHOTO BY TSgt ERIK GEDDENDSON

members often experience it more severely due to constantly shifting flight times. When they do, it increases the risk to their lives and the lives of those with whom they are flying. For example, one of the most commonly cited causes of aviation mishaps is human error—things such as lack of attention to detail, cockpit/crew resource management issues, training deficiencies, or complacency—and fatigue can amplify any mistake.

Fatigue can be difficult to define, but one relatively accurate definition is, "a condition characterized by increased discomfort with lessened capacity for work, reduced efficiency of accomplishment, loss of power or capacity to respond to stimulation, usually accompanied by a feeling of weariness and tiredness." It is generally described as "tiredness from bodily or mental exertion" and is often characterized by deterioration in the quality of work, lack of enthusiasm, and inaccuracy.

In aviation, sleep loss and circadian disruption are two principal sources of fatigue. Sleep loss simply refers to insufficient sleep, causing a buildup of "sleep debt" that can result in uncontrolled sleep episodes, i.e. dozing off, once the sleep debt becomes high enough.

Aircrew members also experience circadian disruption—where the individual's internal clock is attempting to resynchronize to the external environment when moving to a new time zone or constantly shifting a person's natural body clock. The effects of work/rest cycle shifts parallel the effects of what is commonly referred to as "jet lag." When an individual shifts from a typical day-work/night sleep schedule to a day-sleep/night-work routine, the



body is forced to alter its normal schedule of melatonin production gradually. Since most work place environments are typically well lit at night, the effect is moderate. A worker who can find a dark place to rest during the day only has to endure gradually decreasing effects of a shift in their sleep cycle.

However, when aircrew members fly at night, they typically keep the flight deck/cockpit at fairly low light levels to better maintain night vision. This practice, while operationally sound, can magnify the effects of the work cycle shift, as the body is still experiencing periods—sometimes extended periods—of darkness or semi-darkness. This increases melatonin production while the individual is performing duties. So, crews moving from a day schedule to a night schedule not only have to endure the effects of the sudden shift in sleep cycle, but their bodies are more resistant to the change, extending the effect over a longer time period.

When the proper amount of sleep is not attained, the body's performance ability begins to suffer. A recent study examined the comparison between lack of sleep and blood alcohol content. After 17 hours of wakefulness, the body's performance and effectiveness began to decrease drastically to the point where, at 22 hours of wakefulness, the body had an equivalent blood alcohol content of .08%. In many states, this makes an individual too drunk to legally drive a vehicle.

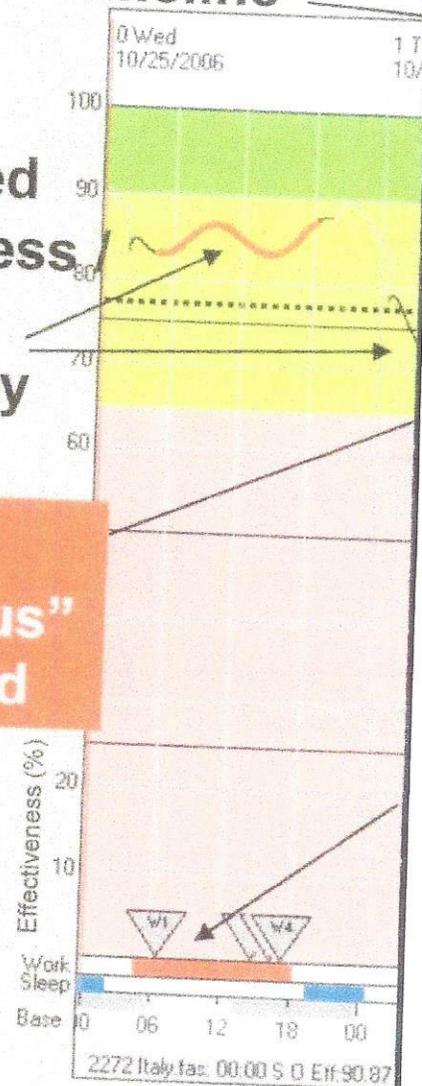
There are many ways of avoiding or alleviating aircrew fatigue. Proper scheduling, for example, is crucial to ensuring crew rest. The U.S. Department of Defense has sponsored and licensed a scheduling software program called Fatigue Avoidance Scheduling Tool (FAST) for military use. Based on a mathematical model, FAST uses graphical visualizations of predicted performance that allow units to schedule aviation and ground crews for maximum effectiveness in terms of day/night cycles and fatigue management. FAST is becoming more widespread in U.S. Naval aviation and is starting to make inroads in the U.S. Air Force as well.

The most important thing anyone can do to prevent fatigue is obvious: get whatever sleep you can, when you can. The average person requires approximately eight hours of sleep each night, and anything less will result in a "sleep debt" that must

## Mission Timeline

**Projected Effectiveness Mental Capacity**

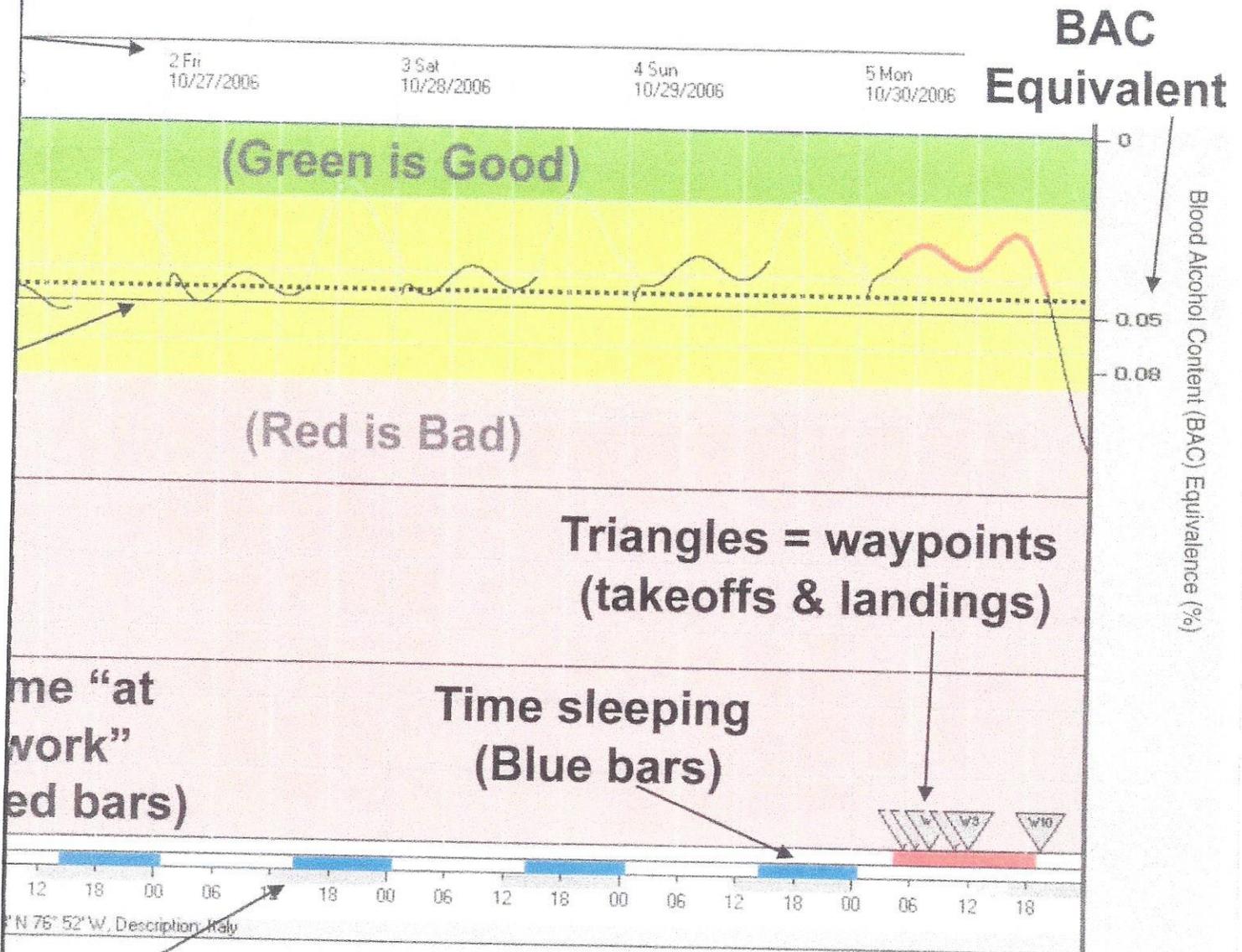
**75% = "Dangerous" threshold**



## Periods of darkness (gr local time zone)

be paid off eventually. When an individual sleeps less than his or her physiologically required duration or experiences poor quality sleep over successive periods, cumulative fatigue develops. Cumulative fatigue persists and results in worsening physical and mental performance until restorative sleep occurs.

Most individuals require two consecutive nights' sleep to fully recover from a significant sleep debt.



bars)

In essence, individuals with chronic sleep debt appear to cognitively shut down. The research seems to suggest that fatigue overloads the mind, leading the individual to abbreviate activities, ignore relatively unimportant information, and not perform redundant tasks.

Fatigue is a major, ever-present danger in civilian and military aviation resulting from physiological

and external factors, as well as personal habits. It affects the human body and an individual's performance and ability to perform a job. The key to fatigue management, however, as with many aviation-related hazards, is awareness. With proper scheduling, adjustment of personal habits, and mandated pre-mission rest, aircrew members can minimize fatigue. 🇺🇸

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# Chronic Fatigue Syndrome

- Author: Burke A Cunha, MD; Chief Editor: Michael Stuart Bronze, MD more...

Updated: Jul 13, 2012

## Background

Chronic fatigue syndrome (CFS) is a disorder characterized by a state of chronic fatigue that persists for more than 6 months, has no clear cause, and is accompanied by cognitive difficulties. It was initially termed encephalomyalgia (or myalgic encephalomyelitis) because British clinicians noted that the essential clinical features of CFS included both an encephalitic component (manifesting as cognitive difficulties) and a skeletal muscle component (manifesting as chronic fatigue).

Various unrelated infectious diseases (eg, pneumonia, Epstein-Barr virus [EBV] infection, diarrhea, upper respiratory tract infections) appear to lead to a state of prolonged fatigue in some persons. Generally, if this condition is accompanied by cognitive difficulties, it is referred to as CFS.

The cause of CFS is unknown, but the disorder is probably an infectious disease with immunologic manifestations. EBV has been excluded as a cause of CFS, even though EBV infection is one of the many causes that may lead to a state of chronic fatigue. CFS is not synonymous with chronic EBV infection or chronic infectious mononucleosis.

Because no direct tests aid in the diagnosis of CFS, the diagnosis is one of exclusion but that meets certain clinical criteria, which are further supported by certain nonspecific tests. The diagnosis of CFS also rests on historical criteria (ie, otherwise unexplained fatigue for more than 6 months accompanied by cognitive dysfunction). The absence of cognitive dysfunction should exclude CFS as a potential diagnosis.

Because no cause of CFS has been determined, no effective therapy exists for CFS.

For patient education resources, see the Back, Ribs, Neck, and Head Center, as well as Chronic Fatigue Syndrome, Fibromyalgia, and Fatigue.

## Diagnostic criteria

According to the Centers for Disease Control and Prevention (CDC),<sup>[1]</sup> in order to receive a diagnosis of CFS, a patient must (1) have severe chronic fatigue of at least 6 months' duration, with other known medical conditions excluded by clinical diagnosis, and (2) concurrently have 4 or more of the following symptoms:

- Substantial impairment in short-term memory or concentration
- Sore throat
- Tender lymph nodes
- Muscle pain
- Multijoint pain without swelling or redness

- Headaches of a new type, pattern or severity
- Unrefreshing sleep
- Postexertional malaise lasting more than 24 hours

The symptoms must have persisted or recurred during 6 or more consecutive months of illness and must not have predated the fatigue.

The CDC case definition also states that any unexplained abnormality detected on examination or other testing that strongly suggests an exclusionary condition must be resolved before further classification is attempted. Conditions that do not exclude CFS include the following:

- Any condition defined primarily by symptoms that cannot be confirmed by diagnostic laboratory tests, including fibromyalgia, anxiety disorders, somatoform disorders, nonpsychotic or melancholic depression, neurasthenia, and multiple chemical sensitivity disorder
- Any condition under specific treatment sufficient to alleviate all symptoms related to that condition and for which the adequacy of treatment has been documented, including hypothyroidism for which the adequacy of replacement hormone has been verified by normal thyroid-stimulating hormone levels, or asthma in which the adequacy of treatment has been determined by pulmonary function and other testing
- Any condition, such as Lyme disease or syphilis, that was treated with definitive therapy before development of chronic symptoms
- Any isolated and unexplained physical examination finding, or laboratory or imaging test abnormality that is insufficient to strongly suggest the existence of an exclusionary condition, including an elevated antinuclear antibody titer that is inadequate, without additional laboratory or clinical evidence, to strongly support a diagnosis of a discrete connective tissue disorder

In children, CFS is poorly defined. Most studies of CFS in the pediatric age range have followed the CDC criteria. However, whether the adult CDC case definition can be applied to children and adolescents is debatable.

Children have typically been referred to specialty clinics after extensive screening by their primary care physician has yielded negative or nonspecific test results. Therefore, common short-lived causes of fatigue are effectively excluded. The length of fatigue (6 months) also effectively excludes many common illnesses and probably should be retained in any forthcoming pediatric case definition.

## Pathophysiology

Because the immune system is upregulated in CFS, the levels of antibodies to various previously encountered antigens are increased. Although increased titers do not indicate a causal relationship in CFS, the titers are nonetheless useful as laboratory clues, which, when taken together, are common in patients with CFS.

Because so many patients with a possible diagnosis of CFS are found to have elevated levels of immunoglobulin G (IgG) viral capsid antigen (VCA) EBV, this determination should be considered as an incidental finding in CFS. Most patients with CFS demonstrate elevated IgG, coxsackievirus B, human herpesvirus 6 (HHV-6), and/or *C pneumoniae* titers. Patients with CFS also commonly have a decreased percentage of natural killer (NK) cells. Most patients with CFS have 2 of the 3 above-mentioned immunological abnormalities.

## Etiology

Many viruses have been studied as potential causal agents, including EBV, HHV-6, coxsackievirus B, spumaviruses, and even human T-cell leukemia virus strains; however, no definitive causal relation has been determined. A role for xenotropic murine leukemia virus–related virus (XMRV) and other murine retroviruses was posited,<sup>[2, 3]</sup> but XMRV has been ruled out as a cause of CFS.<sup>[4, 5, 6, 7]</sup>

Patients with CFS are often referred to an infectious disease specialist because of elevated levels of immunoglobulin G (IgG) to the viral capsid antigen (VCA) of EBV. Increased IgG titers to the VCA of EBV are common in the general population, regardless of whether the patient is fatigued. An increased IgG VCA EBV titer indicates past exposure to EBV but does not indicate acute disease or explain the patient's chronic fatigue state. EBV infection is often the precipitating event that has triggered the patient's chronic fatigue.

Some have suggested that the infectious agent responsible for CFS is *Chlamydia pneumoniae*, which may become activated after contact with another infectious agent. In hospitals or commercial laboratories, immunoglobulin M (IgM)

tests and IgG enzyme-linked immunosorbent assay (ELISA) are used to test for *C pneumoniae*. As with elevated EBV IgG VCA titers, many individuals in the healthy population have elevated IgG titers to *C pneumoniae*.

Some patients with CFS are found to have elevated IgM *C pneumoniae* titers, indicating a recent *C pneumoniae* infection, and these patients are the most likely to respond to antichlamydial therapy. However, definitive proof supporting causality is lacking.<sup>[8, 9]</sup>

Some investigators studying the potential role of *C pneumoniae* in CFS believe that serum tests are insensitive and that a more sensitive test (eg, polymerase chain reaction [PCR]) should be used for evaluation. PCR for *C pneumoniae* is a very sensitive technique but, unfortunately, is available only in research centers.

*Candida albicans* and other yeast infections do not cause CFS.

## Epidemiology

CFS is common in the United States, but the data are difficult to interpret because the various studies define CFS in different ways. Outside the United States, CFS appears to be less common, but it probably exists worldwide. Overall, CFS is more common in females than in males.<sup>[10]</sup> It occurs most commonly in young to middle-aged adults.

## Prognosis

As suggested by the term chronic, the clinical course of CFS is punctuated by remissions and relapses, often triggered by intercurrent infection, stress, exercise, or lack of sleep. The course in adolescents is similar to that in adults.

Most cases improve to some degree over time.

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## Fatigue

Fatigue is when a person feels a strong need to rest and has so little energy that starting and sustaining activity is difficult. Fatigue is normal after physical exertion, prolonged stress, and sleep deprivation. However, fatigue that increases and develops after activities that previously did not cause it may be one of the symptoms, or occasionally, the first symptom of a disorder.

### Causes

Most serious and many minor illnesses cause fatigue. However, most of these disorders have other more prominent symptoms (for example, pain, cough, fever, or jaundice) that are likely to bring the person to the doctor. This discussion focuses on disorders in which fatigue is the first or most severe symptom.

**Common causes:** There is no firm dividing line between causes based on duration of fatigue. However, doctors find that certain causes tend to be more common depending on how long people have had fatigue before they seek medical care.

**Recent fatigue** (lasting less than 1 month) has many causes but the most common are the following:

- Drug adverse effects
- Anemia
- Stress and/or depression

For **prolonged fatigue** (lasting 1 to 6 months), the most common causes are the following:

- Diabetes
- An underactive thyroid gland (hypothyroidism)
- Sleep disturbances (such as sleep apnea)
- Cancer

For **chronic fatigue** (lasting longer than 6 months), the most common causes are the following:

- Chronic fatigue syndrome
- Mental health disorder (such as depression)
- Drug adverse effects

Chronic fatigue syndrome (see [Disorders of Unknown Cause: Chronic Fatigue Syndrome](#)) is a disorder of unknown cause that results in fatigue and certain other symptoms. Not everyone who has fatigue for no apparent reason has chronic fatigue syndrome.

**Less common causes:** Stopping cocaine can cause severe recent fatigue. Less common causes of prolonged or chronic fatigue include adrenal gland underactivity and pituitary gland underactivity.

### Evaluation

Fatigue can be highly subjective. People vary in what they consider to be fatigue and how they describe it. There are also few ways to objectively confirm fatigue or tell how severe it is. Doctors usually start an evaluation by trying to distinguish true fatigue from other symptoms that people may refer to as fatigue.

- **Weakness:** Weakness (see [Symptoms and Diagnosis of Brain, Spinal Cord, and Nerve Disorders: Weakness](#)) is lack of

muscle strength that makes it difficult for people to move the affected muscles. Weakness is typically a symptom of a nervous system or muscle disorder. Disorders such as myasthenia gravis and Eaton-Lambert syndrome can cause weakness that worsens with activity, which may be confused with fatigue.

- Shortness of breath: People, such as those with certain heart and lung disorders, become short of breath with activity but do not feel fatigued at rest.
- Drowsiness: Excessive sleepiness (see [Sleep Disorders: Insomnia and Excessive Daytime Sleepiness](#)) is a symptom of sleep deprivation (for example, caused by lifestyle or by disorders such as allergic rhinitis, esophageal reflux, painful musculoskeletal disorders, sleep apnea, and severe long-lasting disorders). Yawning and lapsing into sleep during daytime hours are common. However, many people with fatigue have disturbed sleep, so symptoms of sleep deprivation and fatigue can overlap.

**Warning signs:** In people with fatigue, certain symptoms and characteristics are cause for concern. They include

- Persistent, unintentional weight loss
- Chronic fever or night sweats
- Swollen lymph nodes throughout the body
- Muscle weakness and/or pain
- Serious accompanying symptoms (for example, coughing up or vomiting blood, bloody or black stools, shortness of breath, swelling in the abdomen, confusion, or suicidal thoughts)
- Involvement of more than one organ system (for example, rash plus joint pain and stiffness)
- Headache or loss of vision, particularly with muscle pains, in an older adult
- Older age (for example, older than about 65 years)

**When to see a doctor:** All people feel fatigue occasionally, and not every case of fatigue requires evaluation by a doctor, particularly those that accompany an acute illness (such as an acute infection) or that go away after a week or so. However, fatigue that seems to last longer or has no obvious explanation should be evaluated.

Older adults with a new or different headache or loss of vision and people who have serious accompanying symptoms should see a doctor immediately. Even if they have no other symptoms, older adults with fatigue should see their doctor as soon as possible. Other people who have other warning signs should see a doctor in a few days. People who have no warning signs should call their doctor. The doctor can decide how quickly they need to be seen. Typically a delay of a week or so is not harmful.

**What the doctor does:** Doctors first ask questions about the person's symptoms and medical history. Doctors then do a physical examination. What they find during the history and physical examination often suggests a cause of the fatigue and the tests that may need to be done (see [Nonspecific Symptoms: Some Common Causes and Features of Prolonged or Chronic Fatigue](#)).

Doctors ask the person

- To describe what is meant by fatigue as precisely as possible
- How long fatigue has lasted
- When fatigue occurs in relation to rest and activity
- What other symptoms occur (such as fever, night sweats, or shortness of breath)
- What measures relieve or worsen fatigue
- How fatigue affects the person's work and social activities

Women are asked about their menstrual history. All people are asked about diet, anxiety, depression, and alcohol and drug use (including use of over-the-counter and recreational drugs).

Doctors then do a physical examination. Because many disorders can cause fatigue, the physical examination is very thorough, particularly in people with chronic fatigue. In particular, doctors also do a neurologic examination to evaluate the person's muscle strength and tone, reflexes, gait, mood, and mental status. The history and physical examination are more likely to reveal the cause of fatigue of more recent onset. A cause is also more likely to be found when fatigue is one of many symptoms than when fatigue is the only symptom. Fatigue that worsens with

activity and lessens with rest suggests a physical disorder.

**Some Common Causes and Features of Prolonged or Chronic Fatigue**

Cause	Common Features*	Tests
<b>Blood disorders or cancers</b>		
Anemia	Decreased exercise tolerance with shortness of breath during activity greater than expected for the activity  Sometimes paleness	CBC
Cancers (such as digestive tract cancer, lung cancer, leukemia, lymphoma, multiple myeloma)	Widespread lymph node swelling, weight loss, and night sweats  With multiple myeloma, low back or other bone pain, often severe at night	CBC
<b>Infections</b>		
Chronic hepatitis	Sometimes jaundice, loss of appetite, and fluid in the abdomen	Blood tests to determine how well the liver is functioning and to identify the hepatitis virus  Sometimes liver biopsy
Cytomegalovirus infection	Enlarged spleen and lymph nodes, fever, and night sweats	Sometimes blood tests for antibodies to cytomegalovirus
Heart valve infection (endocarditis)	Fever and night sweats  Sometimes joint pains  Usually in people who have heart murmurs or inject drugs intravenously	Cultures of blood samples and echocardiography
HIV/AIDS	Fever, night sweats, and frequent infections  Sometimes difficulty breathing, cough, diarrhea, and/or	HIV blood test

	rash	
Mononucleosis	Recent sore throat and lymph node swelling	Mononucleosis blood test
Other infections (for example, fungal pneumonias such as histoplasmosis, parasitic infections, or tuberculosis)	Fever, night sweats, and weight loss	Tests based on which type of infection seems likely
	Sometimes cough, difficulty breathing, and coughing up blood	
<b>Other disorders and causes</b>		
Chronic kidney disease	Shortness of breath, difficulty breathing when lying down that is relieved when upright (orthopnea), and/or swelling	Blood tests of kidney function
Connective tissue disorder (for example, rheumatoid arthritis or systemic lupus erythematosus [lupus])	Fever, night sweats, weight loss, joint pain, rash, and/or other organ involvement (for example, effects on the heart or lungs)	Blood tests for abnormal antibodies
Deconditioning	A history of lack of exercise or being bedbound or hospitalized	Only a doctor's examination
Diabetes (sometimes, other symptoms often more prominent)	Excessive thirst, excessive urination, increased appetite, and unexplained weight gain or loss	Measurement of sugar (glucose) level in the blood after the person fasts overnight and sometimes glucose tolerance testing
Drugs: Antidepressants, older antihistamines, antihypertensives, diuretics that cause low potassium levels in the blood, muscle relaxants, recreational drugs, and sedatives	History of taking a drug known to cause fatigue	Only a doctor's examination
Giant cell arteritis	Headache, pain in the jaw when chewing, pain	ESR and temporal artery biopsy

	when combing hair, loss of vision, and/or muscle pains in a person over 50	
Mental health disorders: Anxiety, depression, drug addiction, panic disorder, or somatization disorder (physical symptoms caused mainly by anxiety)	Anxiety, sadness, loss of appetite, and unexplained sleep disturbance  With somatization disorder, an excessive preoccupation with physical symptoms	Only a doctor's examination
Multiple sclerosis	Fatigue worse with exposure to heat  Past symptoms of nervous system malfunction (such as, numbness, loss of coordination, and weakness), particularly if people had more than one episode of symptoms	Brain and/or spinal cord MRI
Pregnancy	Cessation of menstrual periods, breast tenderness, morning sickness, and abdominal swelling	Pregnancy test
Sleep disorders	Excessive daytime sleepiness, frequent awakenings, breathing interruptions during sleep, difficulty falling asleep, unrefreshing sleep	Sleep laboratory testing (polysomnography)
Underactive thyroid gland (hypothyroidism)	Inability to tolerate cold, weight gain, constipation, and coarse skin	Blood tests of thyroid function
Undernutrition	Weight loss  Sometimes loss of appetite, foul-smelling stool, abdominal pain, or a combination	A doctor's examination  Sometimes other tests

Disorders of unknown cause		
Chronic fatigue syndrome	Sore throat, sleep that is not refreshing, difficulty with concentration or short-term memory, muscle aches, joint pain, headaches, and/or tender lymph nodes in the neck or under the arms	Only a doctor's examination
Fibromyalgia	Long-standing and widespread muscle and bone pain in areas outside the joints, trigger points, lower abdominal pain, gas, bloating, constipation or diarrhea, migraines, and anxiety	Only a doctor's examination

\*Features include symptoms and the results of the doctor's examination. Features mentioned are typical but not always present.

CBC = complete blood count; ESR = erythrocyte sedimentation rate; HIV = human immunodeficiency virus; MRI = magnetic resonance imaging.

**Testing:** The need for tests depends on what doctors find during the history and physical examination. For example, doctors test for human immunodeficiency virus infection and tuberculosis if people have risk factors. Testing for other infections or cancer is usually done only when people's findings suggest these causes. In general, people who have had fatigue for a long time and those who have warning signs are more likely to require testing.

If people do not have any other findings besides fatigue, many doctors do a few common blood tests. For example, they may do a complete blood count, blood tests to measure liver, thyroid gland, and kidney function, and a blood test called the erythrocyte sedimentation rate that suggests the presence of inflammation. However, such blood testing often does not reveal the cause.

### Treatment

Treatment is directed at the cause. People with chronic fatigue syndrome or fatigue with no clear cause may be helped with physical therapy that includes increasing degrees of exercise and by psychologic support (for example, cognitive behavioral therapy).

### Essentials for Older People

Although it is normal for people to slow down as they age, fatigue is not normal. Fatigue is more often the first symptom of a disorder in older people. For example, the first symptom of a urinary tract infection in an older woman may be fatigue, rather than any urinary symptoms (such as burning during urination, frequent urination, or blood in the urine). Older people with pneumonia may have fatigue before they have a cough or fever. In older people, the first symptom of other disorders, such as giant cell arteritis, may also be fatigue. Because serious illness may become apparent soon after sudden fatigue in older people, it is important to determine the cause as quickly as

possible.

## Key Points

- Fatigue is a common symptom.
- Fatigue caused primarily by a physical disorder increases with activity and lessens with rest.
- If a doctor uncovers no findings suggesting a cause of fatigue, tests are often not helpful in identifying the cause.
- Successful treatment of chronic fatigue may take work and persistence.
- Fatigue in older people is not a normal part of aging.

Last full review/revision March 2013 by Michael R. Wasserman, MD

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## Federal Aviation Administration

# Fact Sheet – Pilot Flight Time, Rest, and Fatigue

## For Immediate Release

January 27, 2010

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Ensuring that all pilots receive adequate rest is key to maintaining a safe aviation system. FAA Administrator Randy Babbitt has made the creation of new flight, duty, and rest rules based on fatigue science a high priority. The FAA is working on an aggressive timeline to issue a new proposal this spring.

Airplanes operate globally in 24 time zones. Domestic short leg, multi-leg, and long-haul flights all present challenges. Engine technology has evolved enabling airplanes to fly much further than in the past. Since many air carriers fly non-stop ultra-long-range flights, the FAA continues to evaluate the latest research on the effects of time zone changes on circadian rhythm and time zone changes to mitigate pilot fatigue. The FAA continues to be at the forefront of raising awareness of fatigue and mitigation techniques.

The FAA last proposed updating the rules in 1995 but, based on industry comments, the rule was not adopted. Since then, the agency has reiterated the rules and kept pace with a changing industry by allowing airlines to use the latest fatigue mitigation techniques to enhance safety.

## Overview of the Current Federal Aviation Regulations

Regulations limiting flight time and pilot rest have been in place since the 1940s. The rules for domestic flights do not explicitly address the amount of time a pilot can be on duty. Rather, the rules address flight time limitations and required rest periods. Current FAA regulations for domestic flights generally limit pilots to eight hours of flight time during a 24-hour period. This limit may be extended provided the pilot receives additional rest at the end of the flight. However, a pilot is not allowed to accept, nor is an airline allowed to assign, a flight if the pilot has not had at least eight continuous

hours of rest during the 24-hour period. In other words, the pilot needs to be able to look back in any preceding 24-hour period and find that he/she has had an opportunity for at least eight hours of rest. If a pilot's actual rest is less than nine hours in the 24-hour period, the next rest period must be lengthened to provide for the appropriate compensatory rest. Airline rules may be stricter than the FAA's regulations if the issue is part of a collective bargaining agreement.

Flight time and rest rules for U.S. air carrier international flights are different from the rules for domestic flights. International flights can involve more than the standard two-pilot crew and are more complex due to the scope of the operations. For international flights that require more than 12 hours of flight time, air carriers must establish rest periods and provide adequate sleeping facilities outside of the cockpit for in-flight rest.

An air carrier may not schedule any pilot and no pilot may accept an assignment for flight time in scheduled air transportation or other commercial flying if that pilot's total flight time will exceed the regulatory limits.

It is the responsibility of both the air carrier and the pilot to prevent fatigue, not only by following the regulations, but also by acting responsibly while serving the traveling public. This means taking into consideration weather conditions, air traffic, the health of each pilot, and any other personal circumstances that may affect a pilot's performance. The FAA has recommended that air carriers include fatigue training as part of their crew resource management training programs.

## FAA Actions

### Withdrawal of the 1995 Proposal

In order to move forward with a new rule, the FAA formally withdrew the old proposal by publishing a notice in the *Federal Register* on November 23. The notice reiterated that the 1995 proposal was outdated and raised many significant issues.

### Fatigue ARC

On June 24, Administrator Babbitt announced that the FAA would undertake an expedited review of flight and rest rules. This followed Administrator Babbitt and U.S. Secretary of Transportation Ray LaHood's June 15 meeting with airline safety executives and pilot unions to strategize on how to best reduce risk at regional airlines. The FAA chartered an Aviation Rulemaking Committee (ARC), which began work in July. The ARC, which consisted of representatives from FAA, industry, and labor organizations, was charged with producing recommendations for a science-based approach to fatigue management by September 1. The ARC met their deadline and provided the FAA with a broad framework for drafting the basis for a Notice of Proposed Rulemaking (NPRM).

## 2008 FAA Fatigue Symposium

In June 2008, the FAA sponsored the *Fatigue Symposium: Partnerships for Solutions* to encourage the aviation community to proactively address aviation fatigue management issues. Participants included the National Transportation Safety Board, the Institutes for Behavior Resources, Inc., and many of the world's leading authorities on sleep and human performance. The symposium provided attendees with the most current information on fatigue physiology, management, and mitigation alternatives; perspectives from aviation industry experts and scientists on fatigue management; and information on the latest fatigue mitigation initiatives and best practices.

## Ultra Long-Range Flights

In 2006, the FAA worked with Delta Air Lines to develop and approve fatigue mitigation for flights between John F. Kennedy International Airport and Mumbai, India. The flights were operated for more than 16 hours with four pilots provided that the airline followed an FAA-approved plan to manage rest and mitigate the risk posed by fatigue. The mitigation, approved as an Operations Specification issued to Delta Air Lines, was specific for that city pair. Although that specific route is no longer flown by Delta, the FAA viewed Delta's fatigue mitigation strategy as a model program.

As a result of Delta's efforts, the FAA proposed in November 2008 to amend Delta's, American's, and Continental's Operations Specifications to incorporate fatigue mitigation plans for their ultra long-range flights. Based on comments received from the three air carriers, the FAA withdrew the proposed amendments on March 12, 2009. The FAA is currently working with airlines to gather data that will help the agency enhance the safety requirements for ultra long-range flights. The agency believes that it is in the best interest of passenger and crew safety for airlines to use an FAA-approved fatigue mitigation program to reduce the risk of pilot fatigue.

## 2001 ATA/RAA Request

The FAA denied requests made on June 12, 2001 on behalf of the Air Transport Association (ATA) and Regional Airline Association (RAA) to stay all agency action regarding the November 20, 2000 Whitlow letter of interpretation and the May 17, 2001 *Federal Register* notice of the FAA's enforcement policy regarding pilot flight time and rest. The FAA's letter and *Federal Register* notice were consistent with the agency's long-standing interpretation of the current rules. The documents were consistent with the statutory mandate to issue rules governing the maximum hours or periods of service, the use of plain language in regulations and the regulatory history of the rules. ATA subsequently petitioned for review of the Whitlow letter and the enforcement policy.

On Sept. 5, 2001 the U.S. Court of Appeals for the District of Columbia granted a motion by the ATA to stay the May 17, 2001 Federal Register notice. On May 31, 2002, the court denied ATA's petition for review, ruling in favor of the FAA.

35

### **2001 Federal Register Notice**

An FAA in the May 17, 2001 *Federal Register* reiterated the agency's long-standing interpretation of pilot flight time and rest rules. The notice informed airlines and flight crews of the FAA's intent to enforce its rules in accordance with the Whitlow letter. Each flight crewmember must have a minimum of eight hours of rest in any 24-hour period that includes flight time. That calculation must be based on the actual conditions on the day of departure regardless of whether the length of the flight is longer or shorter than the originally scheduled flight time. The FAA did not anticipate that the notice would result in major disruptions to airline schedules. Beginning November 2001, the FAA would review airline flight scheduling practices and deal stringently violations. The U.S. Court of Appeals for the District of Columbia granted a stay of the notice.

### **2000 FAA Letter**

On November 20, 2000, the FAA responded to a letter from the Allied Pilots Association that set forth specific scenarios that could affect a very small number of all commercial pilots. The FAA's response, known as the "Whitlow Letter," was consistent with the agency's long-standing interpretation of the current rules. In summary, the FAA reiterated that each flight crewmember must have a minimum of eight hours of rest in any 24-hour period that includes flight time. The scheduled flight time must be calculated using the actual conditions on the day of departure regardless of whether the length of the flight is longer or shorter than the originally scheduled flight time.

### **1999 Federal Register Notice**

In response to concerns raised by the pilot community, the FAA Administrator notified the aviation community on June 15, 1999 that it had six months to ensure that it was in full compliance with the agency's current flight time and rest requirements. Reviews of airline scheduling practices conducted in December 1999 and discussions with pilot unions and airlines confirmed that the vast majority of pilots are receiving the amount of rest required by the FAA's rule.

### **1998 ARAC**

In July 1998, the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC) to work with the industry to reach a consensus and develop a new proposal. If no consensus could be reached, the FAA would subsequently enforce the current regulations. In February 1999, ARAC reported that there was no consensus. The group offered five different proposals to update the flight and rest regulations.

### **1995 Proposal for Pilots**

In 1995, the FAA proposed a rule to change flight time and rest limits. The agency received more than 2,000 comments from the aviation community and the public. Most of those comments did not favor the rule as proposed, and there was no clear consensus on what the final rule should say. Highlights of the 1995 proposal:

36

- Reduce the number of duty hours (the time a flight crewmember is on the job, available to fly) from the current 16 hours to 14 hours for two-pilot crews. It would have allowed up to 10 flight hours in the 14 duty hours. Current rules allow up to 16 hours continuous duty time.
- Additional duty hours would be permitted only for unexpected operational problems, such as flight delays. In no event could such delays add more than two hours to the pilot's duty day.
- Airlines could no longer schedule pilots in advance that exceeds the duty time.
- To ensure that pilots have an adequate opportunity to rest, off-duty time would be increased from eight hours to 10 hours under the proposal.
- Pilots would have to be given at least one 36-hour off-duty period every seven days. Current rules call for a 24-hour period.

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This page was published at: [http://www.faa.gov/news/fact\\_sheets/news\\_story.cfm?newsId=6762](http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=6762)

37

# Fatigue in Naval Aviation

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*Note: The opinions or assertions contained in this article are the private views of the author, and are not to be construed as official or reflecting the opinions of the Department of the Navy or the Department of Defense. The author has no material interest, financial interest, or other relationship, with Science Applications International Corp. (SAIC) or the Fatigue Avoidance Scheduling Tool (FAST™). This article was originally published in CONTACT, the Newsletter of the Society of U.S. Naval Flight Surgeons, Volume 29, Numbers 2, 3 & 4; April, July & October 2005.*

## Part 1

Suppose your squadron is on the last leg of a flight back to home base from a typically busy at-sea workup period. The crews have gassed up, grabbed a bite to eat at the air station gedunk, and are ready to man-up. Your Skipper asks one of the pilots how he's doing, and he replies, "Skipper, I'm good to go – I'm just a little tired."

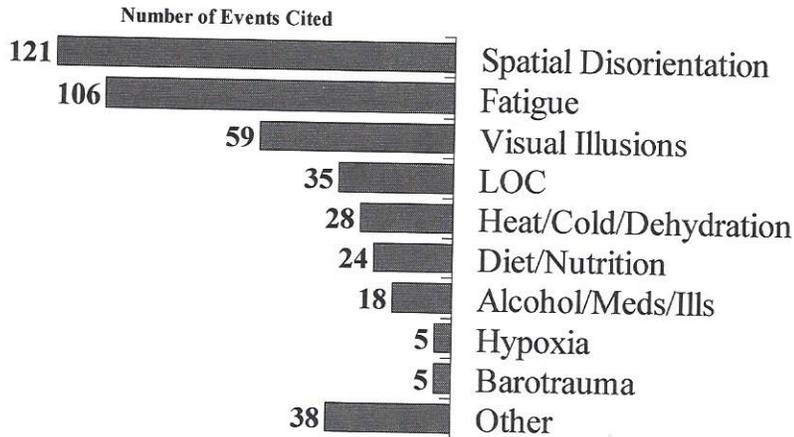
You can probably imagine how the CO might respond. Maybe he'd ask "you really OK?" expecting some self-assessment and reassurance that his pilot was up for the mission. Or perhaps "yeah, so am I – let's go!"

Now change the scenario just a bit. Suppose your aviator replied, "Skipper, I'm good to go – I'm just a little drunk."

I use this example as an intro to the lecture on fatigue I give Aviation Safety Officers and prospective Commanders here at the School, and typically get a snort and chuckle. It's obviously a ridiculous scenario, since no one would drink before flying, or climb into a plane while intoxicated. But we do fly, and drive, and engage in lots of other demanding activities in a fatigued state. Often we have no choice, and for those of us who have suffered through typically busy residency programs or work-up periods at sea, we've gotten very familiar with the experience. And doctors, aviators and others, of course, make these decisions based on experience, common sense, and knowledge of the data.

So let's look at the data. In an informal review I did of data from the Naval Safety Center on aviation mishaps and hazard reports during the period 1997-2002, I looked for aeromedical factors which were cited as contributory. Over half of the reports had one or more aeromedical factors listed, and when plotted they looked like this (Figure 1.):

# Aeromedical Factors Cited in Mishaps & HAZREPS



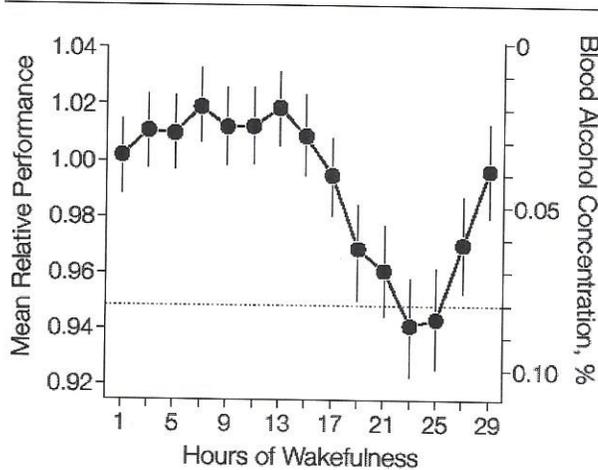
*CAPT Nick Davenport: NAVSAFECEN Data 1997 - 2002*

Figure 1.

You'll notice that alcohol is buried along with medication usage and illnesses in general as causal factors, but fatigue was cited as #2, second only to spatial disorientation in these reports. The data seems to suggest that fatigue is a much greater hazard than alcohol. But that seems contrary to our common experience. Is this a statistic leading us to a ridiculous conclusion, or is there something wrong with our current understanding of fatigue as a hazard? My aviators correctly observe that this data is skewed, since we know better than to fly while drinking – it's prohibited by NATOPS. But if you look at NATOPS Chapter 8, on rest, sleep, and flight time, you'll find some suggested guidance on what is ideal regarding work and sleep, but little in the way of mandated rules. So the denominator for flying while drunk is much smaller than it is for those who are flying fatigued - we know better! That's why it appears that fatigue is a greater risk – the number who are exposed to this hazard is much greater.

Someone once said that "statistics can be made to prove anything – even the truth." Let's look at some more data. In 1997, Australian researchers reported in *Nature* a study they did where they compared the effects of fatigue and wakefulness to the effects of alcohol intoxication (1). Reprinted is the following graph:

**Figure.** Effect of Sleep Deprivation on Psychomotor Performance Compared With Blood Alcohol Concentration



The legal limit for blood alcohol concentration while driving a motor vehicle is as low as 0.08% (dotted line) in some states. Mean relative performance is expressed as percentage of performance at the start of the session. The effects of sleep deprivation on psychomotor performance become equivalent to the effects of acute alcohol intoxication in the early morning after nearly 24 hours without sleep. Reproduced with permission from *Nature* (<http://www.nature.com/>).<sup>8</sup>

Figure 2.

These researchers discovered similar decrements in performance after 22 hours of sleep deprivation to that seen at a blood-alcohol level of 0.08% - legally drunk! Fatigue-alcohol studies have been replicated by a variety of researchers, who have shown that, although there are some specific differences in levels of performance on individual tests, alcohol and fatigue produce similar levels of performance deterioration. Why do we tolerate aviators flying fatigued when we'd never allow them to fly drunk? Maybe we need to revise our views on fatigue. Let's review our current information on fatigue physiology and sleep deprivation.

The human brain is an extremely complex electro-chemical digital computer. It is estimated to have over 100 billion neurons and many more synapses (logic gates). It cannot run continuously in the awake state. Mammals that are kept awake for indefinite times die – around 2-4 weeks – from insulin resistance, immune system failure and sepsis. With continual awake activity, the neurons may deplete required stores of neurotransmitters and substrate and may accumulate free radicals and cellular damage – much of this is currently being studied. As the brain continues in wakefulness, performance, as measured on a variety of tests, declines. We interpret this as an accumulation of “fatigue.” The brain requires regularly-scheduled maintenance and repair intervals to maintain computing efficiency, which we know as sleep. Sleep is as necessary for survival as oxygen, water, and nutrition. Since we evolved around a 24-hour day, these repair intervals follow a 24-hour cycle, and are governed by circadian rhythms.

There are hundreds of individual processes in the body which proceed on 24-hour cycles, and are kept in synchrony by “the circadian rhythm.” It is helpful to consider the circadian rhythm as an alerting signal which programs the brain when to fall asleep and when to wake up. As the brain fatigues, the circadian alerting rhythm helps prop up alertness to maintain relatively constant performance throughout the day. When the depleted brain approaches the normal time of sleep, the circadian alerting rhythm starts declining, unmasking the fatigue and signaling the brain to switch to sleep mode. As the brain recovers during sleep, the circadian alerting rhythm continues its decline to keep the brain asleep until a full 8 hours of sleep has been accomplished. Now restored, when the circadian rhythm begins to alert again, the brain wakes up to start another day. In a well-rested brain without a sleep debt, the periodicity of this circadian clock is remarkably accurate, as you’ll notice on those occasions when you wake up within a minute or two before your alarm clock goes off.

Much research has been done on sleep, and studies are ongoing to help better understand the need for Rapid Eye Movement (REM) sleep, deep or non-REM sleep, and the reasons for both. Consensus is that most people require 8 to 8 ¼ hours of efficient sleep per night. It appears that cellular restoration is accomplished during non-REM deep sleep, and that memory and learning is more dependent on REM sleep, but controversy still exists. It is apparent that whatever the function each supplies, the body requires both, and will compensate to achieve both in sleep periods, depending on need. Healthy sleep efficiency depends on both. Inefficient or fragmented sleep will result in increased fatigue levels and again, declining performance.

There’s more, but the crux of all this is that fatigue is a function of real physiology. It’s the way this digital computer operates. As fatigue accumulates, performance, mood, complex decision making, judgment, response times, error tolerance, risk-taking, motor skills, etc. all start to deteriorate. Our culture, especially in the military (and in my experience, in medical training too), holds that somehow training, habit, motivation and/or attitude can overcome all this. Mishap statistics suggest otherwise. After an aviation mishap, we routinely measure for glucose, alcohol, carbon monoxide, cyanide, drugs, lactic acid, etc., etc. but we have no good measure for fatigue, so we’ve historically missed it as a causal factor. We’re ripe for a cultural change. There are excellent sources of additional information on sleep deprivation, fatigue and performance. One good summary is a report put out by the Battelle Memorial Institute for the FAA (2). If you’re unable to locate this on the WWW, drop me an e-mail and I’ll forward a copy.

## **Part 2**

In the previous issue of CONTACT we discussed some of the current physiology of fatigue and showed data that suggests fatigue ranks high in the aeromedical causal factors in naval mishaps and hazard reports. There are plenty of data out there from scientific studies which show the deterioration in performance that occurs as the brain fatigues. The brain requires regular periods of maintenance and restoration, which we know of as “sleep.” We also know that we’re programmed to obtain this sleep at night and that the circadian alerting rhythm is primarily responsible for telling the brain when to switch into sleep mode, and when to wake up. And the phase of the circadian rhythm is tied to local daylight and its 24-hour period is tied to the orbital

motion of the planet. That's how we evolved. The brain can't continue to function in the continuously awake mode. Fatigue accumulates and performance drops. The following plot (Figure 3.) shows both the accumulating fatigue and declining performance in subjects over a three-day sleep deprivation study, along with the modulating effect of the underlying circadian rhythm (1).

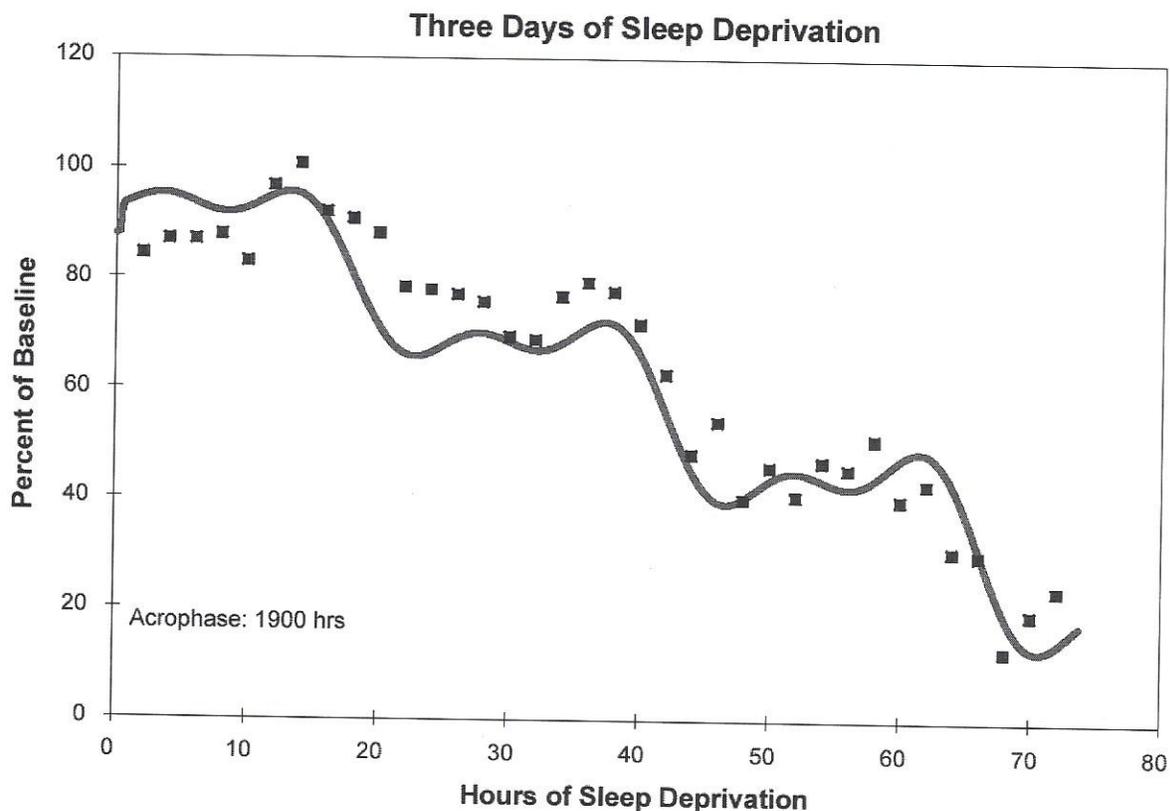


Figure 3.

Another problem with accumulating fatigue is that the brain will try to insert snatches of sleep to restore itself – lapses or “microsleeps.” These typically last 5-15 seconds or so, during which the individual may appear awake with eyes open, but is actually asleep. The brain has switched to sleep mode and is not processing external stimuli. Performance deteriorates due to fatigue, but during these lapses, performance drops to zero. These lapses become more frequent as fatigue accumulates. What's most dangerous is that individuals are often unaware that these are occurring. External events – radio calls, warning lights, sudden threats, or mandatory responses – don't get recognized and aren't processed during lapses.

Like most of you, one of my past life experiences included medical residency training. In my case, I selected a general surgery residency program in a typically busy major metropolitan area. And one particularly brutal rotation involved spending 3 months on a service where the work-week was limited to 168 hours. If you do the math, that's 24-on/24-on. Days off? – nope!

Surgery residents typically would grab 1 ½ - 2 hours sleep per 24-hour shift if they were lucky. In my three months on this rotation, I once managed to get 4 hours of uninterrupted sleep (on a night when The Boss was out of town). Residents rapidly degenerated into walking zombies as the fatigue overwhelmed us. Short-term memory disappeared – I had to write down notes on everything. Simple tasks became impossible. I had difficulty deciding which was right and left when putting up an x-ray; I couldn't do the mental rotation in my head. We'd doze off while examining patients, leaving them to wake us up. On rounds, we'd envy the sick, since at least they were lying down. If we made mistakes (which were frequent), The Boss would taunt us - "... are you stupid, doctor, or do you just don't care?" We were too fatigued to realize we had a third choice – fatigue! This might have even been considered useful training if we'd remembered more of it.

I'm sure you've had similar experiences with fatigue. Let's review the symptoms and signs:

- High-level frontal lobe stuff goes first: The fatigued individual gets irritable and cranky – not good for Crew Resource Management.
- Complex decision-making suffers, personality changes, and mood deteriorates.
- Communication is impaired – people quit talking.
- Vigilance decreases and people become inattentive.
- Task-fixation develops as brain processes slow.
- Tolerance for both error and risk increase.
- Motivation is reduced, and effort is conserved – the brain tries to preserve its remaining resources.
- Short-term memory declines.
- Reaction times increase – this is one of the most fundamental measurable changes with fatigue.
- And as mentioned, the risk of microsleeps goes up.

It's completely obvious that none of this is desirable when doing something so demanding and potentially dangerous as caring for patients or flying a plane.

We can measure the performance deterioration that results from fatigue, and observe for the signs and symptoms of fatigue, but unfortunately we don't have any ready measure of the brain's fatigue level itself. But can we predict fatigue levels based on knowledge of work and sleep cycles, time of day and circadian rhythms? Turns out that we can, and with surprisingly good accuracy. Which brings us to FAST<sup>TM</sup> – the Fatigue Avoidance Scheduling Tool.

Several teams of researchers have attempted to take the known physiology of work and sleep cycles, sleep deprivation and circadian rhythms, and predict the accumulation of fatigue and the level of resulting performance deterioration. These computer models were compared with each other on standard data sets of performance in sleep-deprived subjects in a "shootout" of which program performed best. The full report of this evaluation was published in *Aviation, Space and Environmental Medicine* in a March 2004 Supplement (3). Luckily for us, the "winner" was a program developed with Department of Defense sponsorship and is licensed for our use in official military applications. The FAST program is based on a mathematical model developed by Dr. Steven Hursh at the Science Applications International Corporation, and is specifically

designed to help optimize the operational management of aviation flight and ground crews. It displays a graphical plot of predicted performance after you specify times for sleep and work, and will accept events such as transmeridian travel, and calculate the phase of the circadian rhythm and anticipate how it adjusts to travel over time zones. It calculates light and dark cycles depending on latitude and longitude, and will recommend sleep intervals once you've specified duty periods.

Take a look at figure 3 again. The little squares plotted are the actual data taken on the sleep-deprived test subjects, but the smooth curve isn't some "best fit" approximation to the data, but a predicted line generated by the FAST program. In this case, the predicted performance curve matches the actual data to an accuracy of 94% - pretty impressive for a software program predicting something as notoriously variable as human performance!

A typical plot from the FAST program is shown in figure 4.

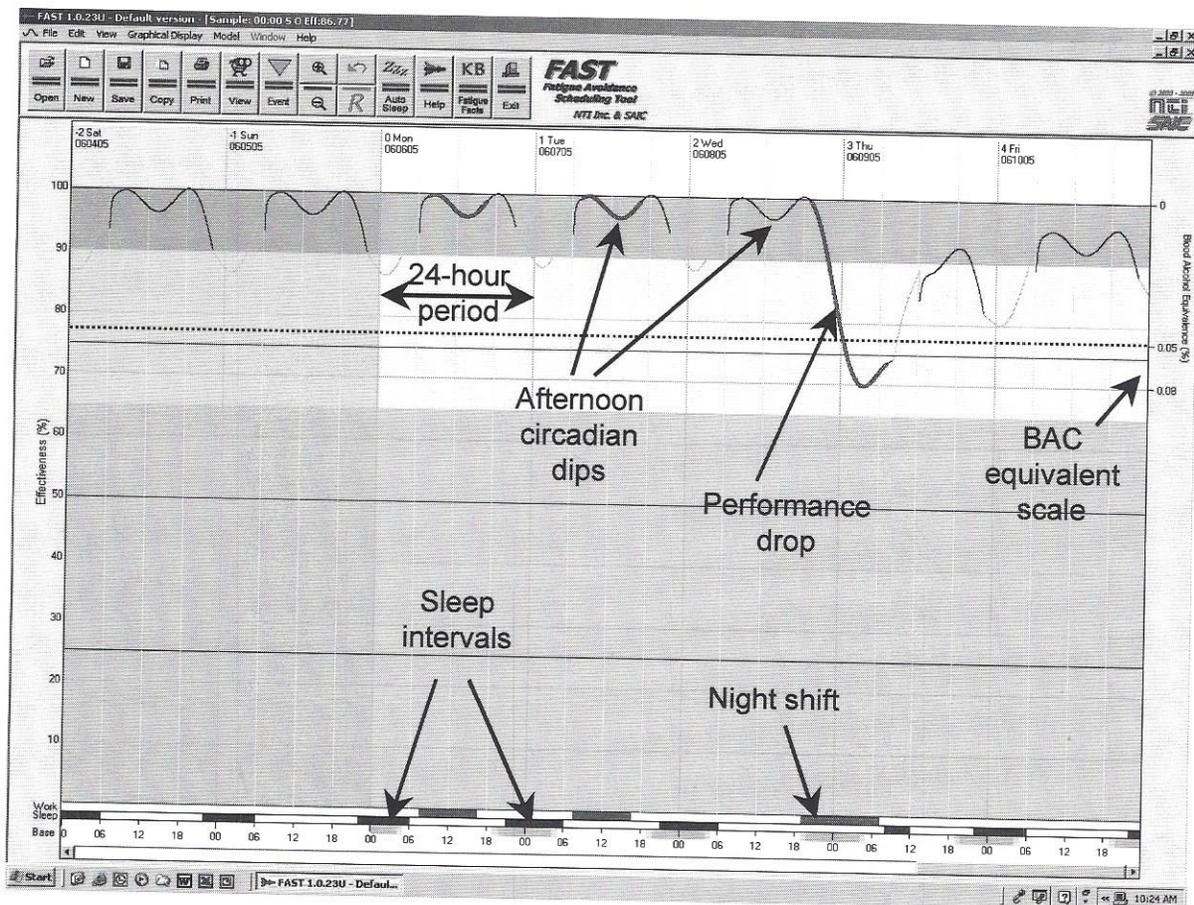


Figure 4.

In this particular example, the program plots a performance curve, and the expected deterioration while working an all-night shift. The dotted line – a criterion line - represents a level of performance which is degraded enough to be a safety hazard. In this instance it's set to a similar deterioration in performance that would be seen in a subject who is intoxicated at a blood alcohol

concentration (BAC) of 0.05%. The program also plots a BAC equivalent of the 0.08% level, which is considered legally drunk for driving in all U. S. states. At this level of impairment, performance drops to 70% of baseline. Our theoretical shift worker in figure 4, during the last half of his work shift, is performing at a level the same as if he were drinking on the job!

FAST promises to be an excellent tool to do trial runs on schedules, assist your aviators in planning flight schedules and travel across time zones, and in analyzing the contribution of fatigue as a causal factor in mishaps. The software is available for download to authorized users, and I'd encourage you to install a copy on your computer, and become familiar with its use. Drop me an e-mail for more information on obtaining a copy of the software and in using the program.

### **Part 3**

In the two previous issues of CONTACT, we reviewed what we know about the physiology of fatigue, and how it affects performance. Fatigue and sleep deprivation are significant causes of mishaps, but we've been slow to spot these as causal factors, probably because we have no good measures for fatigue. And our culture doesn't recognize fatigue as out of the ordinary, since it's so common in our 24-hour work-round-the-clock culture. We also looked at a tool, the Fatigue Avoidance Scheduling Tool (FAST<sup>TM</sup>), which takes the known physiology of fatigue and predicts a person's performance based on sleep and work cycles, "jet lag" issues, and quality of sleep. In this issue, we'll take three hypothetical examples and see how FAST might help us analyze the contribution of fatigue to some issues we might face in Naval Aviation.

#### **Scenario #1:**

You've gotten settled in as the Senior Medical Officer on the fusion-powered USS ESSESS (CVF-80), the latest and greatest carrier in the U. S. Naval Fleet, and are looking forward to your first port call on this WestPac Cruise. But sure enough, at the last minute, the carrier has been ordered to the Persian Gulf at best possible speed, where you'll work with a sister carrier in 'round the clock operations. And since you've got a fresh crew, you're going to be the "night carrier," conducting flying operations from 1900-0700 each day. Your CO, Captain Charger, wants to know how best to transition to a night shift for the ship's crew. His idea is to keep everyone up and hold a party all night long the day before you enter the Gulf, then have everyone except the watchstanders go to bed at 1000 – 1800, and remain on that schedule until the exercise is over. You, however, armed with the latest knowledge of fatigue physiology, suspect that this will only add another 8 hours of sleep debt to your already tired crew, and suspect your Skipper is making a huge blunder.

"Let me thoroughly research this, Skipper, and I'll get back to you shortly with the best scientific recommendation possible based on our current knowledge of human fatigue physiology, ensuring that the crew functions at their optimum, and that you keep your front runner status for flag rank", you say fawningly as you retreat to your stateroom to work your magic in FAST. You open the program and tell it you want to look at a month-long schedule. Plugging in the existing sleep schedule of 2200-0600 up to the day of transition, you then skip the first night's

sleep, and plug in day sleep from 1000-1800 for the rest of the month. FAST plots the following (Figure 5):

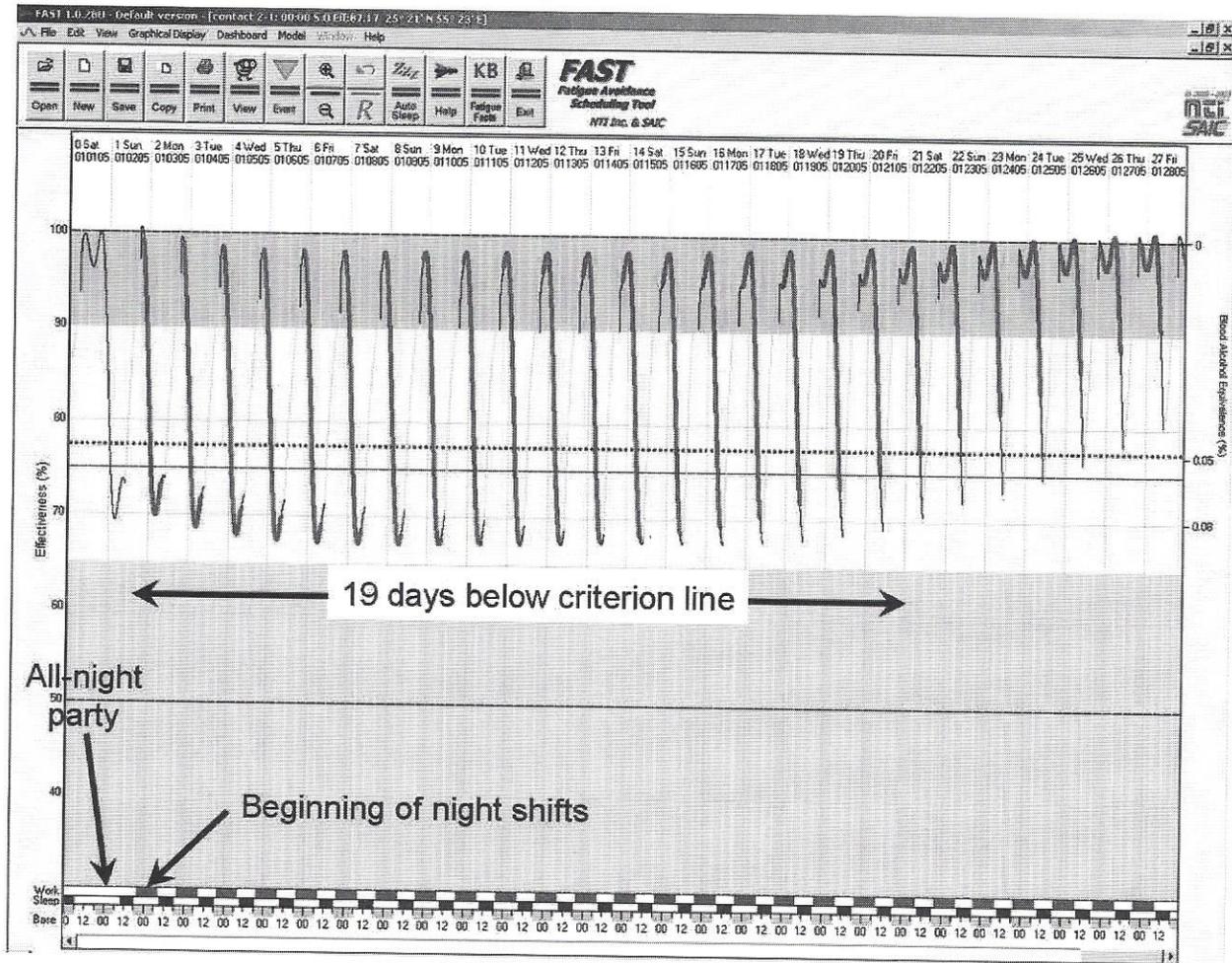


Figure 5.

Wow, the Skipper's plan is even worse than you thought! FAST predicts the crew will be spending the latter part of each shift well below the 90% effectiveness level, and won't be fully adapted to the night shift until after 25 days. For nineteen days, they'll spend at least some time toward the end of each shift below the "criterion line" where performance is predicted to be 77% or less, equivalent to having a blood alcohol concentration (BAC) of 0.05%.

Now you revise the schedule, and instead of throwing a party the night of transition, you not only allow the crew their normal night's sleep but add in a 3 hour nap at the afternoon circadian dip the following day, just before the crew starts its first full night of duty. FAST plots the following (Figure 6.):

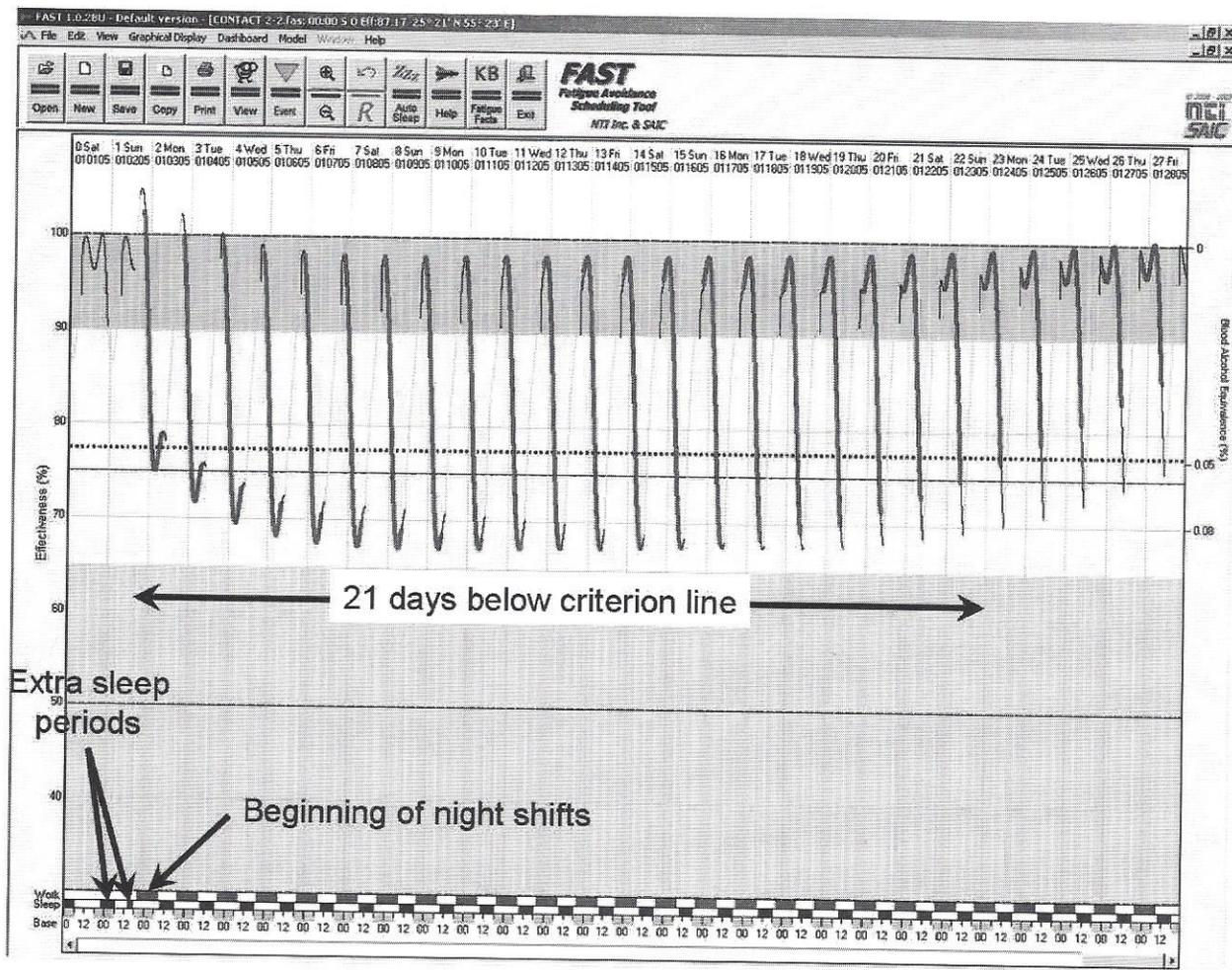


Figure 6.

Holy smokes! This isn't much better. The first few days of the new schedule, people will be working a bit better than before during the first part of the shift, but in fact, it now takes 2 days longer before the crew are fully adapted to the night shift (27 days vs. 25), and for 21 days they're spending at least some of the latter part of each shift below the criterion line. Your plan has given them a bit of an edge during the first few days, at the cost of delaying their ultimate adaptation to a night schedule by another day or two.

You go back to your Skipper, and tell him the crew is going to be significantly degraded with either schedule, and you recommend that the other carrier be designated the night carrier. Your Skipper fires you on the spot, and appoints your General Surgeon to be the new SMO who, having survived a general surgery residency, feels that all this stuff about fatigue is mere piffle.

Dr. Steven Hursh, the inventor of the SAFTE model used in the FAST program, explains that, due to continued daylight exposure with people on a night schedule, they never fully adapt to night shift work. The FAST program projects that it takes 2.6 times longer to shift from a day to night schedule than it would for the equivalent transmeridian travel of 12 hours, based on experimental data. Dr. Nita Miller, fatigue researcher at the Naval Postgraduate School, has

shown that crews who are completely below decks and away from daylight exposure, can adjust their circadian rhythms to accommodate night shift work, but those who work the flight deck never fully accommodate. FAST is simply illustrating what shift workers have known for years – few really adapt fully to a night schedule. In order to become the “night carrier” you’re going to have to recognize the significant degradation in performance that the crew will be operating under, and develop additional risk controls such as increased error-checking and oversight, more rigorous work rules, simplifying mission demands, and providing backup staffing, among others.

## **Scenario #2.**

You’ve been in the Gulf awhile now, and are still due for your first port call. With great anticipation, tomorrow you’ll pull into Jebel Ali for a well-earned 6-day port visit, beer in the Sand Box, and all the other benefits of beachside life. But one of your Wing Flight Surgeons approaches you with a problem. Turns out that the new Executive Officer of the Dark Clouds is reporting aboard today, and the Carrier Air Group Commander wants him to get his day carrier quals before going into port tomorrow. Oh, by the way, the prospective XO has just traveled from CONUS, with a 9-hour transmeridian time shift, and has been up for the past 45 hours except for 4 hours of sleep he snatched last night in the Dubai airport before reporting aboard this morning. You and your Wing Flight Surgeons suspect fatigue will be an issue, and that it would be better to convince CAG to give this poor aviator a nap instead of a day CQ.

“CAG, Sir, I’ve heard that CDR ‘Roger’ Ball arrived this morning by helo, and that you plan to have him do his day CQ this afternoon? Are you crazy, Sir?”

You explain what you know about fatigue physiology, sleep deprivation, circadian shifts, and the resulting performance decrement and increased risk of mishaps, but CAG tells you that: a) no, he’s not crazy; he’s CAG; b) that CDR Ball is a senior, experienced Naval Aviator, a great stick, and that he can hack it, and that; c) this fatigue stuff doesn’t apply to Naval Aviators, who are not made of mere mortal flesh.

Muttering under your breath, you retreat to your office and crank up the computer. You enter what you know about the XO’s sleep schedule before he reported aboard, and the latitude and longitude of Norfolk, his point of origin; London, where he changed planes; and Dubai, his ultimate destination, 9 time zones to the east (FAST calculates this automatically based on the coordinates of the origin and destination). You enter all times into the program based on local time in Norfolk. When you enter the sleep period in the Dubai airport, you rate it as “poor” (you have two other choices, “excellent” and “fair”), based on your extensive experience sleeping in airports in the past. FAST gives the following predicted performance plot for CDR Ball (Figure 7):

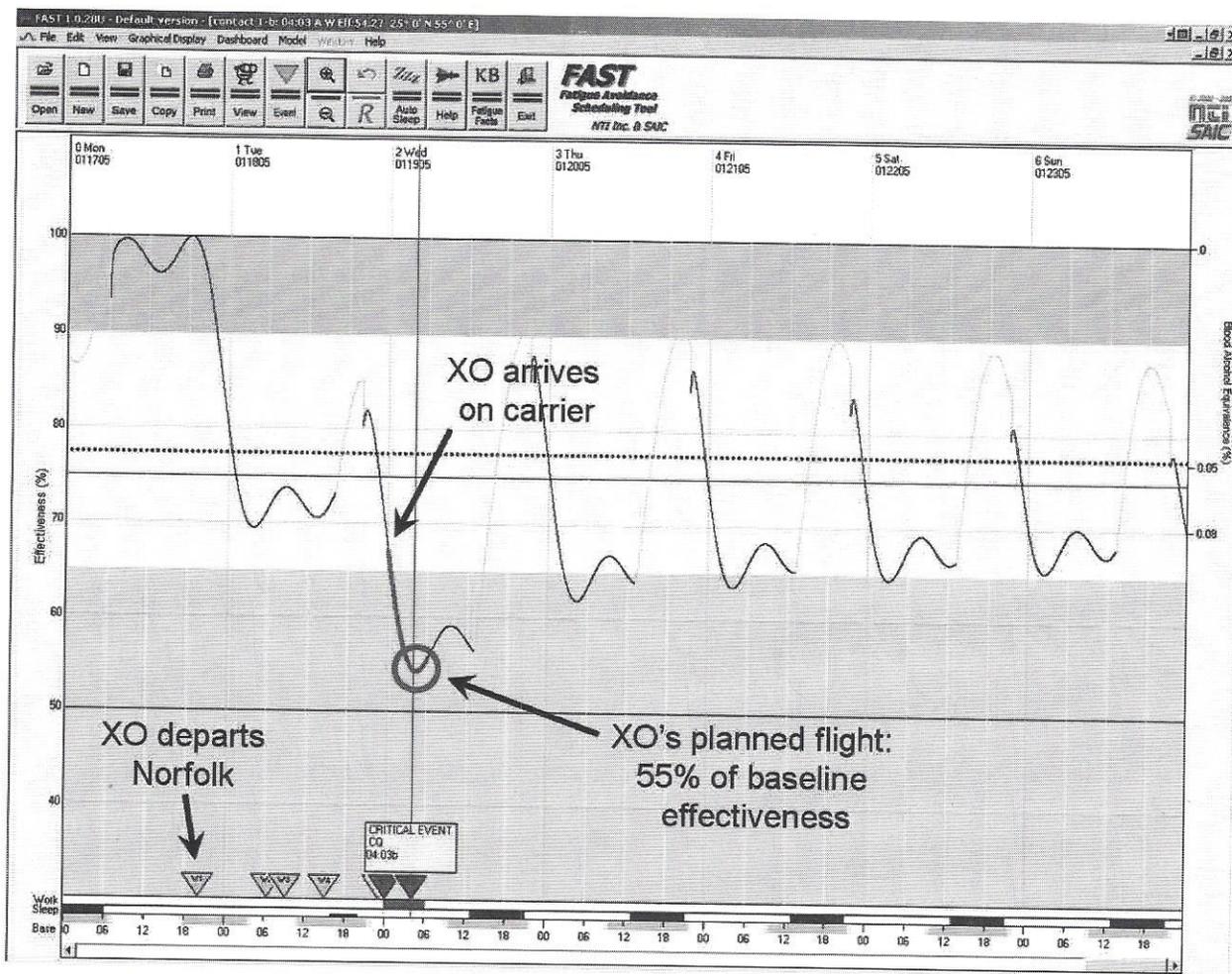


Figure 7.

As you suspect, FAST predicts that CDR Ball is significantly fatigued, and that at the time of his scheduled flight, he'll be around 55% of baseline effectiveness, and much worse than the equivalent legally intoxicated line of a BAC of 0.08%. FAST predicts that the whole day the new XO is aboard ship, his performance would be more impaired than if he were legally drunk! You go back to CAG and give him the plot, showing your numbers.

“CAG, Sir, you can put this into your Operational Risk Matrix worksheet concerning CDR Ball’s flight,” and you harrumph off. CAG, being an aviator, is able to ignore the best of medical advice, but he cannot ignore a number. He decides to postpone CDR Ball’s Day CQ until after the port call.

### Scenario #3:

You’re the Flight Surgeon investigating a mishap where you think fatigue might be an issue. The mishap involves a flight crew that gets distracted by a missing strobe light on approach, allows the plane to get dangerously slow, with an eventual departure from controlled flight and impact short of the runway. The mishap happened a little after 1600 local time, after the pilot

had been continuously awake for 29 hours. You take a very good 72-hour history on the involved flight crew (who survived the mishap), along with some knowledge of their usual sleep habits, and plot these in FAST (Figure 8).

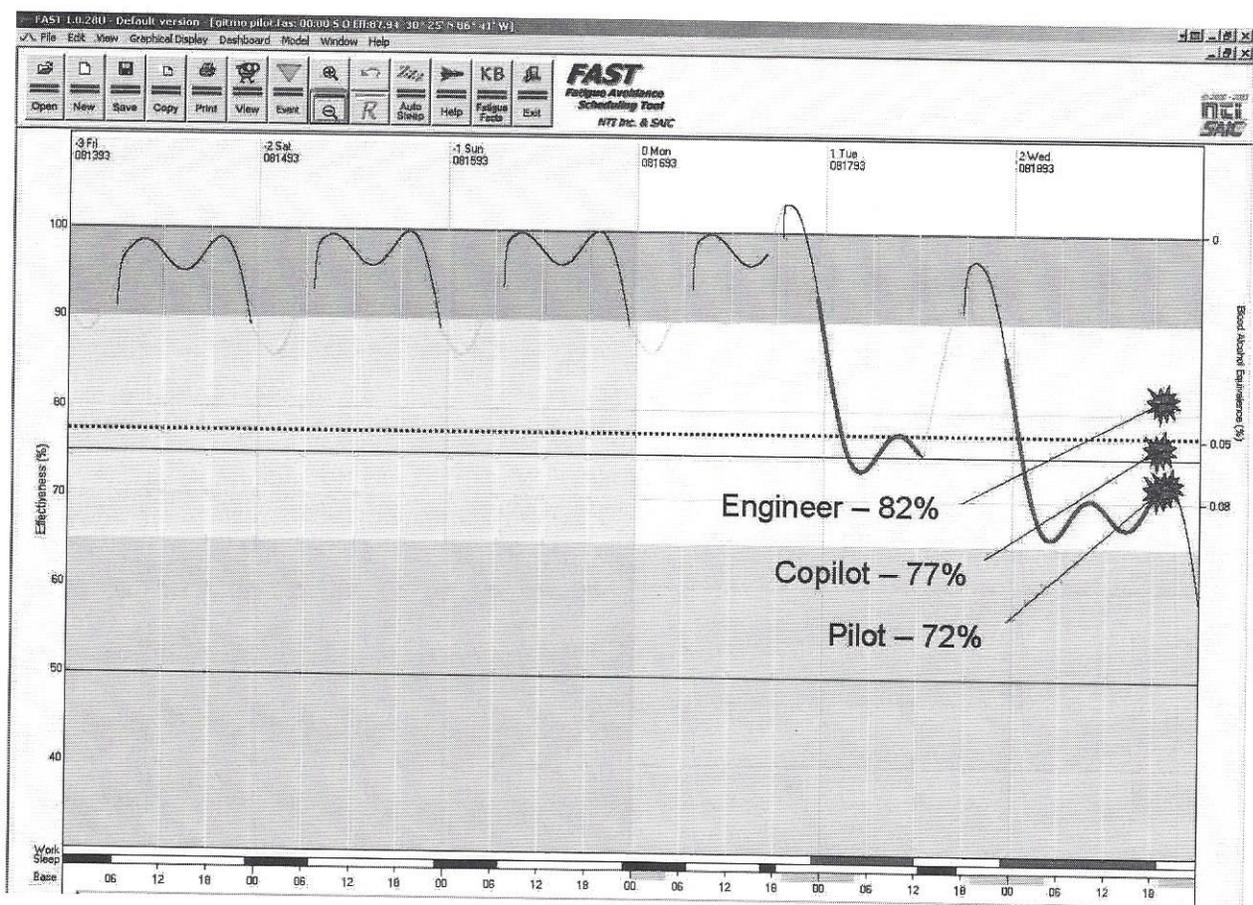


Figure 8.

(For clarity, only the pilot's sleep, duty and fatigue plot is shown, but the results of the copilot and flight engineer at the time of the mishap are also listed). FAST shows us that all three aircrew are projected to be significantly impaired due to sleep deprivation and extended duty periods. (This is an actual mishap example, taken from the National Transportation Safety Board files, at <http://www.nts.gov/>. Search their database for **NTSB Report Number: PB94-910406**, if you're curious about the details).

We've used FAST in these three examples to demonstrate where it might assist you in quantifying the impact of fatigue on performance, based on knowledge of sleep and duty cycles. FAST will also suggest rational sleep schedules, if you specify the duty times involved. Recognize that FAST estimates performance deterioration in average individuals only, and can't account for individual variation. Self-reported sleep is known to be less accurate than sleep that is measured by wrist actigraphy or EEG recordings. And the impairment from fatigue and alcohol isn't strictly comparable on all tests of performance used, only that the general drop in performance between both is similar. FAST currently doesn't account for the effects of

performance maintaining drugs like caffeine, amphetamine, or modafinil. Developers are investigating ways to model those effects in newer versions of the program. Yet within these limitations, FAST promises to be extremely useful in assisting with flight schedules, assessing the average deterioration that might be expected from sleep deprivation, and in analyzing mishap scenarios for fatigue effects. And it's an outstanding tool to help you educate your aviators on the detrimental effects of fatigue.

The FAST program is still under development, and is being updated and revised on a continual basis, but you can obtain a copy for download and use if you're in the Department of Defense. Please drop me an e-mail for additional information on obtaining the program, and additional fatigue information. By becoming an expert in the assessment and management of fatigue, you can help protect your aviators and perhaps change the culture on one of our most important mishap causal factors. I look forward to hearing from you.

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Figure 2 reproduced in *CONTACT*, the Newsletter of the Society of U.S. Naval Flight Surgeons, Vol. 29, N. 2, April 2005, with permission from *Nature* (<http://www.nature.com>).

Figure 3 taken from: *The SAFTE<sup>TM</sup> Model and Fatigue Avoidance Scheduling Tool (FAST<sup>TM</sup>)*. Hursh, Steven R.; Program Manager, Biomedical Modeling and Analysis, Science Applications International Corp.

Figures 4-8 plotted from FAST<sup>TM</sup>; version U-1.28.

Refs:

(1) Dawson D, Reid K. *Fatigue, Alcohol and Performance Impairment*. Nature 17 Jul 1997. Vol 388, p235. Reprinted with permission.

(2) Battelle Memorial Institute & JIL Information Systems. (1998). *An overview of the scientific literature concerning fatigue, sleep, and the circadian cycle*. Washington, DC: FAA Office of the Chief Scientific and Technical Advisor for Human Factors.

(3) Neri, DF, et. al. *Proceedings of the Fatigue and Performance Modeling Workshop*. Aviation, Space & Environmental Medicine. Vol 75, No. 3. Section II, Supplement. Mar 2004.