

# ***Fatigue Management for Improved Performance***

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# ***Fatigue vs. Awake***

## **FATIGUE**

State of diminished  
physical and/or  
mental efficiency



## **AWAKE**

Stable level of arousal,  
Alertness, and cognitive  
ability

## *As Fatigue Progresses*

- ❖ Errors of omission increase
- ❖ Followed by errors of commission
- ❖ Followed by microsleeps\*

\* **Microsleep:** Involuntary sleep lapses lasting from a few seconds to a few minutes

## *As Fatigue Progresses*

- ❖ Fatigue can cause uncontrolled and involuntary shutdown of the brain regardless of the how hard you try, professionalism, or the training level of the person

# ***Fatigue Degrades Performance and Mental Abilities***

## **Attention Problems**

- ❖ **Attention Span Narrows**

  - Inattention to minor, but potentially important details

- ❖ **Increased Lapses of Attention**

  - Greater time lapses occur as fatigue increases

- ❖ **Memory Problems**

  - The ability to integrate, store, and retrieve information declines

# ***Fatigue Degrades Performance and Mental Abilities***

## Attention Problems

### ❖ Reaction Time

Slow and irregular reaction times - we miss relevant cues

### ❖ Cross Checking Declines

Take too much mental effort

### ❖ Perceptual Changes

Channeling of attention, Tunnel Vision, Tunnel Hearing

# ***Fatigue Degrades Performance and Mental Abilities***

## Attention Problems

- ❖ Cognitive Processes Slow Down
  - Automatically slows down to maintain accuracy
- ❖ Alertness Declines
  - Brain shuts down to conserve energy
- ❖ Micro-Sleeps Occur
  - Involuntary lapses into sleep – Increase over time

# ***Fatigue Degrades Performance and Mental Abilities***

## **Attitude Problems**

### **❖ Motivation**

Decreased motivation and conservation of effort

### **❖ Attitude & Mood Deteriorate**

“It’s good enough” attitude prevails, Psychological depression, Poor morale

### **❖ Increased Irritability**

Little things bother us more – We become more moody



# ***Fatigue Degrades Performance and Mental Abilities***

## Teamwork Problems

- ❖ Team Breakdown

  - Impairments in communication, cooperation, and team coordination

- ❖ Communications Breakdown

  - Social interactions decline

# ***Fatigue Degrades Performance and Mental Abilities***

## Performance Problems

- ❖ Accuracy and Timing Degrade
  - Critical Actions—Crosscheck—Relevant Cues
- ❖ Lowering of Performance
  - Poor and careless performance, increased errors
- ❖ Lowering of Standards
  - Lower standards of performance become acceptable
    - Greater tolerance for error

# ***Fatigue Degrades Performance and Mental Abilities***

## Performance Problems

- ❖ **Flawed Decision Making**

  - Decisions made on missed, flawed, or incomplete information

- ❖ **Thought Processes Suffer**

  - Ability to logically reason is impaired - Difficulty concentrating & thinking clearly

- ❖ **Skills Decline**

  - Everything becomes more difficult to perform, even simple tasks

# ***Fatigue Degrades Performance and Mental Abilities***

## Performance Problems

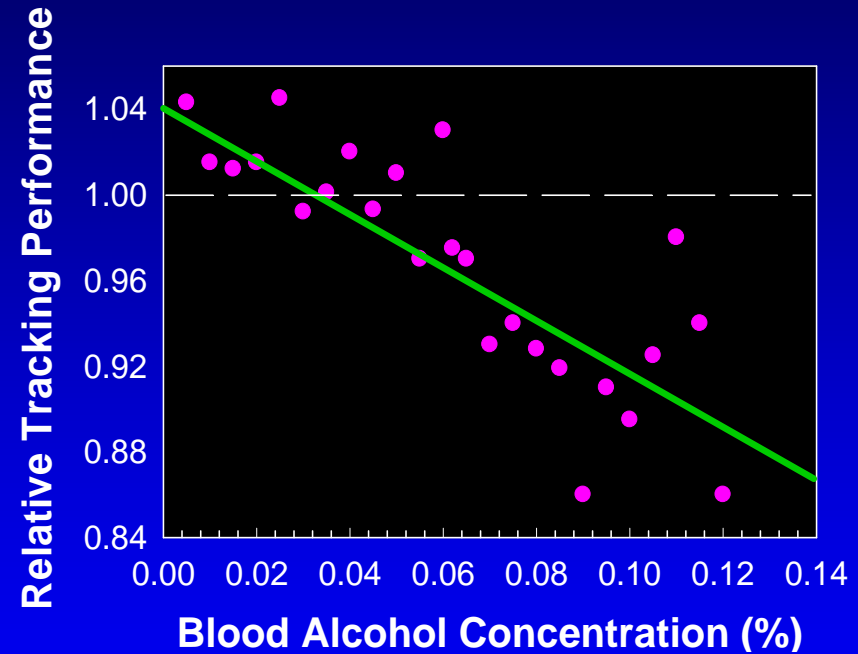
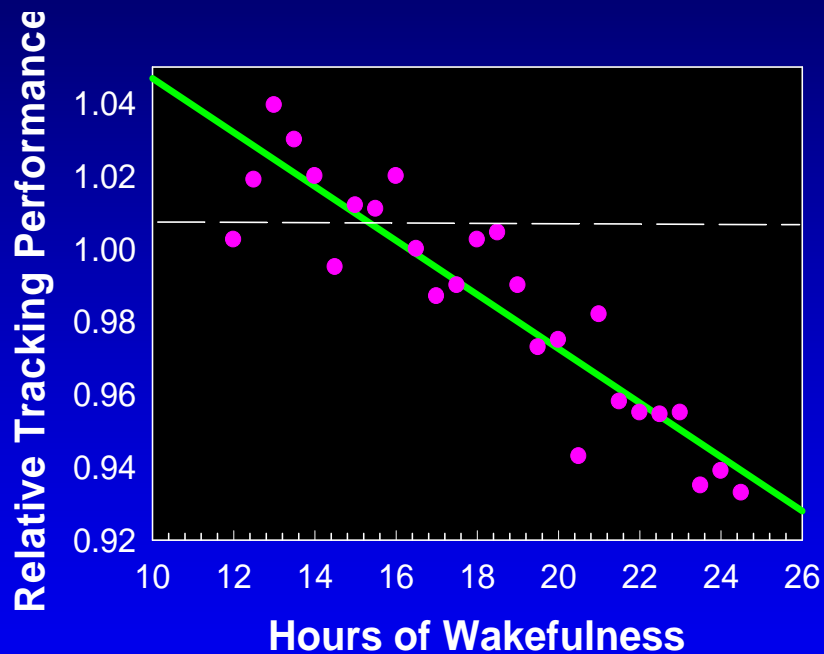
- ❖ Physical Symptoms Increase
  - Dizziness, headaches, stomach aches increase
- ❖ Mental Tasks Harder To Perform
  - Mental arithmetic, programming, entering data, remembering

## *Performance Decrement*

- ❖ 19 hours of wakefulness or
- ❖ 19 hours of wakefulness plus sleep debt

Equals mental & performance level of a legally drunk driver in most states (.08 Blood Alcohol Concentration)

# Fatigue-Related Decrements are Similar to Those Caused by Alcohol



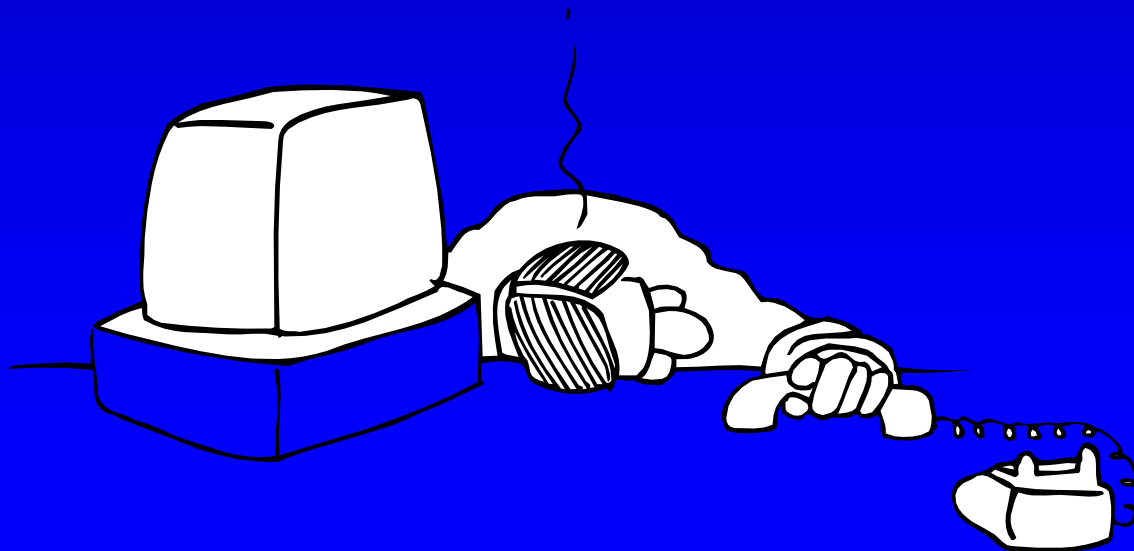
↑  
**Legally drunk in most states!**

## ***Motivational Variation***

- ❖ You can see the performance plots on the previous slide vary
- ❖ Research shows that this variability is due to motivation – not how hard you try
- ❖ If the task is fun and you are motivated – performance increases slightly
- ❖ It can also drop a lot more if you are not motivated

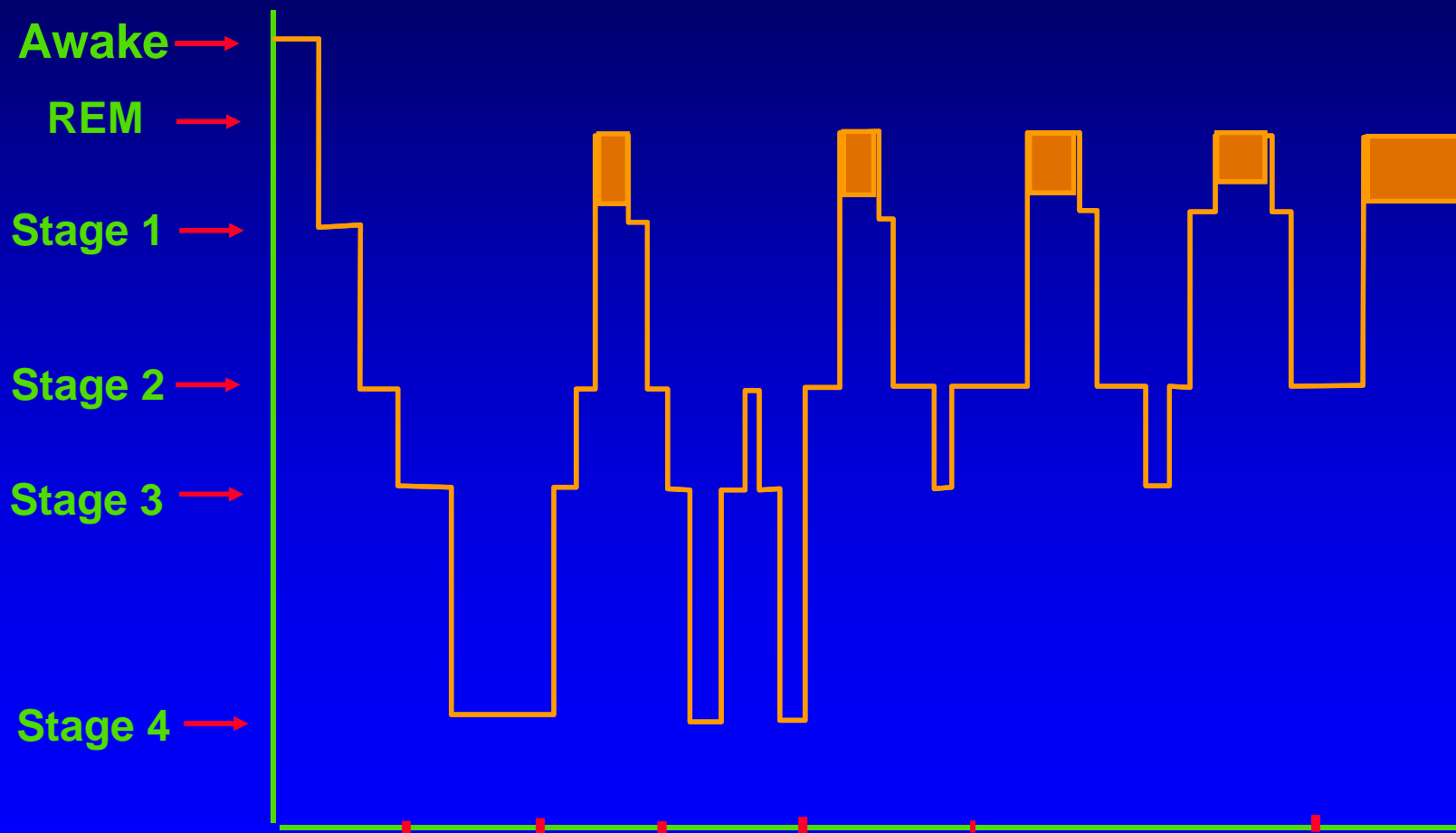
# *Why Do We Get Fatigued?*

- ❖ Lots of Reasons...
  - ◆ Sleep Loss

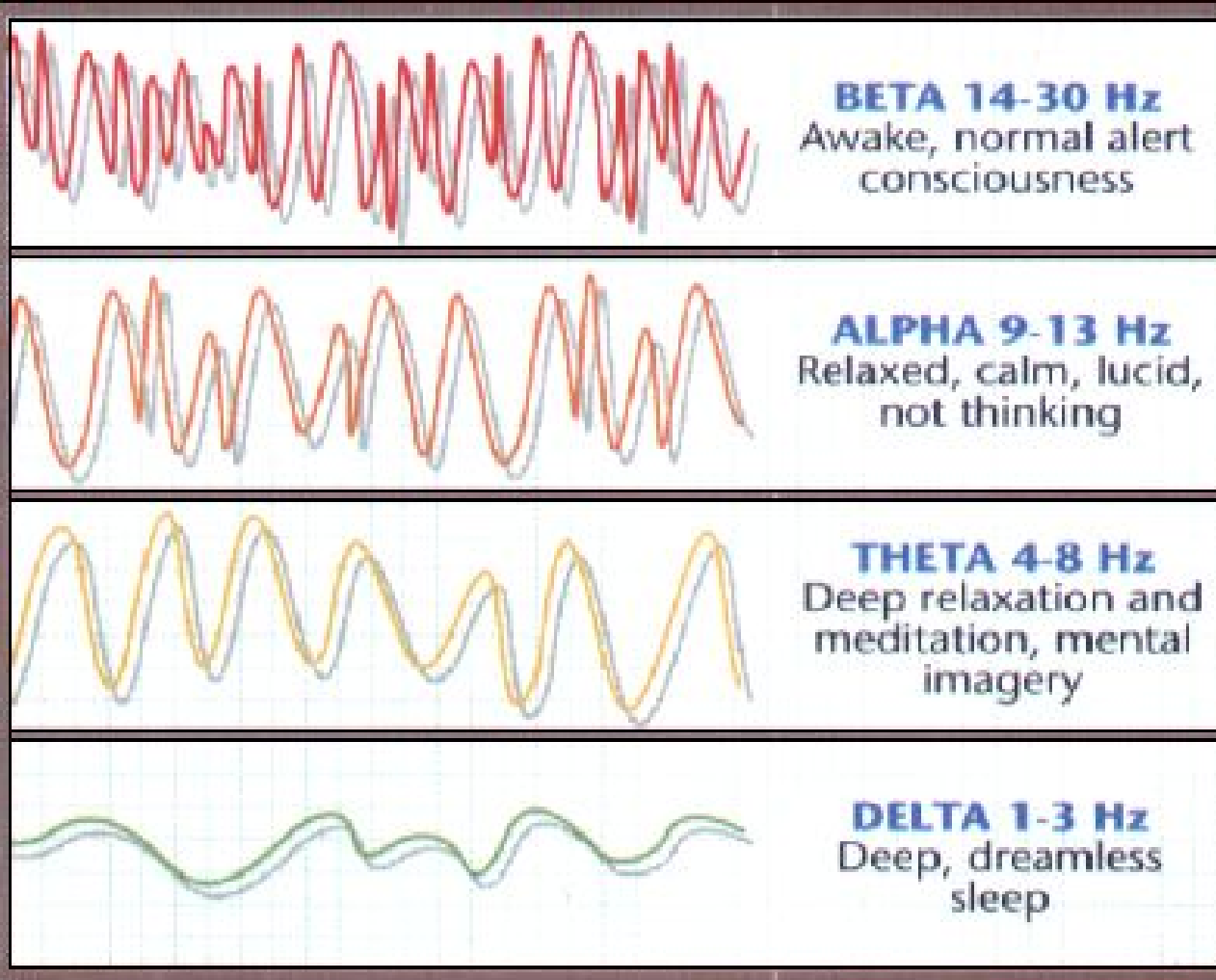




# *Normal Sleep, Brain Wave Pattern*



# Brain Waves



## ***Beta Waves***

- ❖ Beta is associated with normal, waking consciousness
- ❖ Attention directed towards the external environment
- ❖ You are most likely in the "beta state" as you read this

# *Alpha Waves*

- ❖ Alpha is relaxed, not thinking about anything in particular, sometimes a pleasurable feeling of "floating"
- ❖ Alpha waves have for the past twenty years been associated with calm, lucid mental states (the "alpha state")
- ❖ They are also often detected during dream sleep (REM Stage)

# *Theta Waves*

- ❖ Theta is found in states of deep relaxation
- ❖ Theta activity is also associated with bursts of creative insight, twilight ("sleep") learning and vivid mental imagery
- ❖ Sleep Stages 1&2

# *Delta Waves*

- ❖ Delta, the slowest of brainwave activity, is found during deep dreamless sleep
- ❖ Sleep Stages 3&4

# *Sleep Loss*

## ❖ Two Stages of Sleep

### ◆ NREM

- Non-Rapid Eye Movement
- Light Sleep (Stages 1 and 2)
- Deep Sleep (Stages 3 and 4)

### ◆ REM

- Rapid Eye Movement
- Active Brain in a Paralyzed Body

# ***NREM Sleep***

- ❖ Physical Restoration—Deep Cycle
  - ◆ Physiological and Mental Activity Slowed
    - 4 Stages
    - 20-90 minutes from awake to stage 4
  - ◆ Most deep sleep (NREM) occurs in the first half of the sleep period



# ***NREM Sleep***

## ❖ Physical Restoration—Deep Cycle

### ◆ Stage 1 and 2

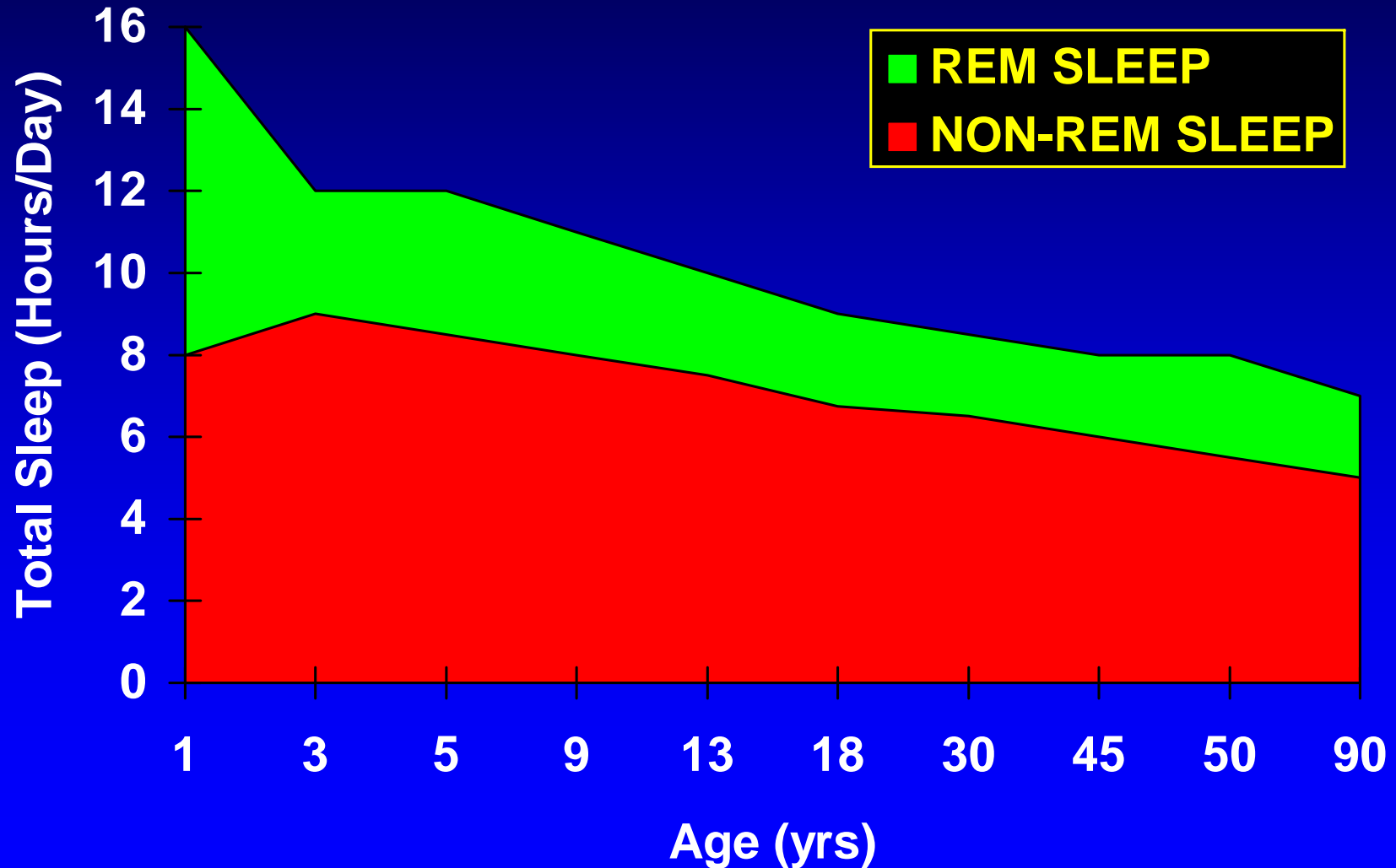
- Light sleep and micro sleep
- Can merge with REM/reality-based dreams

### ◆ Stages 3 and 4

- Deep Sleep
- Sleep Inertia – How fast you return to normal

# *A Lifetime of Sleep*

## *REM Vs Non-REM*



\*Reprinted from Mountcastle, 1968

# *Importance of Sleep*

## ❖ Basic Physiological Need

### ◆ Quality

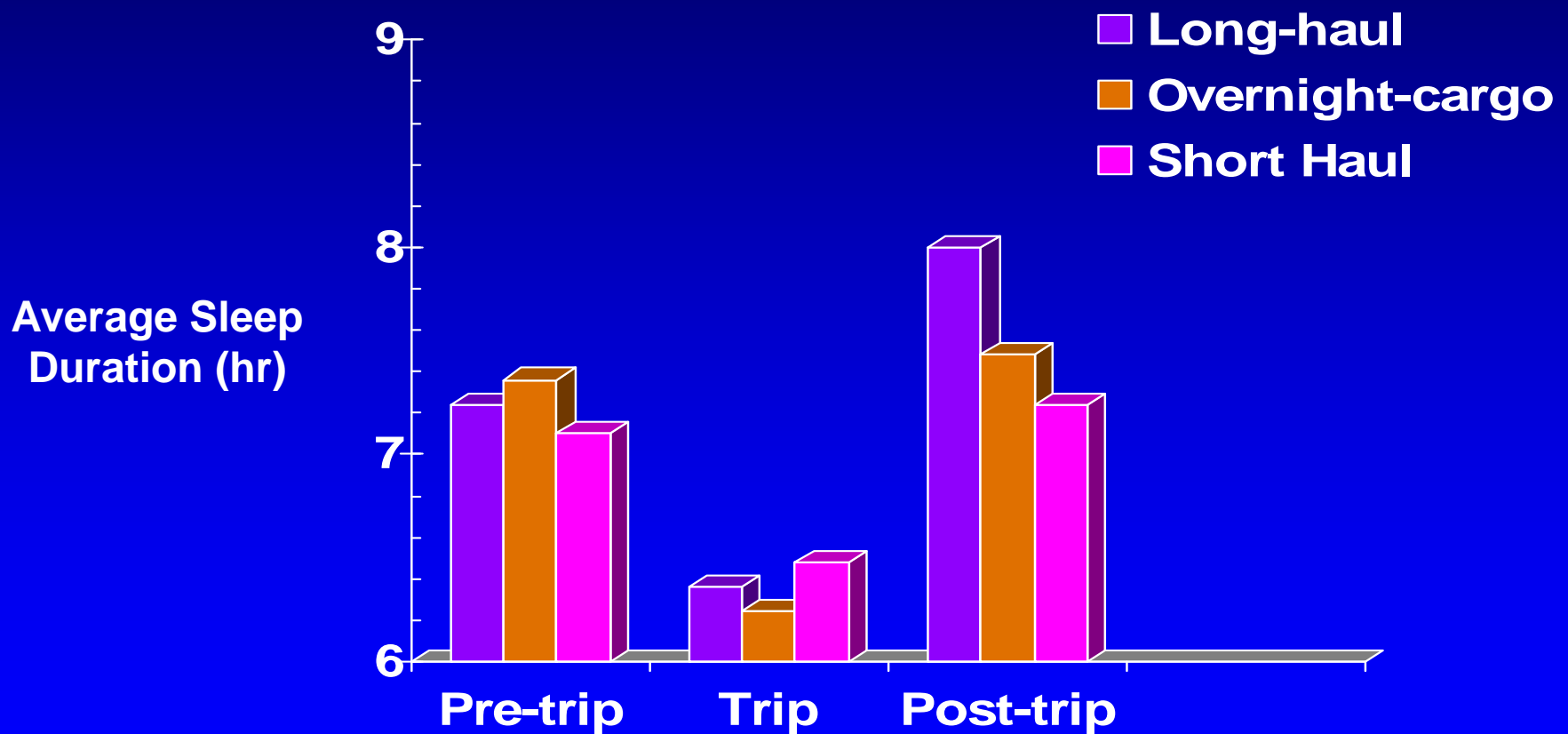
- REM and NREM
- Undisturbed

### ◆ Quantity

- Sleep loss is additive
  - Results in sleep debt
- Sleep loss leads to increased drowsiness



# *Sleep Loss in Different Flight Operations*

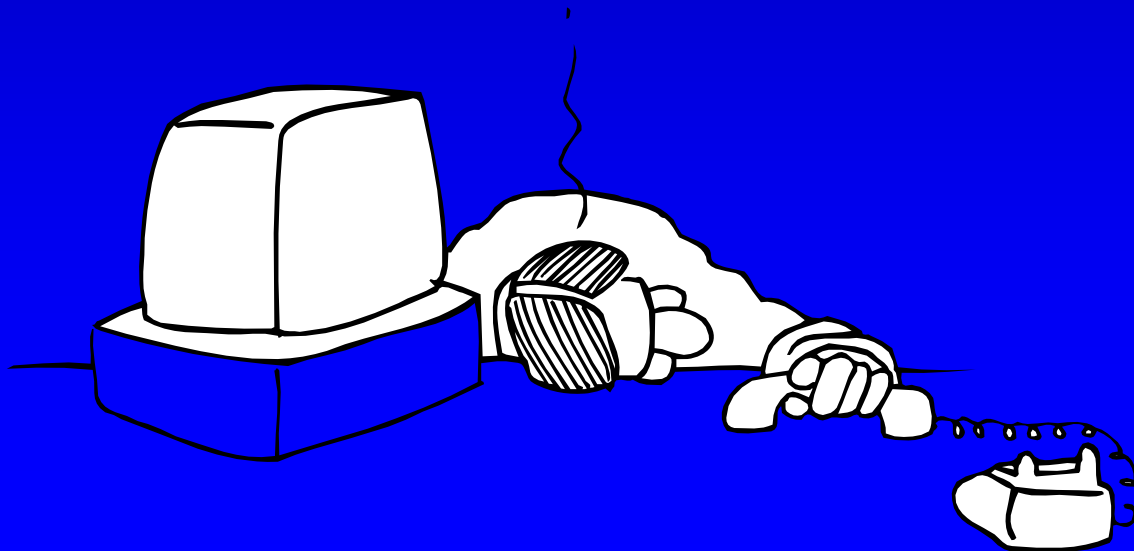


# *Average Sleep Requirements*

- ❖ **Toddlers: 11 Hours**
  - ◆ Plus 2-hour nap during the day
- ❖ **Preschoolers: 11-12 Hours**
  - ◆ Half of preschoolers also nap
- ❖ **Teens: Avg. of 9 ½ Hours**
  - ◆ Most get less
  - ◆ Sleep on weekends to recover sleep debt
- ❖ **Adults: Generally 8 Hours**
  - ◆ Avg. 6.9 weekdays
  - ◆ Avg. 7.6 weekends

# *Why Do We Get Fatigued?*

- ❖ Lots of Reasons...
  - ◆ Circadian Rhythm Disruption



# *Circadian Rhythm Disruptions*

- ❖ Daily Biological Clock – Oscillates on a 25 hour basis
  - ◆ Sleepiness
  - ◆ Performance
  - ◆ Temperature—Digestion—Hormones
- ❖ Reset by Environmental Time Cues (Zeitgebers)
  - ◆ Light
  - ◆ Meals
  - ◆ Work/Rest Schedule

# *Circadian Rhythm Disruption*

## ❖ Symptoms

- Disturbed Sleep Patterns
- Decreased Performance
- Gastrointestinal Problems

## ❖ Causes

- Jet Lag
- Shift Work



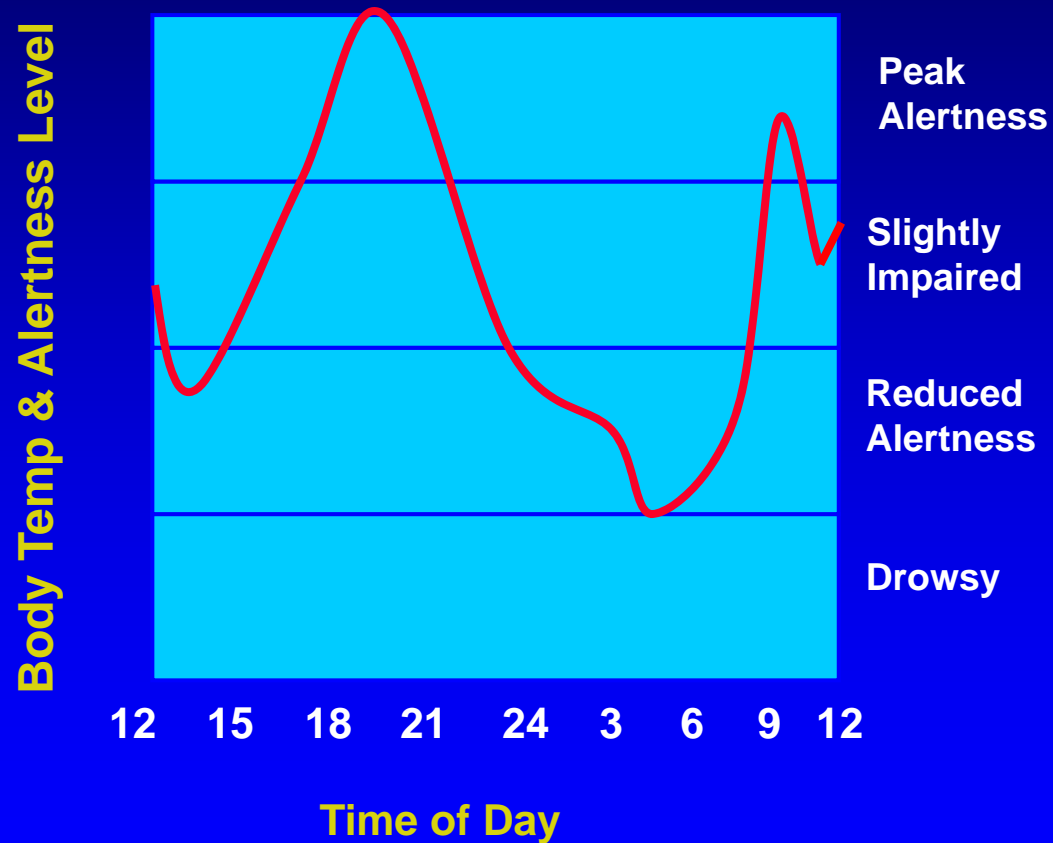
# ***Jet Lag or Shift Work***

*Definition: An abrupt change in environmental time*

## **Symptoms:**

- ❖ Disturbed Sleep
- ❖ Increases Drowsiness
- ❖ Decreased Physical or Mental Performance
- ❖ Increased Reports of Fatigue
- ❖ More Negative Moods
- ❖ Gastrointestinal Problems

# *Circadian Rhythm Cycle & Alertness*



## ***Alertness Rule of Thumb***

- ❖ 3:00 AM – 5:00 AM Lowest Level
- ❖ 3:00 PM – 5:00 PM Next Lowest level

# ***Factors Affecting Circadian Adaptation***

- ❖ Number of Time Zones Crossed –
  - ◆ 1 day recovery for every time zone crossed
- ❖ East Vs West Travel
  - ◆ Going East against direction of sun = shorter day
  - ◆ Going West with the sun = longer day
  - ◆ Easier to adjust traveling West

## ***Factors Affecting Circadian Adaptation***

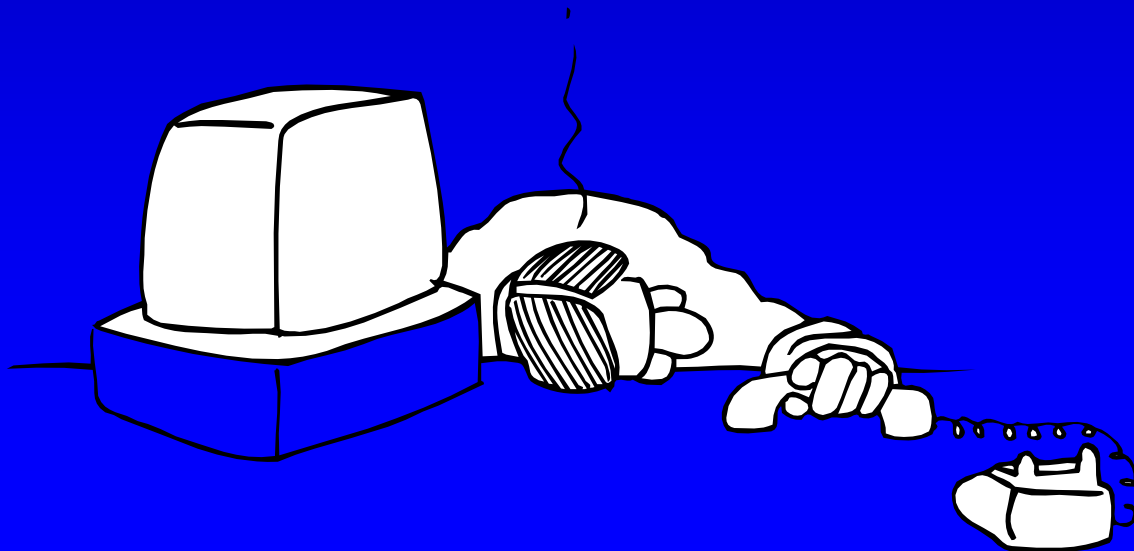
- ❖ Hours of sleep before shift change
- ❖ Sleep patterns during shift change
- ❖ Individual Differences
- ❖ Ability to Adapt Decreases With Age

# *Adaptation Problems*

- ❖ People don't stay long enough to synchronize
- ❖ Schedules often prevent a 24 rest/activity pattern
- ❖ Biological clock unable to stabilize
- ❖ Additional sleep loss

# *Why Do We Get Fatigued?*

- ❖ Lots of Reasons...
  - ◆ Sleep Debt



## ***Cumulative Sleep Loss - Sleep Debt***

- ❖ Most adults require 8 hours of restful sleep to stay out of sleep debt
- ❖ With aging there is usually a significant decline in habitual daily sleep due to increased awakenings
- ❖ Results in more daytime fatigue, sleepiness, dozing, and napping



## ***Cumulative Sleep Loss - Sleep Debt***

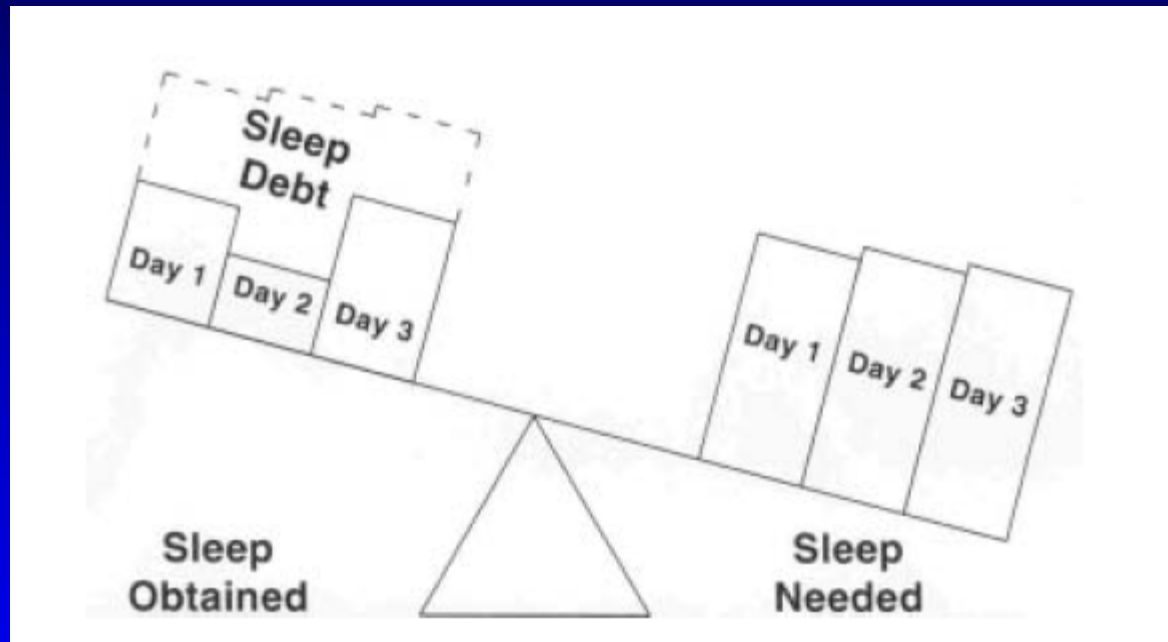
Sleep Debt = # hrs. less sleep x # days

- ❖ 2 hrs less sleep per night for 10 days = 20 hours of sleep debt
- ❖ Research shows 10 days of restrictive sleep leads to progressively worsening performance and eventually a zone of impairment (Unsafe to drive or engage in safety-sensitive tasks)

## *Sleep Debt Recovery*

- ❖ Will not occur after a single sleep period
- ❖ Usually requires 2 nights of recovery and 10 hours of sleep

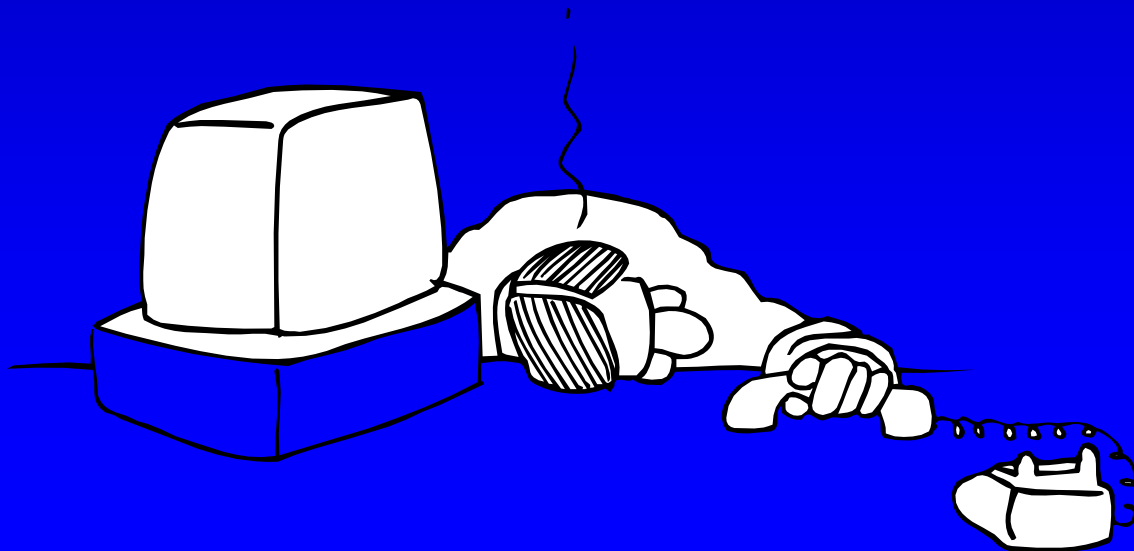
# *Sleep Debt Recovery*



It can take more than two days  
depending on the sleep debt

# *Why Do We Get Fatigued?*

- ❖ Lots of Reasons...
  - ◆ Type of Task



## ***Boring / Repetitious Work***

- ❖ Research has demonstrated that monotonous vigilance tasks decreased alertness by 80% in one hour
- ❖ Referred to a “Boredom Fatigue”

## ***Boring / Repetitious Work***

- ❖ Boredom and monotony are widely recognized as undesirable side effects of repetitious work and lead to under stimulation
- ❖ Typical examples of under stimulation include sensory and perceptual deprivation, vigilance (monitoring) tasks, repetitive tasks, and unsatisfying work

## ***Boring / Repetitious Work***

- ❖ Boredom and monotony are in fact stressors that lead to fatigue and may be as potentially harmful to the individual as are the same commonly acknowledged effects of exposure to over stimulating conditions
- ❖ These factors can be detrimental to morale, performance, and eventually to the quality of work

## *Prolonged Work*

- ❖ Prolonged work usually leads to fatigue because of cumulative sleep loss



# *Falling Asleep at the Wheel is No Laughing Matter*



Thag Anderson becomes the first fatality as a result of falling asleep at the wheel.

# ***Common Causes Fatigue Aviation Personnel***

- ❖ Movement restriction
- ❖ Variable air flow
- ❖ Low barometric pressure & humidity
- ❖ Noise
- ❖ Vibration
- ❖ Vigilant monitoring - Tedious tasks
- ❖ Continuous wakefulness
- ❖ Disturbance of circadian rhythms
- ❖ Cumulative sleep loss

## ***Common Causes of Fatigue Medical Personnel***

- ❖ Job Stress
- ❖ Vigilant monitoring - Tedious tasks
- ❖ Continuous wakefulness
- ❖ Shift work – Shift rotations
- ❖ Hours of service – Interns 60-130 hrs/week
- ❖ Responsibility – Compassion fatigue
- ❖ Disturbance of circadian rhythms
- ❖ Cumulative sleep loss

## ***Common Causes of Fatigue Law Enforcement***

- ❖ Vigilant monitoring - Tedious tasks
- ❖ Continuous wakefulness
- ❖ Shift Work – shift rotation
- ❖ Work load
- ❖ High threat environment
- ❖ Disturbance of circadian rhythms
- ❖ Cumulative sleep loss
- ❖ Long hours - Overtime

# *Common Misconceptions*

—“I know how tired I am”

—“I’ve lost sleep before and done just fine”

—“I’m motivated enough to push through it”

*WHY?*

# ***Common Misconceptions***

—“There is a quick fix, a magic bullet”

—“One cure will work for everyone”

***WHY?***

# ***Physical Fitness is Not a Safeguard Against Mental Fatigue***

- ❖ Organizations have historically tried to decrease fatigue susceptibility by improving physical fitness
- ❖ This strategy works well in jobs which require physical labor

# ***Physical Fitness is Not a Safeguard Against Mental Fatigue***

- ❖ However, it does not protect against mental fatigue
  - ◆ **One study showed fewer subjective complaints from night workers after physical training, but actual performance was not affected**
- ❖ Physical fitness may help you look better and live longer, but don't depend on it to overcome fatigue!



## ***My Team Members Will Tell Me When They're Tired!***

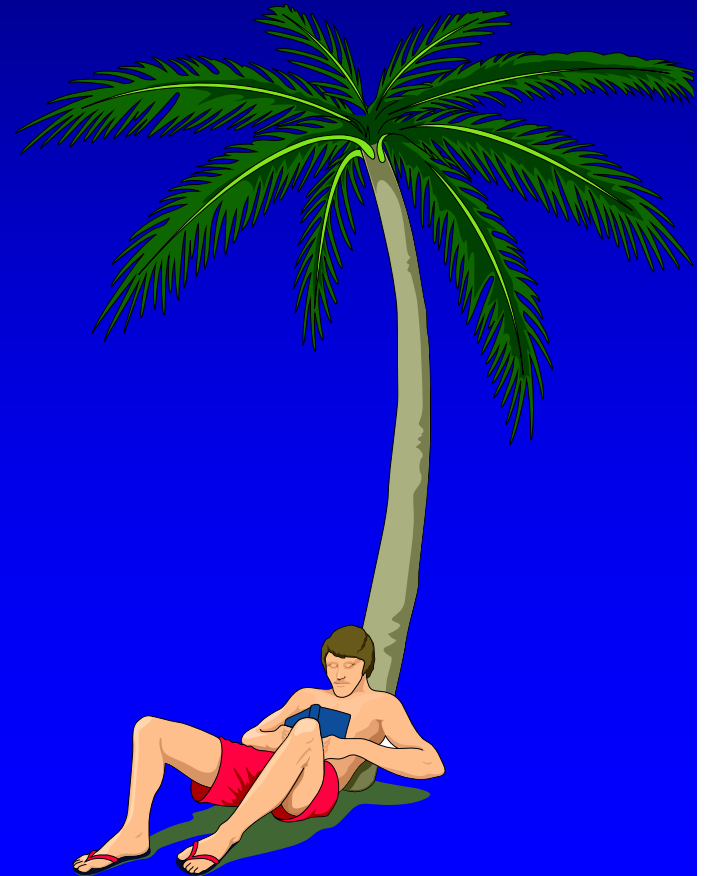
- ❖ Individual can't accurately gauge their own level of impairment, due to sleep loss.
- ❖ Don't rely on the individual to tell you. Managers and team members must learn to look for the symptoms of sleep loss in others.

# ***Risk Assessment***

- ❖ Previously acceptable risks may no longer be acceptable since the frequency of errors is increased
- ❖ Older workers (45 years and older) tend to suffer more from sleep loss than younger workers on externally paced tasks
- ❖ Younger workers may suffer more on self-paced tasks because they tend to exert too much effort at the beginning and fail to conserve energy for later

# *Preventive Strategies* *Circadian Rhythm Disruption*

- ◆ Shift Work
- ◆ Jet Lag
- ◆ Proper Schedules
- ◆ Sleep Onset Time



# ***Shift Lag and Jet Lag***

## **❖ Shift Lag**

- ◆ As individuals transition from one work schedule to another, physical and mental resources lag behind the rapid change in the sleep/wake cycle**
- ◆ The most difficult challenge to the body clock occurs during the transition from the day shift into the early morning shift or into nighttime duty hours**

# ***Shift Lag and Jet Lag***

## ❖ Jet Lag

- ◆ After travel across time zones, physical and mental resources lag behind the rapid change to the destination light/dark cycle and the new sleep and work schedule
- ◆ Following eastward or westward travel during which four or more time zones are crossed, readaptation can take from 4 days to several weeks

## ***Develop Proper Shift Schedules***

- ❖ Subjective complaints of sleepiness, fatigue, and poor performance are big problems for personnel working reverse cycle
- ❖ Thus, make efforts to:
  - ◆ **Reduce demands on night workers**
  - ◆ **Avoid long shifts since fatigue at night is already problematic**

# ***Develop Proper Shift Schedules***

- ◆ **Schedule teams in ways that ensure enough daily sleep**
- ◆ **If using split shifts, schedule them so personnel will have their time off when sleep is naturally easy to obtain**
- ◆ **Ensure clockwise transitions when changing work schedules**
- ❖ **Remember, people never really adjust to night work**

## ***Develop Proper Shift Schedules***

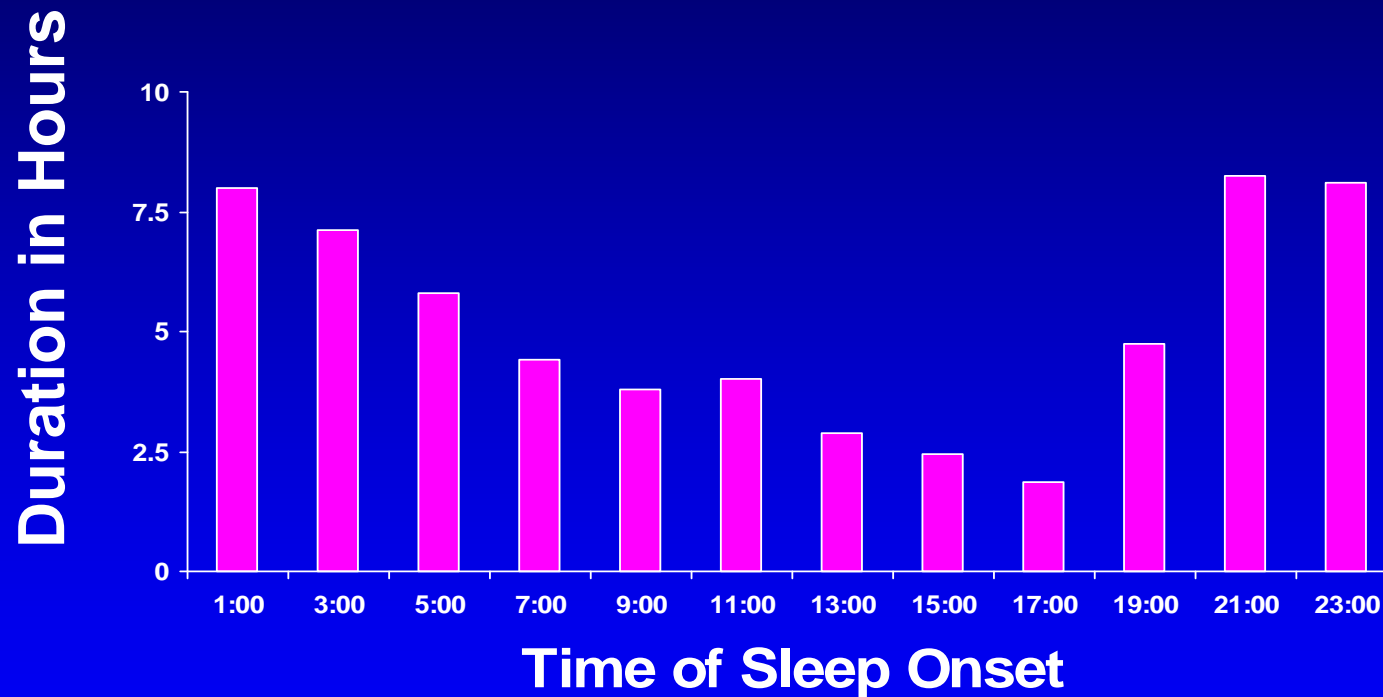
- ❖ Isolated Night Shift – Sleep as soon as possible after work and force yourself to get up after 4 hours. Return to sleep at normal bedtime.
  - ◆ Work: 2400-0800, Sleep: 0900-1200, Normal sleep time



## ***Develop Proper Shift Schedules***

- ❖ Short Stretches of Night Shift – Sleep in two 4 hour periods adjacent to your normal sleep time
  - ◆ Work: 2400-0800, Sleep: 0900-1200, 2000-2300
- ❖ Memory is sharpest after restorative sleep
- ❖ When you go to sleep may determine how much sleep you can get

# *Hours of Sleep Obtained by Time of Sleep Onset*



Source: Smiley, 1998

## ***Shift and Jet Lag***

- ❖ Use sufficiently bright lights in the work environment during the night shift in order to resynchronize the circadian timing system to the nocturnal schedule
- ❖ Maintain complete darkness in daytime sleeping
- ❖ Reduce daytime environmental noise to a minimum (e.g., traffic noise)
- ❖ Follow a consistent sleep- and meal-timing schedule from day to day

## ***Shift and Jet Lag***

- ❖ Eat light meals prior to retiring and schedule the heaviest meals around 1300 to 2000.
- ❖ Maintain the same schedule of sleep, wake-up, and meal times during days off
- ❖ Avoid frequent shift rotations. Allow shifts to continue for at least 2 to 3 weeks

# *Preventive Strategies Sleep Loss*

- ◆ Daily Sleep
- ◆ Chronic Sleep Restriction



## ***Emphasize Sufficient Sleep on a Daily Basis***

- ❖ Sleep restriction severely degrades performance
- ❖ When sleep is less than 6 hours per night, fatigue becomes a problem almost immediately
- ❖ When sleep is cut to less than 4 hours per night, uncontrolled micro sleep attacks occur

## ***Emphasize Sufficient Sleep on a Daily Basis***

- ❖ Thus, make sleep a priority and remember:
  - ◆ **7 hours per night is the minimum requirement**
    - *However, some people will need more*
  - ◆ **Determining individual needs is a trial-and-error process**

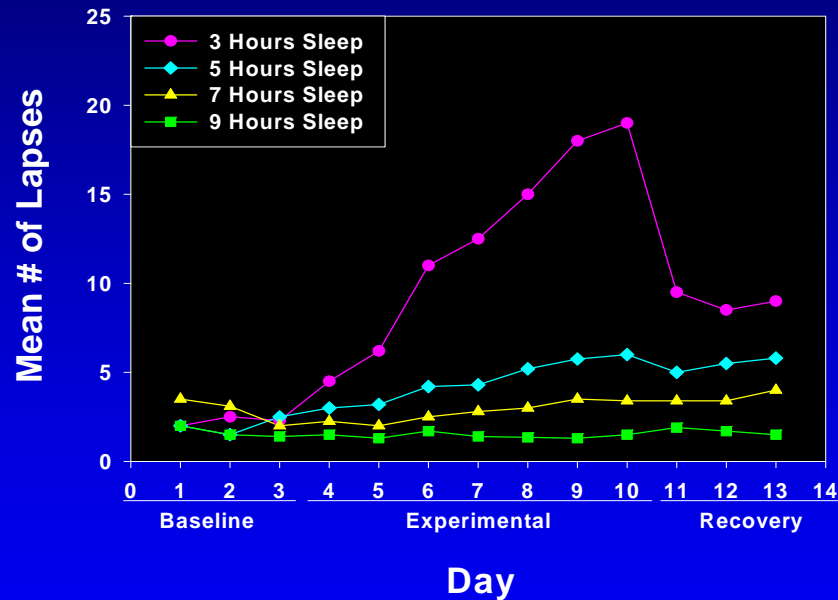
## ***Emphasize Sufficient Sleep on a Daily Basis***

- ◆ You'll know you've found the right amount when it's easy to stay alert even during boring and/or sedentary tasks
- ❖ You can't train yourself to get by on less sleep!

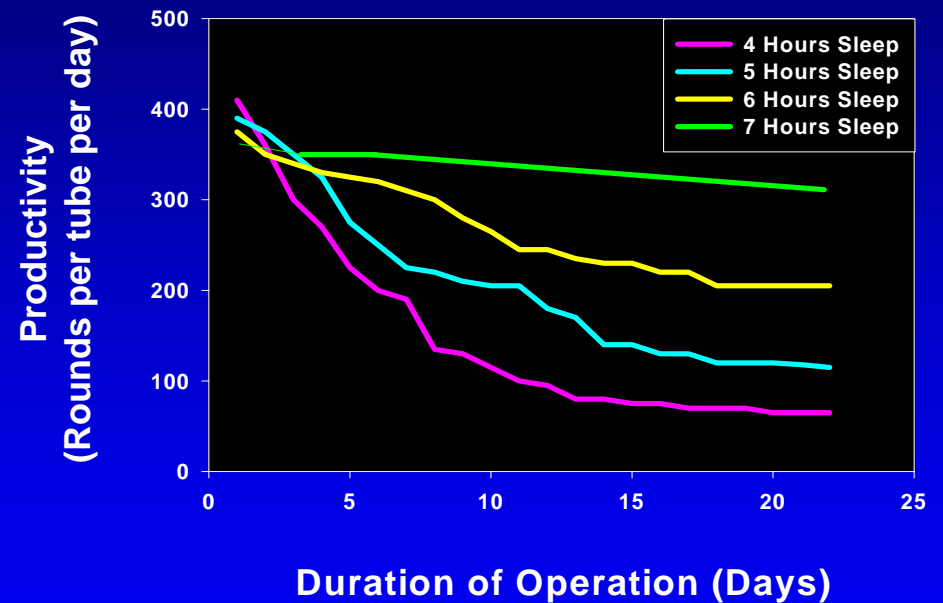


# Chronic Sleep Restriction Has Its Price

## VIGILANCE TASK PERFORMANCE



## ARTILLERY COMPANY PERFORMANCE



Source: Belenky et al. 1994; Belenky, 1998

# *Preventive Strategies*

## *Sleep Loss*

### ❖ At home

- Maintain a zero balance sleep debt

### ❖ While traveling

- Try to get same amount of sleep as normal

### ❖ Trust your own physiology

- Can't sleep (15-30 mins)...then don't
- Can't stay awake...then don't

## ***Individual Controlled Fixes***

- ❖ Sleep must always take place in darkness, (black out windows to exclude light and use sleep masks)
- ❖ Avoid variation in the timing of initial daylight exposure after awakening, variations of more than 3 hours from day to day induce maladaptation)
- ❖ individuals shifting to a day-oriented work schedule should seek as much daylight exposure as possible.

## ***Individual Controlled Fixes***

- ❖ During transition to night operations, it is best to avoid early morning daylight from sunrise to wake-up time.
- ❖ Daylight exposure should take place approximately 8 hours from bedtime.
- ❖ Wake-up time must be adjusted to accommodate the 8 hours in darkness.

## ***Individual Controlled Fixes***

- ❖ On days when early morning daylight exposure cannot be avoided, dark sunglasses can be used to reduce the amount of light reaching the eyes.
- ❖ Retiring as soon as possible is important because sleep quality decays as bedtime occurs later in the morning.

# ***Preventive Strategies***

## ***Good Sleep Habits***

- ❖ Pre-sleep routine
- ❖ Use bedroom only for sleep
- ❖ Keep sleep time sacred
- ❖ Sleep environment
- ❖ Diet and fitness
  - Avoid heavy meals, alcohol and caffeine
  - Exercise promotes REM sleep

# ***Preventive Strategies\****

## ***Good Sleep Habits***

### ❖ Sleep Environment

- ◆ Dark - Masks, Curtains
- ◆ Quiet - White noise, Turn off phone
- ◆ Comfortable - Cool temperature

### ❖ Lifestyle

- ◆ Exercise regularly
- ◆ Avoid alcohol and caffeine at bedtime
- ◆ Eat a balanced diet

# ***Exercise, Cold Air, and Music Don't Really Help***

- ❖ Some research shows that exercise can slightly improve alertness
  - ◆ However, the effect is short-lived (maybe 20 minutes) and probably leads to more fatigue later
  - ◆ Frequent exercise breaks aren't feasible in most operations



## ***Exercise, Cold Air, and Music Don't Really Help***

- ❖ Listening to a radio *slightly* improves reaction time and decreases subjective sleepiness
  - ◆ **However, there is no evidence that it improves driving or other types of performance**
- ❖ “Cold air to the face” has not been proven to stave off fatigue

# *Preventive Strategies*

## *Controlled Napping*

- ◆ Naps improve alertness
- ◆ Avoid sleep inertia
  - What is your baseline?
  - Don't allow nap to end in Stage 3 or 4
- ◆ Some sleep is better than none



## ***Controlled Napping***

- ❖ Naps can maintain or restore performance when sleep is shortened, disrupted, or missed altogether
- ❖ When napping, it is best to either get up after 30 minutes (before Stage 3 & 4) or sleep through a full sleep cycle (Stages 1 – 4) which is an hour and a half

## ***Controlled Napping***

- ❖ Naps can maintain or restore performance when sleep is shortened, disrupted, or missed altogether
- ❖ Naps ranging an average of 30 minutes are best, but even short naps (15-20 minutes) are better than nothing

## ***Controlled Napping***

- ❖ When possible, allow time for sleep inertia to dissipate – Usually from 30 – 45 minutes

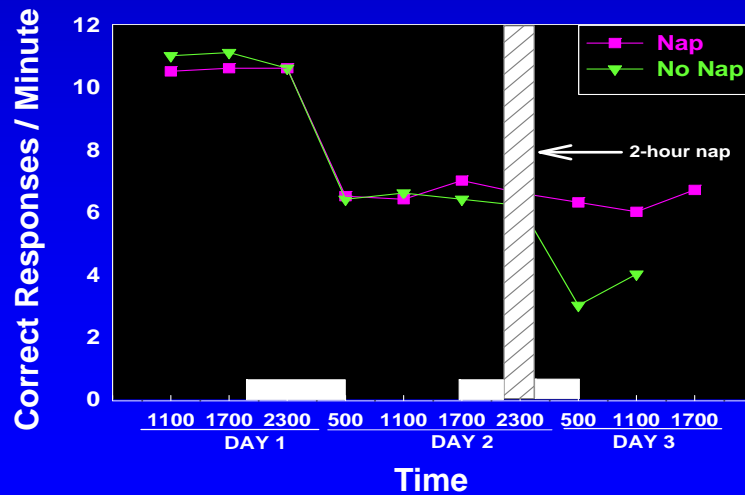
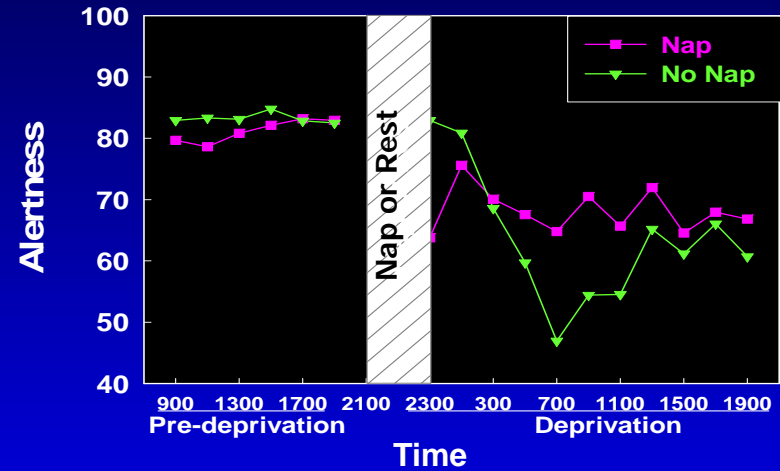
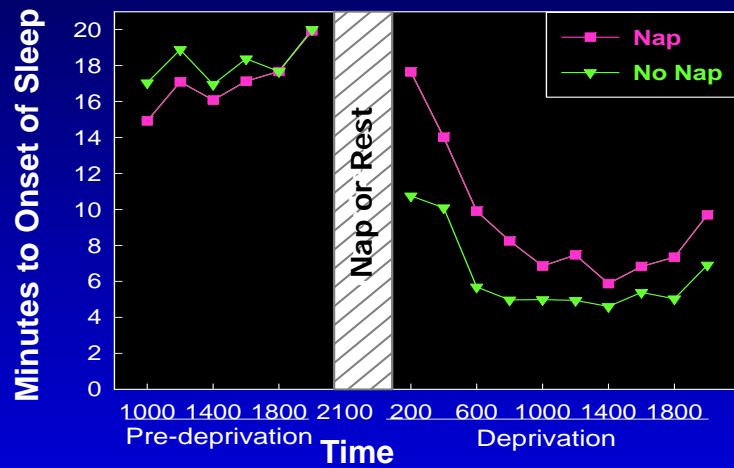
# ***Take Advantage of Strategic Naps***

## **❖ To implement naps:**

- ◆ Create a quiet, dark, cool environment (mask out noise & light)**
- ◆ Plan naps at conducive sleep times (0100-0500 or 1400-1600)**
- ◆ Place naps early in the work period (or before sleep loss)**
- ◆ Set aside as much time as possible for the nap**
- ◆ Allow time for sleep inertia to dissipate**

**Naps can bridge the gap  
between regular sleep periods**

# Naps Can Temporarily Make Up for Lost Sleep



Source: Caldwell and Caldwell, 1998; Angus, et al., 1992

## 1990 NASA Study with 21 747 Pilots\*

- ❖ Control group—Business as usual—No naps
  - ◆ 120 Episodes of microsleep
  - ◆ 22 Episodes on landing
- ❖ Test group—Strategic naps—40 min at cruise
  - ◆ 34 Episodes of microsleep
  - ◆ None on landing



# *Preventive Strategies*

## *Type of Task*

- ◆ Boring Tasks
- ◆ Repetitious Tasks
- ◆ Monitoring Tasks



# ***Implement Properly-Spaced Rest Breaks***

- ❖ Long bouts of work produce fatigue and boredom which can seriously impair performance
  - ◆ Liberal rest breaks provide for physiological recovery, increased mental stimulation, and improved mood

# ***Implement Properly-Spaced Rest Breaks***

- ◆ **Studies have shown that work breaks improve productivity and reduce subjective sleepiness**
- ❖ **A break at least every 2 hours is recommended when possible**

# ***Implement Properly-Spaced Rest Breaks***

- ❖ The more repetitious, boring, and tedious the task, the more frequently breaks should be scheduled
- ❖ Short term fix- only provides temporary relief

# *Summary and Conclusions*

- ❖ Fatigue is a major contributor to accidents, lost productivity, and poor quality of life
- ❖ As the activity continues, the potential for fatigue-related problems will only increase
- ❖ However, safety, performance, and general well-being can be preserved by:
  - ◆ **Adhering to good task-scheduling practices**

# ***Summary and Conclusions***

- ◆ **Implementing proven fatigue countermeasures**
- ◆ **Providing sleep-conducive environments for off-duty people**
- ◆ **Making adequate daily sleep a top priority**
- ❖ **Remember, sleep is a physical necessity--not a luxury, and there is NO substitute for SLEEP!**

# *If You Remember Nothing Else...*

- ❖ Sleep is vital...sleep or die
  - Sleepiness has serious consequences
  - Poor judge of how tired you are
  - Fatigue will set in
- ❖ Napping improves performance
- ❖ There is no simple answer
  - Everyone's different
  - Find out what works for you

**GOOD Fatigue Management**



**BAD Fatigue Management**

