

# Things We Once Believed: *A Reflection on the Evolution of Fatigue Management*

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# Introduction

- Fatigue has been a problem since the advent of the industrial age
  - Because: competition, technological advances, and transportation improvements have seriously challenged our basic physiology
- However, we have denied these challenges for decades
  - But, science has revealed the folly of our macho attitudes and replaced it with a focus on evidence-based, fully-integrated fatigue management
- Today's talk will trace the pathway from WHAT WE ONCE BELIEVED to WHAT WE NOW MUST DO

# Where It All Began

- The 3 most dangerous words in Science, Medicine, and as it turns out, *Fatigue Management* are:
- Because personal experiences, personal opinions, personal beliefs, etc. are not based on data!!

## In My Experience

- And if you don't think that's a problem, let's look at some things we (i.e. EVERYBODY, like ALMOST WITHOUT EXCEPTION) once believed

# A Sample of Widespread Beliefs We Once Held

I believe!

# *The Sun Revolves Around Earth*

- This theory, dates back to at least 600 B.C. and was widely held to be true for 1500 years
- It's in part based on biblical text, and really, *it's pretty obvious based on individual perception...*



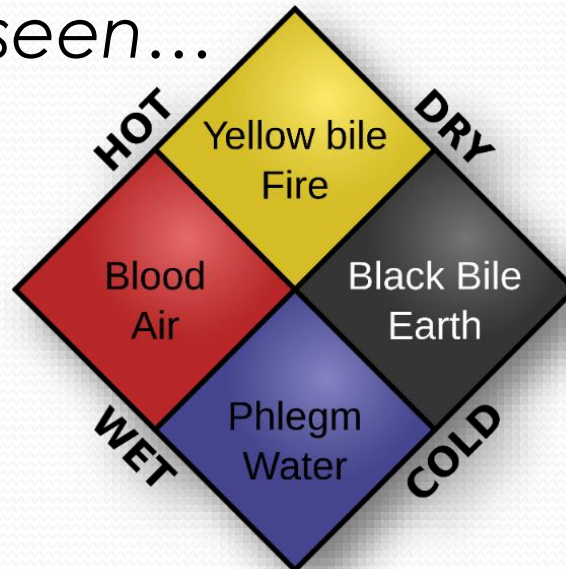
# *Disease is Caused by Bad Air*

- Cholera, Black Death, & other diseases were long thought to be due to poison vapors or “bad air”
- *It's obviously true because unpleasant odors, poor sanitation, disease, and death often go together...*



# Health is a Function of the 4 Humors

- Since 200 AD, 4 humors (black bile, yellow bile, phlegm, and blood) were thought to determine health
- *It's true because when blood is drawn in a glass container & left for an hour, the 4 different color layers can be seen...*



# Smoking is Good For You

- In Europe smoking began in the 1600's and most physicians believed it was an effective medicine
- Obviously true because a French physician cured a patient's tumor with tobacco poultices & nicotine can be relaxing at low doses...



## The Doctors behind the Doctor

• Medical peritellin... the amazing "milk"... and now the new super-...  
... Think the man of re-  
... search medicine for these... and for  
... all the other schools... they  
... have found in the search "black lung".  
... Biochemists and bacteriologists...  
... pathologists and physiologists...  
... wherever the field of research...  
... they are, first and foremost, doctors!  
... And, like all doctors, they are stan-  
... dardly devoting themselves to the cause  
... of human health and happiness.

According to a recent *Nationwide survey*:

**MORE DOCTORS SMOKE CAMELS**  
**THAN ANY OTHER CIGARETTE**

• What cigarette do you smoke, Doctor? ...that was the question put to 113,597 doctors from the Atlantic to the Pacific, from the Gulf of Mexico to the Canadian border. These independent research organizations did the asking...covered doctors in every branch of medicine.  
*The brand named most was Camels!*  
Like the rest of us, doctors smoke for pleasure. Their taste recognizes and appreciates the rich, full flavor and cool mildness of Camel's excellent tobacco just as yours does.

**CAMELS** *Castler Tobaccos*

YOUR "I-ZONE" WILL TELL YOU...



**I for Taste...**  
**I for Thrust...**  
that's your proving ground for any cigarette. See if Camels don't rate your "I-Zone" as a "1."





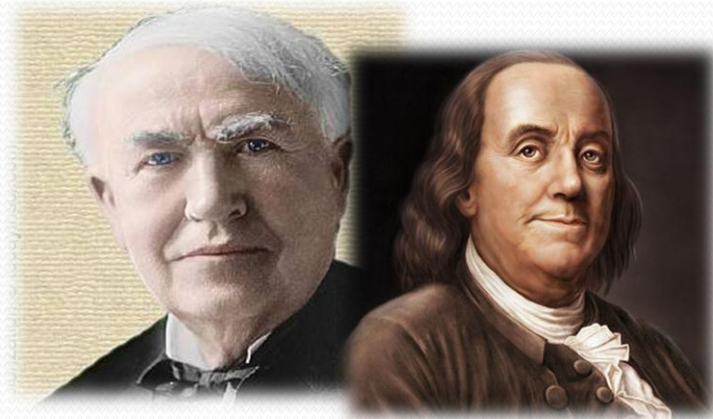
# *Cocaine is a Wonder Drug*

- Came into clinical use in the 1800's & was praised by great minds in medical history, such as Freud and the surgeon William Halsted
- *It's not only great as a pain killer, but it alleviates depression, fatigue, and headaches as well...*



# *Sleep is a Waste of Time*

- For centuries people thought the brain simply shut down during sleep, so it's importance was minimized
- With the dawn of the industrial age, sleep was considered a waste of time. Edison said "Sleep is an absurdity, & a bad habit," Ben Franklin said "Up sluggard and waste not life; in the grave will be sleeping enough!"
- *Sleep is obviously irrelevant since it's impossible to be productive while you're snoozing your life away...*

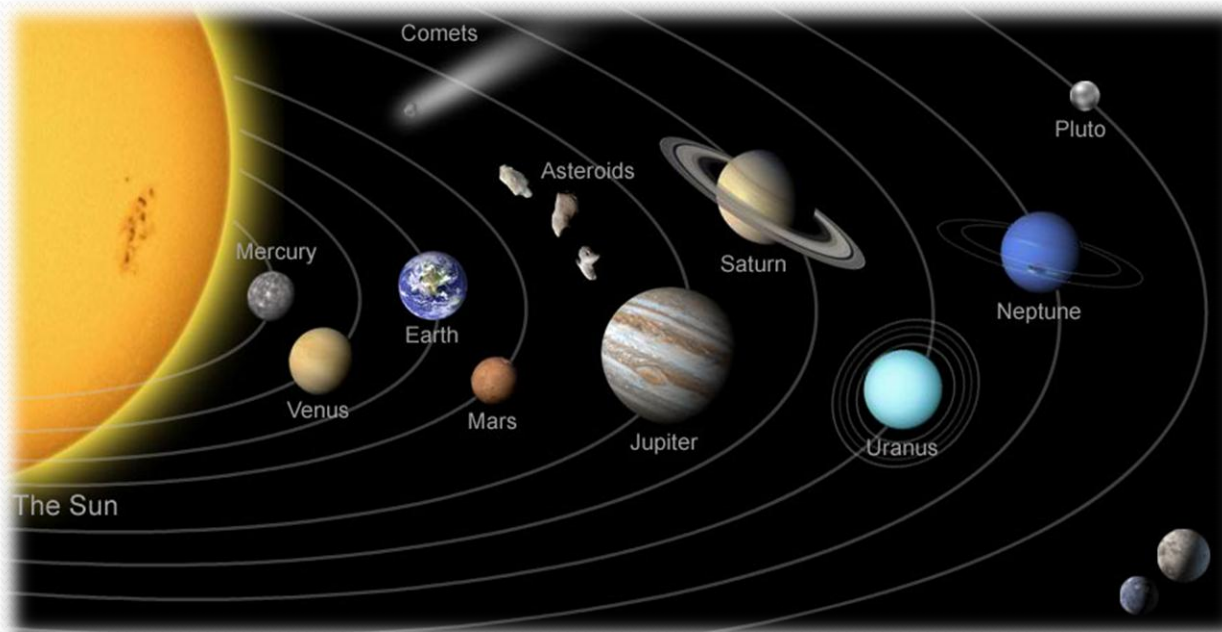


# But Now We Know The Truth!



# *Earth is NOT the Center of the Universe*

- The Geocentric theory was disproven by Copernicus in 1543. In **FACT**, the Earth and lots of other planets revolve around the Sun!



# *Disease is NOT Caused by Bad Air*

- The “bad air” theory was disregarded in the 1800s. In **FACT**, germs, viruses, and other factors cause disease!

## The Germ Theory of Disease

Pasteur’s work showed microbes are in the air, can spoil food, and cause animal diseases

Joseph Lister (1860s)

- used a chemical disinfectant to prevent surgical wound infections.

Robert Koch (1876)

- provided proof that a bacterium causes anthrax



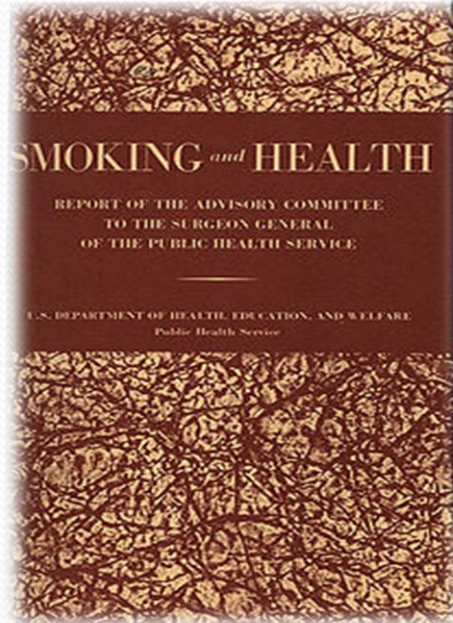
# *Health is NOT a Function of the 4 Humors*

- This idea was ditched in 1800's. In **FACT**, health is a function of many microscopic factors as well as the proper mechanistic functioning of numerous body parts and internal systems!



# *Smoking is NOT Good For You*

- The belief that smoking is good was dumped in the 1960's. In **FACT**, evidence proves that cigarette smoking causes lung cancer & other health-related problems



# *Cocaine is NOT a Wonder Drug*

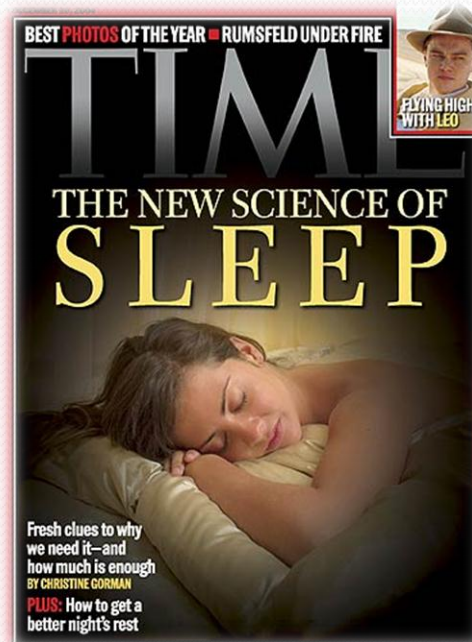
- The wonder-drug concept was dumped in the early 1920's. In **FACT**, cocaine creates numerous unfortunate effects (i.e., heart attack, stroke, seizure, kidney failure)





# *Sleep is NOT a Waste of Time*

- We disregarded the “waste-of-time” idea in the 1950’s. In **FACT**, science has shown sleep to be an active physiological process that is important for health, safety, mood, and cognition



# How Does All of This Relate to Fatigue Management?



# The Science of the Matter

- **We Once Believed** (in the early 1900's): fatigue risk was a function of hours worked and hours of rest between work
  - *Working day vs night didn't make a difference*
  - *Crossing time zones wasn't a problem*
  - *Only the number of hours on duty was important!*
- **We Now Realize** (beginning in the 1980's): fatigue risk is a matter of sleep quality, the circadian times of work and sleep, and the length of continuous wakefulness
  - *None of these are effectively managed by duty-time limits!*

# We Also Now Realize

- People cannot train themselves to need less sleep
- It's not easy to tell when fatigue starts to impact performance
- Once sleepiness is evident, it's impossible to force alertness
- Prior experience with sleep loss doesn't make it less of a problem
- Training under the influence of fatigue doesn't make it easier to perform under the influence of fatigue
- Rest/relaxation and sleep are not equivalent
- Alcohol is not a good “sleep medication”
- Stimulants cannot replace the need for sleep

# So, What IS The Truth About Fatigue?



# The Three Factors of Fatigue

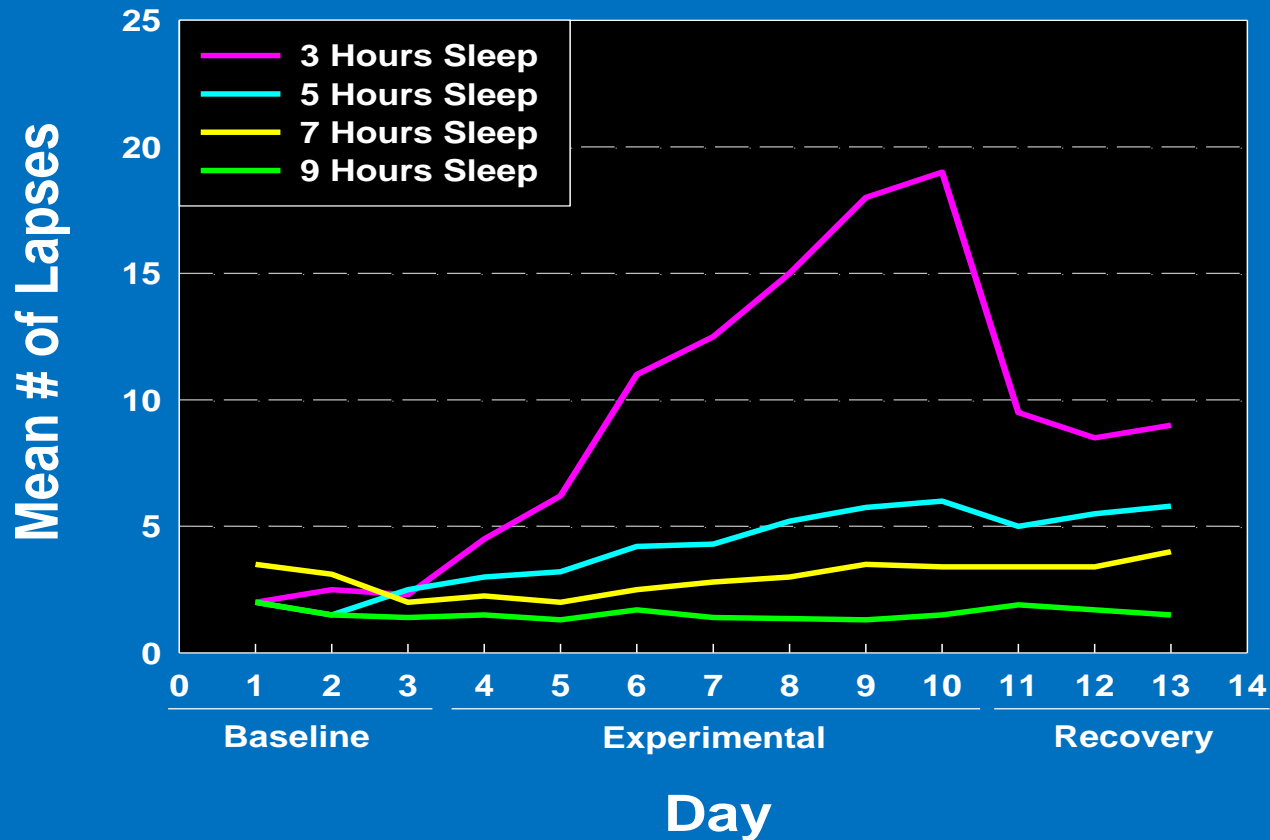
- Fatigue is physiologically based on:
  - *Acute sleep loss and sleep debt*
  - *Continuous hours of wakefulness*
  - *Circadian factors*
- In scientific terms, these are called the **homeostatic** and **circadian** components of sleep/wake regulation
- The effects of these factors cannot be overcome by money, motivation, professionalism, training, or anything else!

# Factor I: Sleep Loss

- The average adult needs 7 hours of restful sleep every 24 hours in order to be fully alert
- Some are affected more by sleep loss than others
- Despite individual differences in sleep needs, less than 5 hours of sleep is a universal safety hazard
- Research has proven that people cannot overcome sleep restriction by repeatedly exposing themselves to insufficient sleep
- In addition, it is now clear that chronic sleep restriction poses serious recovery problems

# The Price of Sleep Restriction

## Vigilance Task Performance



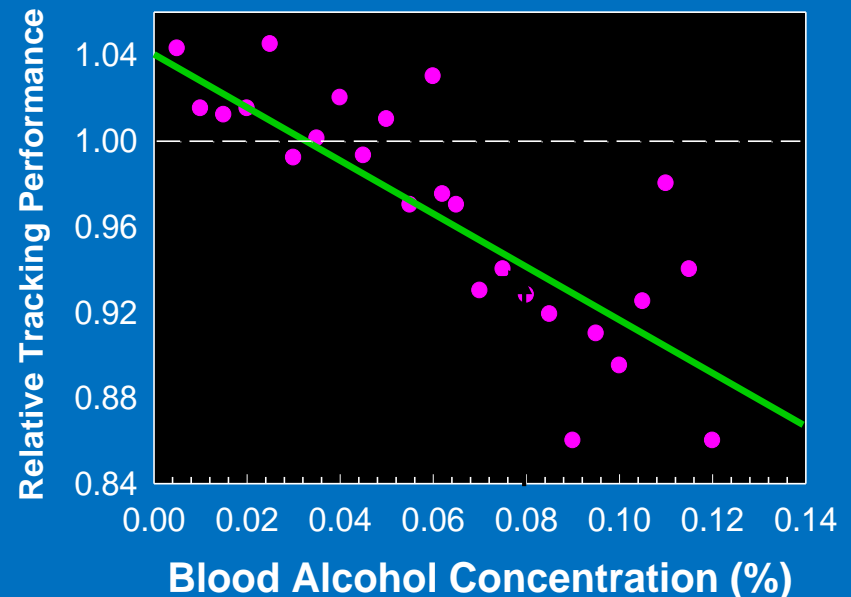
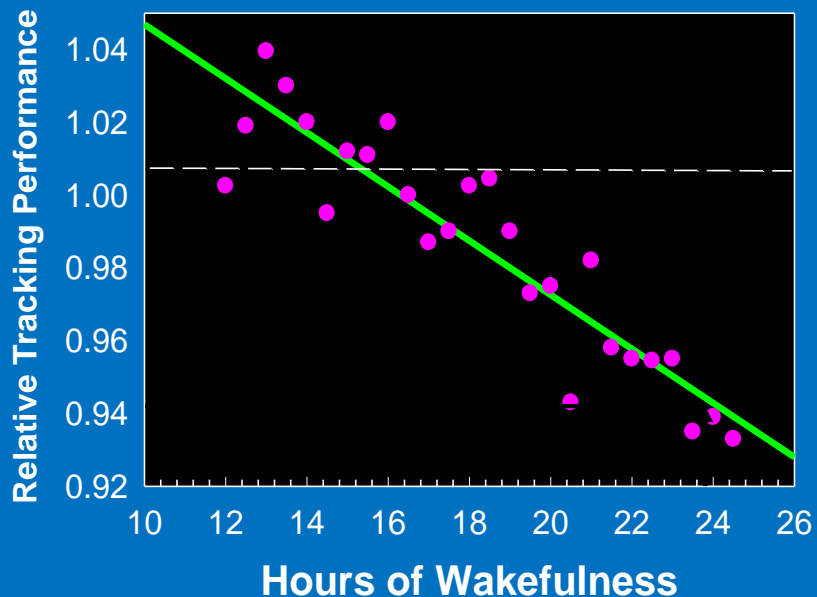
Johnson ML et al. (2004). Modulating the homeostatic process to predict performance during chronic sleep restriction. *Aviation, Space and Environmental Medicine*, 75(3 Suppl):A141-6.



# Factor II: Hours of Wakefulness

- Individuals can tolerate about 16 continuous hours of continuous wakefulness before serious decrements begin to occur
- Research suggests that 12-hour work periods should be considered the upper limit for “time on duty,” but it’s really time awake that counts
- More than 17 hours awake has been associated with the same types of performance decrements observed with alcohol intoxication!

# *Fatigue vs Alcohol Intoxication*



**Note that 22-24 hours of continuous wakefulness equates to a BAC of .08%.**

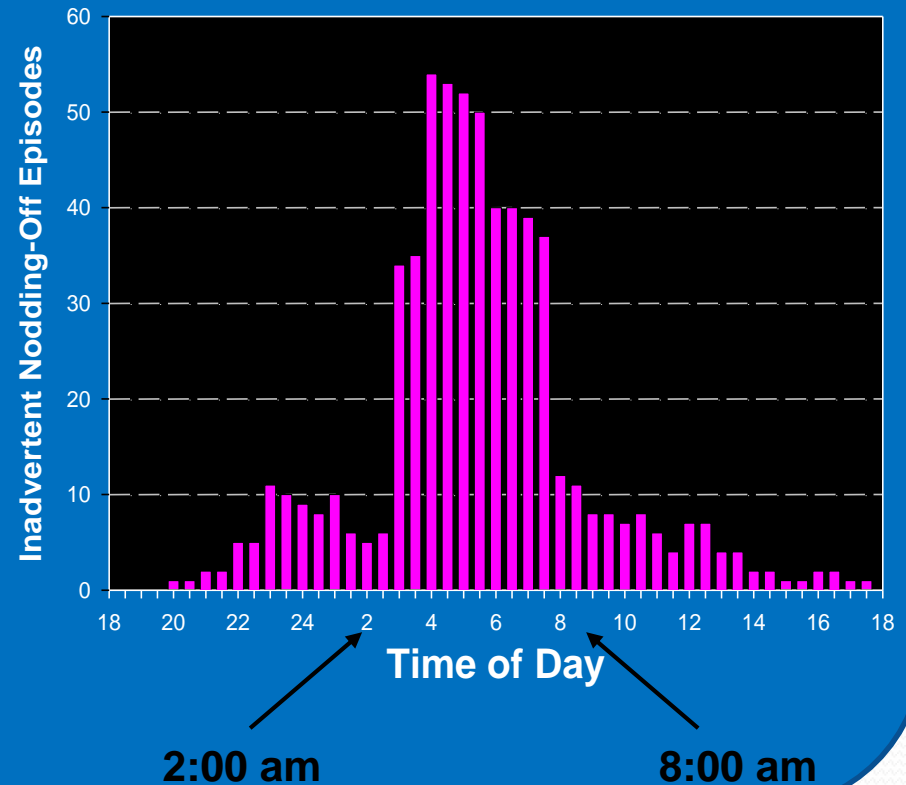
***Legally too Drunk to Drive!!***

# Factor III: Circadian rhythms

- The body has numerous internal functions that operate on a 24-hour schedule
- Alertness is particularly low between 0200 and 0600 (although often even later)
- Attention lapses, flight-control deviations, and maintenance errors are more frequent and severe when duty overlaps the subjective nighttimes of personnel
- Vigilance can degrade up to 500% at nighttime as compared to daytime
- A NASA simulator study found micro-sleeps in 9 of 14 subjects during the last part of 6-h night flights
- AMT's have not been the focus of such studies, but there is no doubt they suffer similar effects!

# Alertness Problems at Night

- In the early morning hours, pilots are 10 times more likely to inadvertently nod off in the cockpit
- Note that many of these occur well after sunrise!



Moore-Ede, MC. (1993) The twenty-four hour society: Understanding human limits in a world that never stops. Addison-Wesley, Boston, Mass. 1993

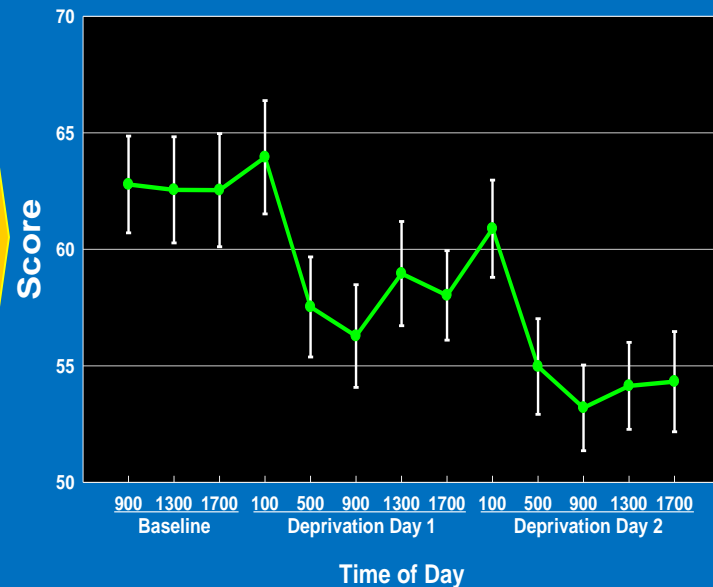
# The Bottom Line



# Factors I, II, and III: Combined

- When the three primary fatigue factors combine, safety and performance are at risk!

**Sleep loss**  
+  
**Long Duty Hours**  
+  
**Circadian Low Points**



**Severely Impaired Alertness**

# Sleepiness on the Flight Deck



# Fatigue Matters!!

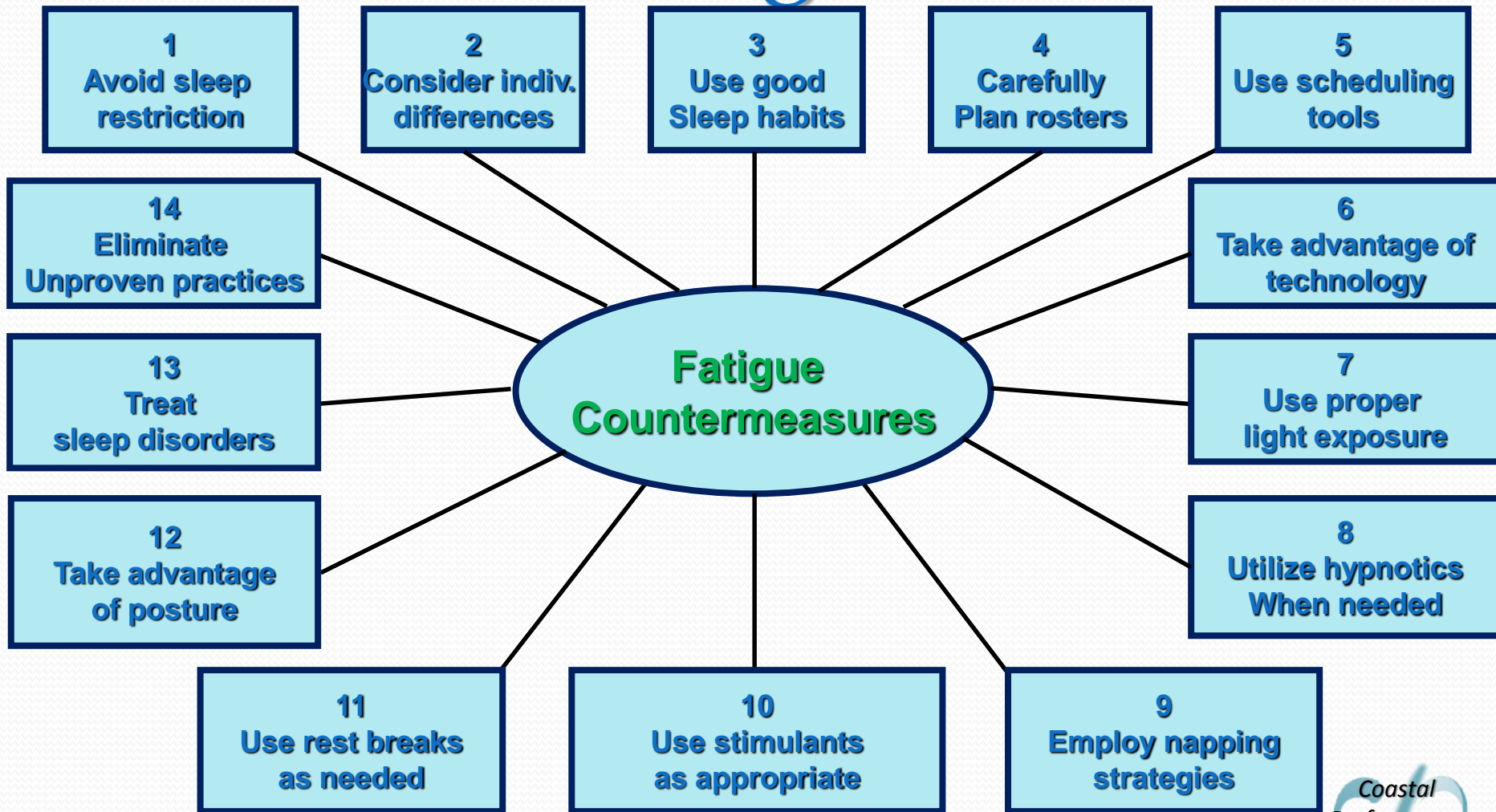
- Fatigue is a threat to pilot performance, but it plays a role in maintenance errors too!
- Aviation maintenance errors have been blamed for:
  - 15% of major mishaps from 1982 to 1991 (*costing 1400 lives*)
  - 50% of flight delays (*costing airlines \$10,000/hour*)
  - 20-30% of in-flight shutdowns (*at a cost of \$500,000/shutdown*)
  - 50% of flight cancellations due to engine problems (*at a cost of \$50,000/cancellation*)
- Obviously, fatigue risk management is important for EVERYONE in the aviation system!



# There Are Proven Tools to Effectively Manage Fatigue



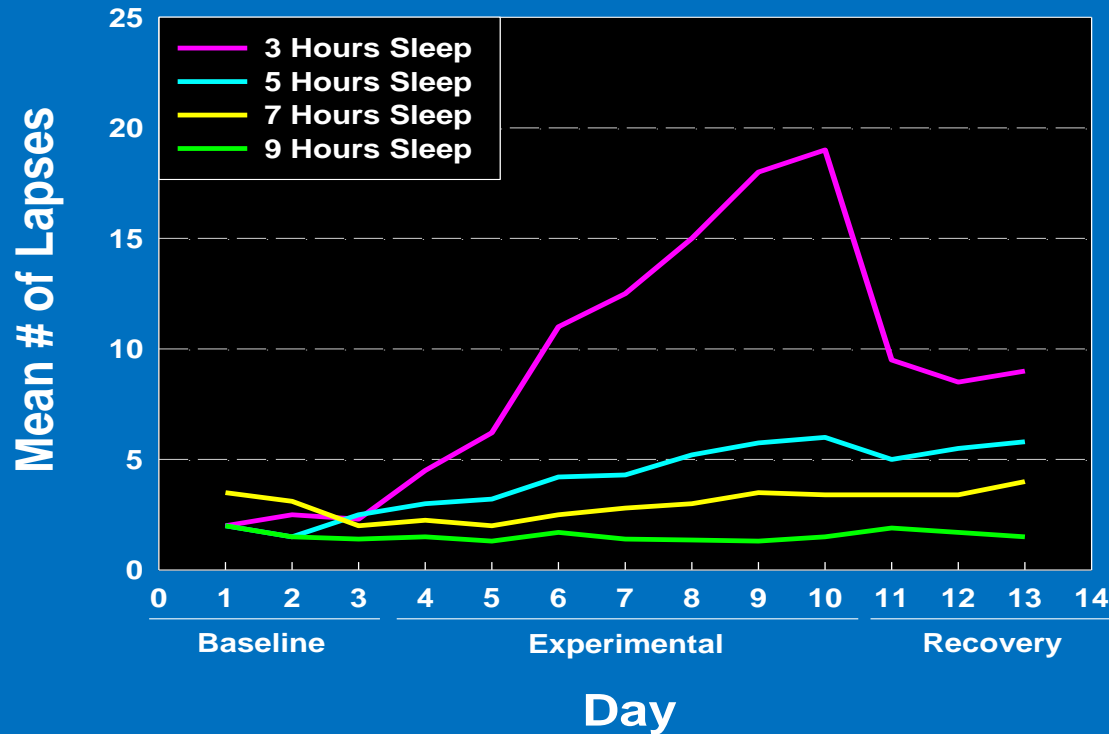
# The Anti-Fatigue Tool Box



# 1) Avoid Sleep Restriction

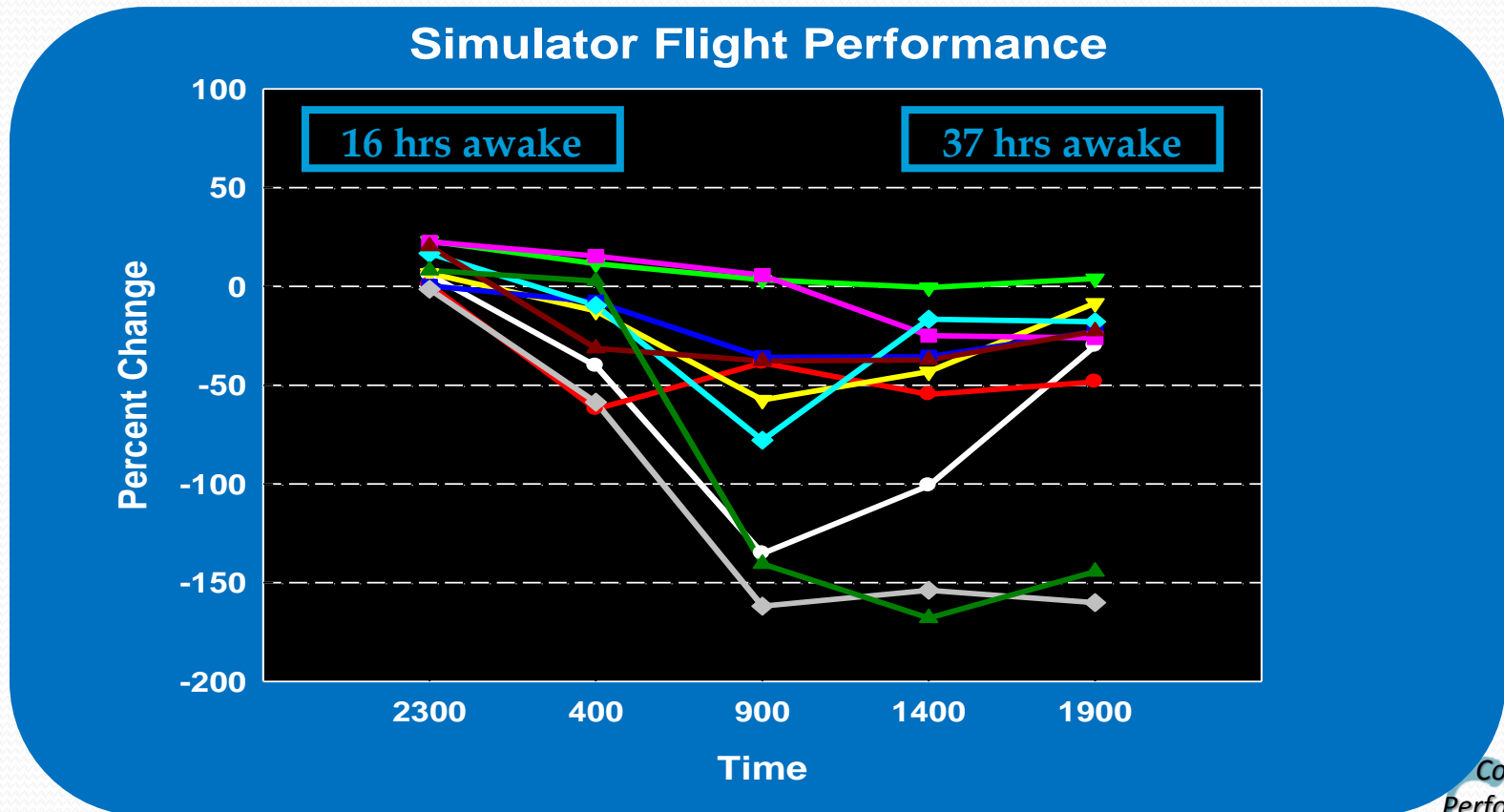
- Even small amounts of chronic sleep loss matter!

## Vigilance Task Performance



## 2) Account for Individual Differences

- Everyone is affected differently by fatigue!



# 3) Use Good Sleep Habits

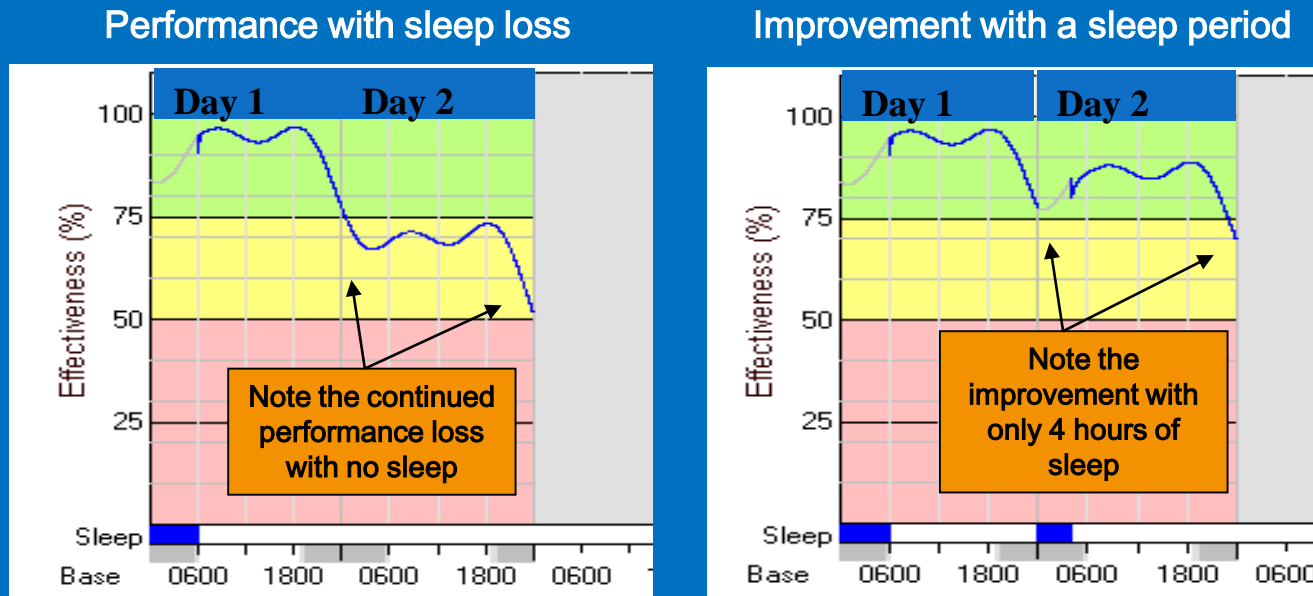
- When possible make the daily schedule consistent
- Use the sleep area only for sleep and sex
- Resolve daily dilemmas away from sleep area
- When possible use consistent “getting ready for bed” routine
- Develop cardio exercise routine and stick to it
- Ensure quiet, dark, cool, comfy sleep environment
- Don't consume caffeine within 4 hours of bedtime
- Don't use alcohol as a sleep aid
- Don't take naps during the day
- Don't smoke immediately before bed
- Don't be a clock-watcher

## 4) Carefully Plan Rosters

- Provide at least 2 days off after night rotations
- Allow employee input
- Provide education to families
- Pay attention to workload and staffing levels
- Consider ergonomic/environmental factors (i.e., light)
- Emphasize double-checking work at night
- Make sure those working at night have full access to resources available to day workers
- Educate the personnel about circadian rhythms, sleep and night work and appropriate fatigue countermeasures

# 5) Use Scheduling Tools

- Biomathematical models can help for schedule design and accident investigation



**Fatigue Avoidance Scheduling Tool (FAST)**

# 6) Take Advantage of Technology

- Some technologies can monitor sleep and track alertness

## Activity Monitoring



## Eye Monitoring





# 7) Use Light Exposure

- Alter light exposure to modulate circadian rhythms, alertness, and performance

Increase Blue Light Levels @ Night



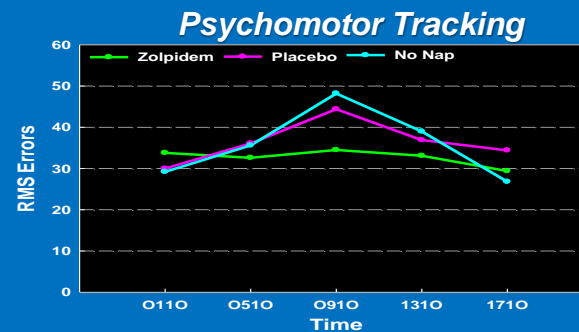
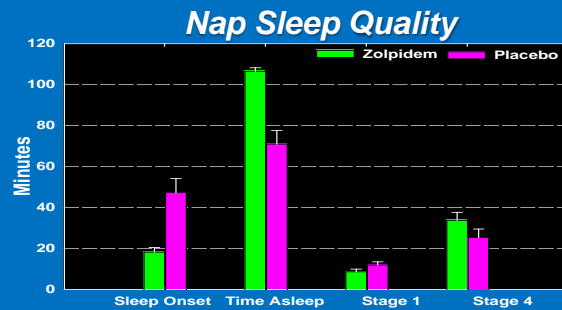
Block Blue Light on the Drive Home



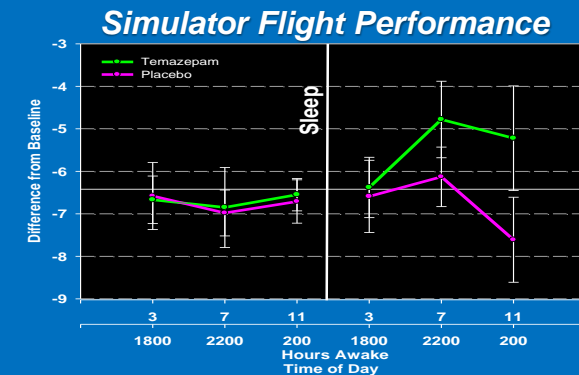
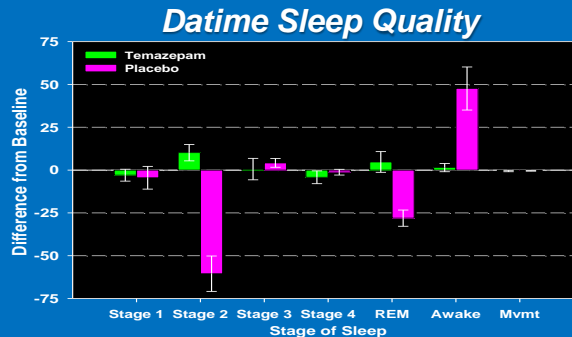
# 8) Consider Hypnotics

- Medications that improve daytime sleep can enhance nighttime performance

## Zolpidem Improves Naps



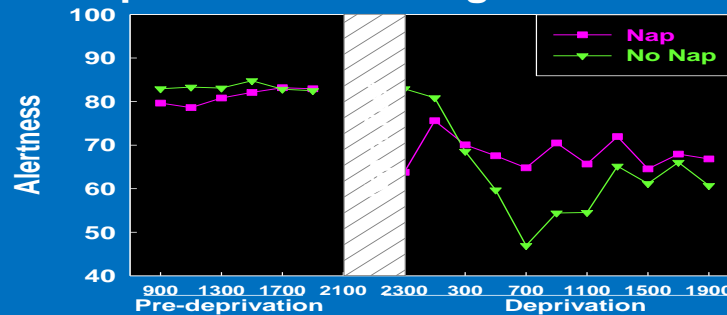
## Temazepam Improves Day Sleep



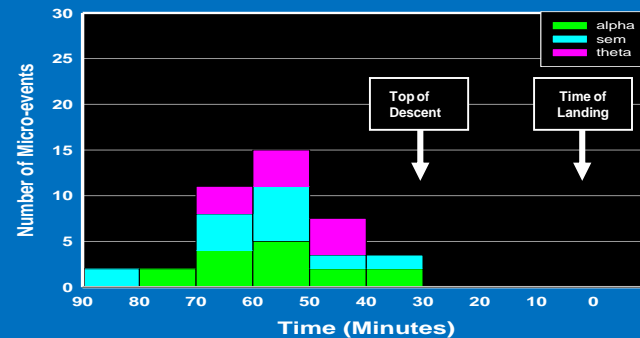
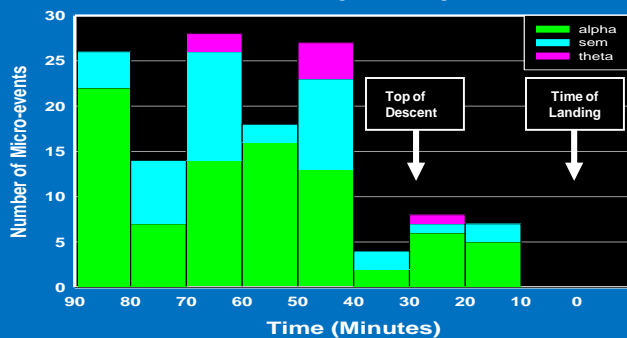
# 9) Employ Nap Strategies

- When schedule issues prevent adequate sleep, naps can help maintain performance.

### A Nap BEFORE A Long Work Period



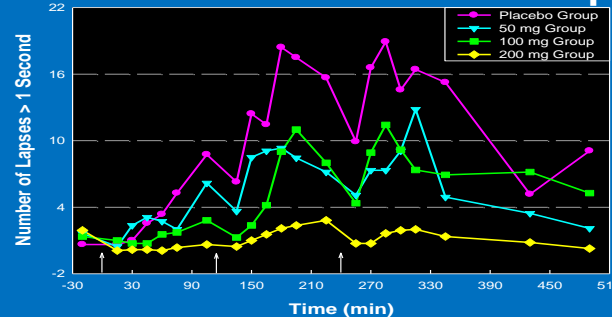
### In-Seat Cockpit Naps



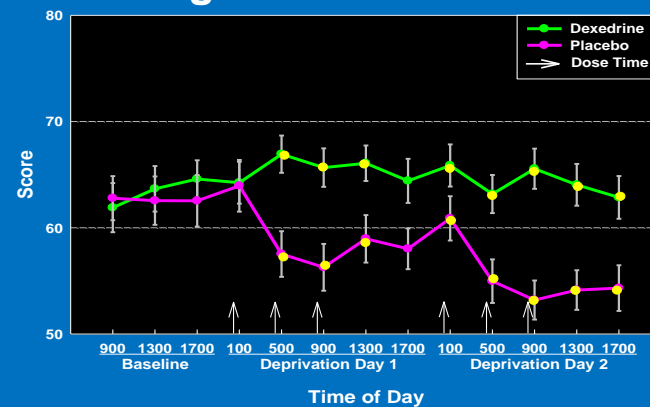
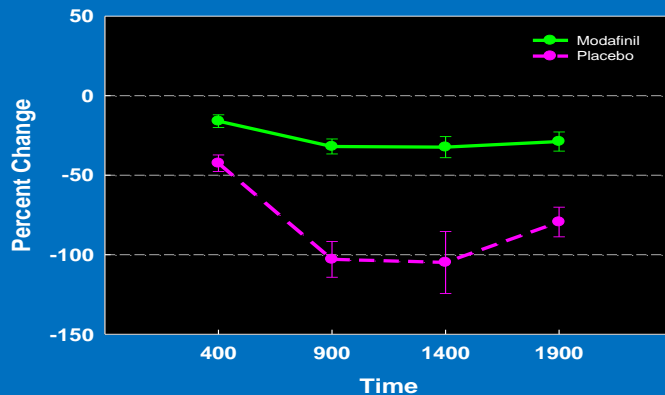
# 10) Use Stimulants

- When adequate sleep is impossible, stimulants can help mitigate sleepiness

## Caffeine Reduces Attention Lapses



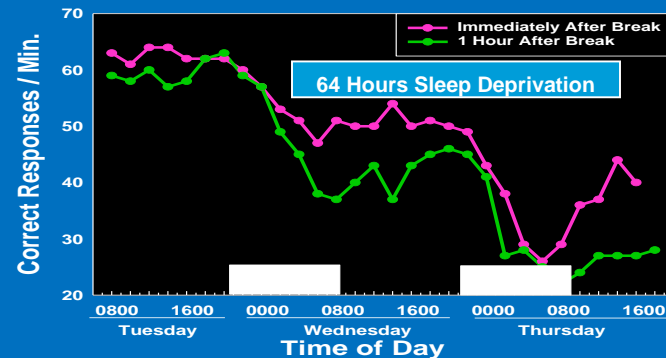
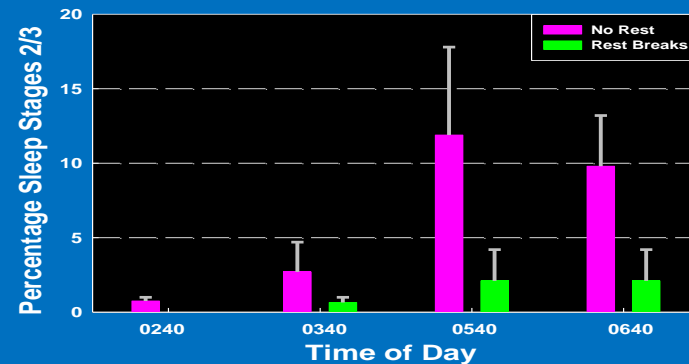
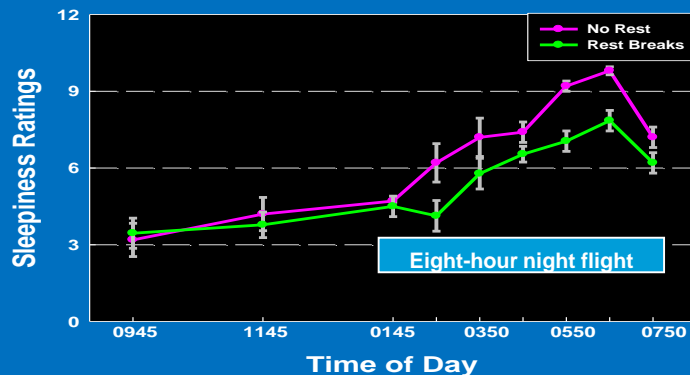
## Modafinil & Dexedrine Sustain Flight Performance



# 11) Utilize Rest Breaks

- Breaks help performance, physiological recovery, mental stimulation, and mood

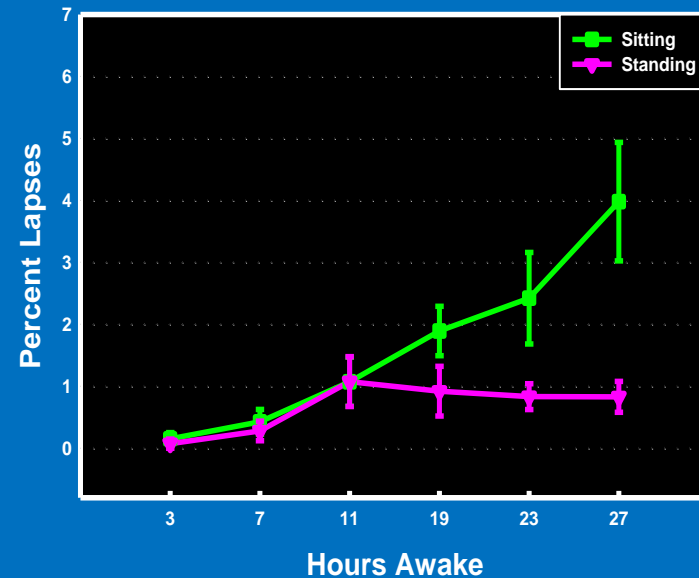
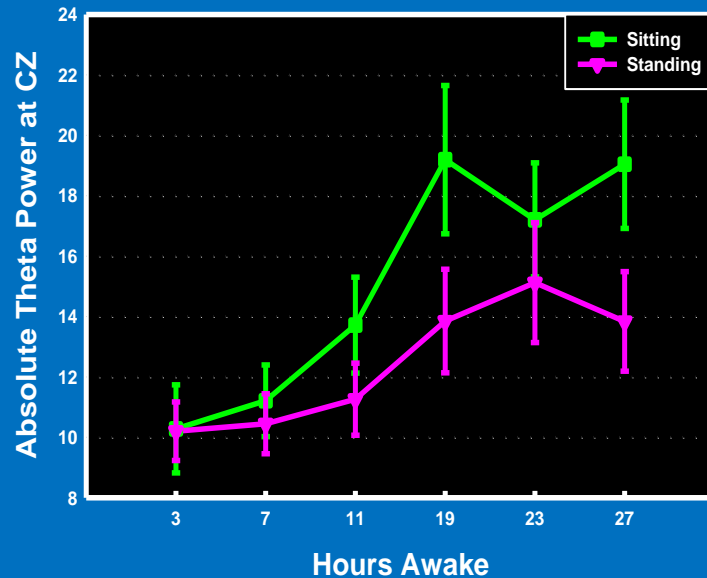
## Breaks Briefly Boost Alertness



# 12) Use Body Posture

- The more upright the body's position, the less sleepiness there will be

## Slow EEG Activity & Attention Lapses Decrease While Standing



# 13) Treat Sleep Disorders

- Sleep disorders can significantly degrade sleep quantity and quality
  - Sleep apnea, periodic limb movements, restless legs, etc.
- 24% of males between 30 and 60 experience sleep apnea
- The American Academy of Otolaryngology reveals that a BMI at or above 32 has an 89% positive predictive value for identifying OSA
- Sleep apnea has been identified as a risk factor in motor vehicle accidents

# 14) Eliminate Unproven Strategies

- Many counter-fatigue strategies have not been shown to work well (or at all)
- Some research shows that exercise can slightly improve alertness, but only briefly
- “Cold air to the face” is not scientifically supported
- Listening to music doesn't improve driving or other types of performance
- The nicotine in tobacco products has variable effects on alertness
- Physical fitness is not a safeguard for mental fatigue



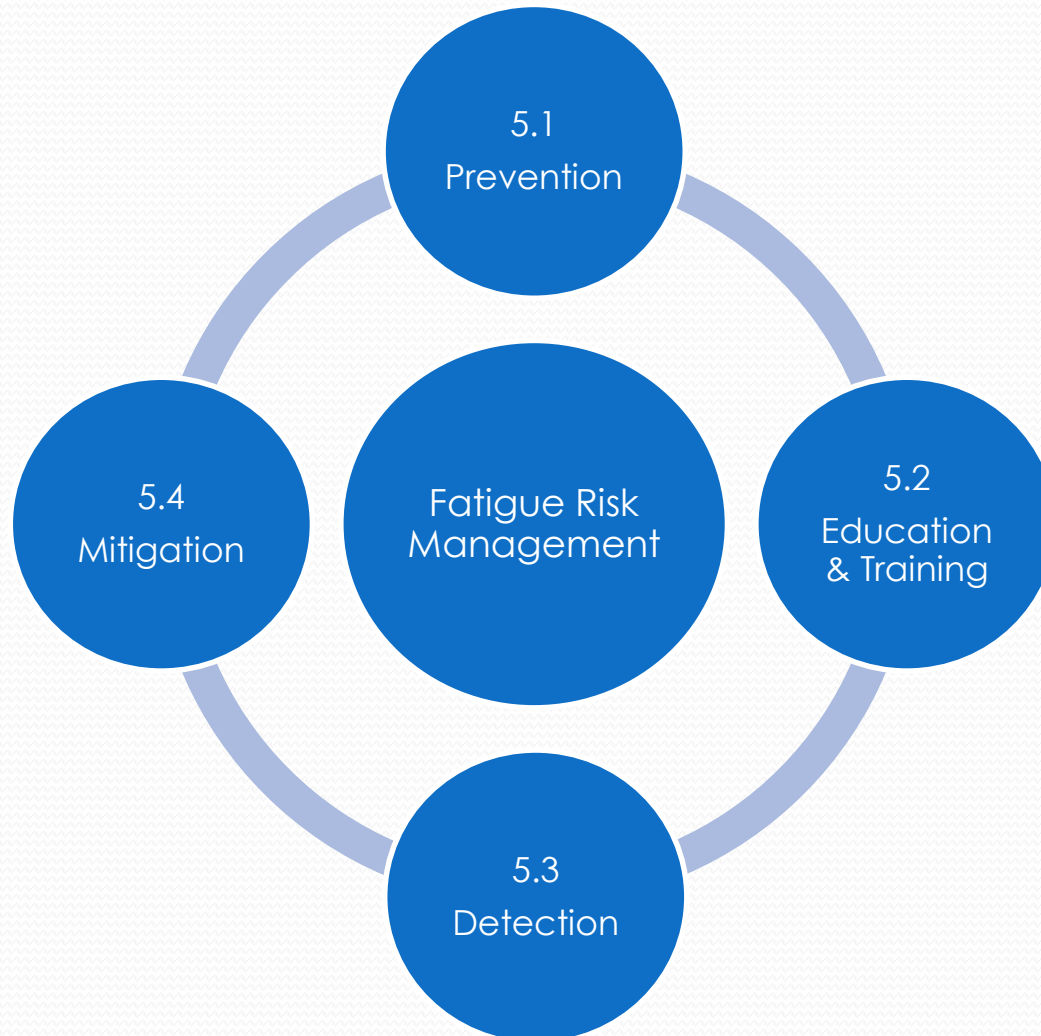
# It All Should Be Part of A Fatigue Risk Management System



# A Successful FRMS

- To maximize success, ditch the myths, and build a valid FRMS that is:
  - **Science based** - Supported by established peer-reviewed science
  - **Data driven** – Bases decisions on collection and objective analysis of data
  - **Participative** - Designed together by all stakeholders
  - **Fully Implemented** - Uses tools, systems, policies, & procedures on a system-wide basis
  - **Integrated** - Built into the corporate safety & health management systems
  - **Continuously improved** - Progressively reduces risk using feedback, evaluation & modification
  - **Budgeted** - Justified by an accurate ROI business case
  - **Owned** - Accepted and owned by senior leadership

# Address The Four Pillars

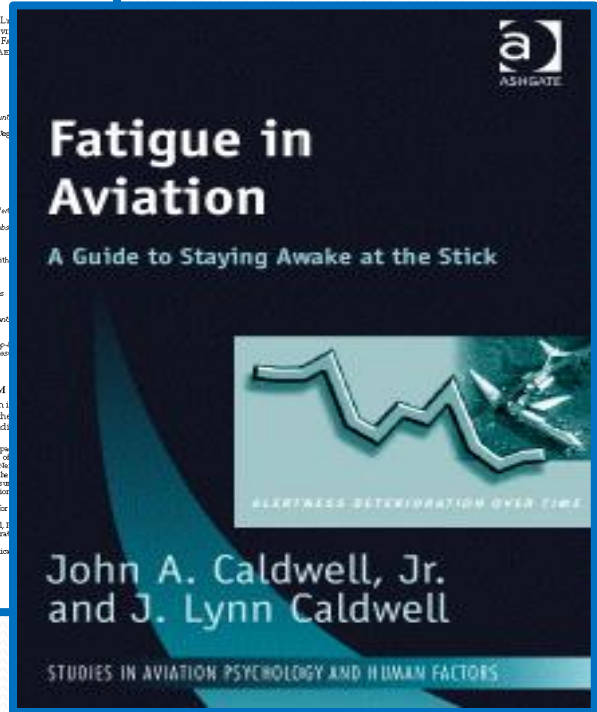
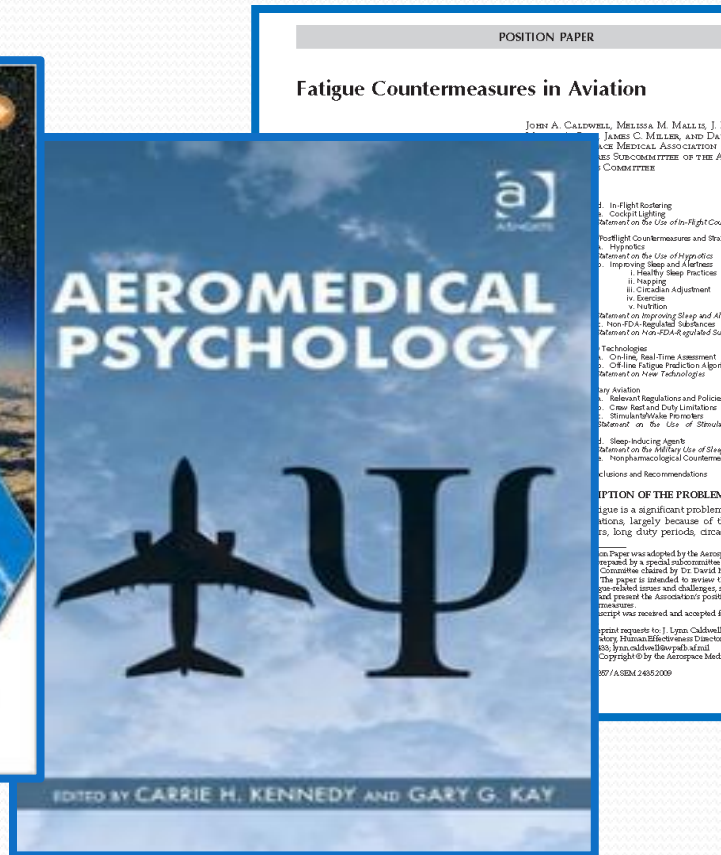
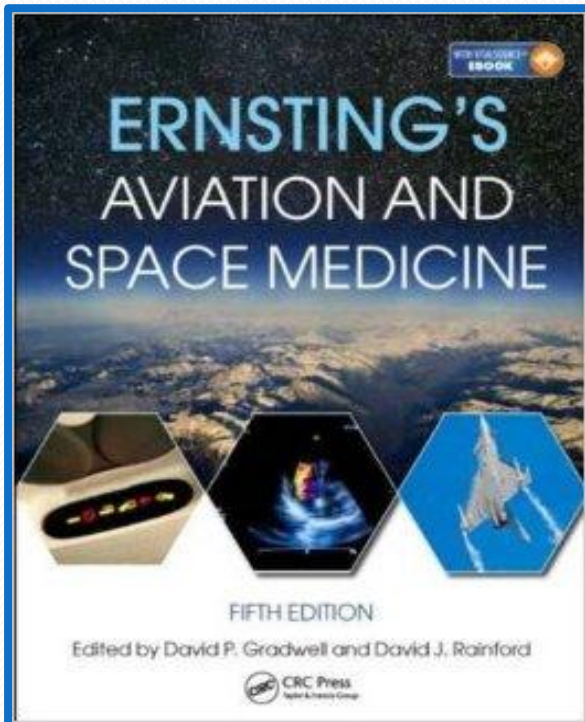


# Summary & Conclusions

- Fatigue is a huge problem throughout aviation operations--from the pilots to the maintainers
- However, it CAN be managed once the scientific underpinnings are understood
- A host of scientifically-supported countermeasures are available for use in isolation or in combination
- Within the context of a well-planned FRMS, fatigue risks can be effectively mitigated!!

# For Additional Information

Read one of these books and the 2009 Position Paper adopted by the Aerospace Medical Assoc.



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