

Parallel Session

Operational Evidence of Fatigue: Flight Operations

Sleep and Psychomotor Performance during Commercial Ultra-Long Range Flights

John A. Caldwell, Ph.D.
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14:20 - 14:45

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John A. Caldwell, Ph.D.
Biography

Dr. John Caldwell has over 21 years of experience conducting applications-oriented research and development aimed at improving safety and performance in operational contexts. He has conducted numerous studies in specialized laboratories and specially-instrumented flight simulators and aircraft, and he has collected and analyzed a wide variety of cognitive, mood, physiological, and flight-performance data from pilots. He has developed and delivered a number of tailored aviation counter-fatigue workshops and well over 100 presentations to physicians, pilots, scientists, and the general public. He has published one book, six book chapters, over 32 first-author peer-reviewed scientific papers, and more than 60 first-author articles in user-focused journals, conference proceedings, and government reports. He is a fatigue-management consultant for a major airline, NASA, the Army, the Air Force, and the Marines. Before joining Archinoetics, Dr. Caldwell was employed by the U.S. Air Force and the U.S. Army, conducting research, training, and consultations designed to enhance and sustain the effectiveness of the operational aviation community. He has completed two assignments with NASA's Human Factors Division at Ames Research Center in California where he focused on counter-fatigue research and applications aimed at aviation and space personnel.

Effects of Fatigue on Operational Performance



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This presentation will cover four topics

- **Quick overview of the primary causes of pilot fatigue**
- **A summary of the general symptoms of pilot fatigue**
- **A review of what controlled studies have revealed about the impact of fatigue on basic piloting capabilities**
- **A look at how fatigue-induced decrements translate into operational performance problems**

What are the primary sources of pilot fatigue



Presented at the FAA Fatigue Management Symposium: Partnerships for Solutions; Vienna, VA: June 17-19, 2008

Both long-haul and short-haul pilots commonly associate fatigue with scheduling issues

- **Night flights (operating at circadian low point)**
- **Multiple time-zone crossings (jet lag)**
- **Early wakeups (truncated sleep)**
- **Time pressure (increased workload)**
- **Multiple flight legs (extended work periods)**
- **Consecutive duty periods without sufficient recovery time (chronic sleep loss)**

Regional pilots also say scheduling factors are top contributors to operational fatigue

- **Multiple take-offs and landings every day (chronically high workload)**
- **Continuous-duty overnights (shift lag)**
- **Reserve status (acute sleep deprivation)**
- **Night flights (operating at circadian low point)**
- **Early report times (truncated sleep)**
- **Breaks that are too short to eat or nap**
- **Extended breaks that translate into long work hours with minimal flight time**

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What are some of the symptoms of pilot fatigue



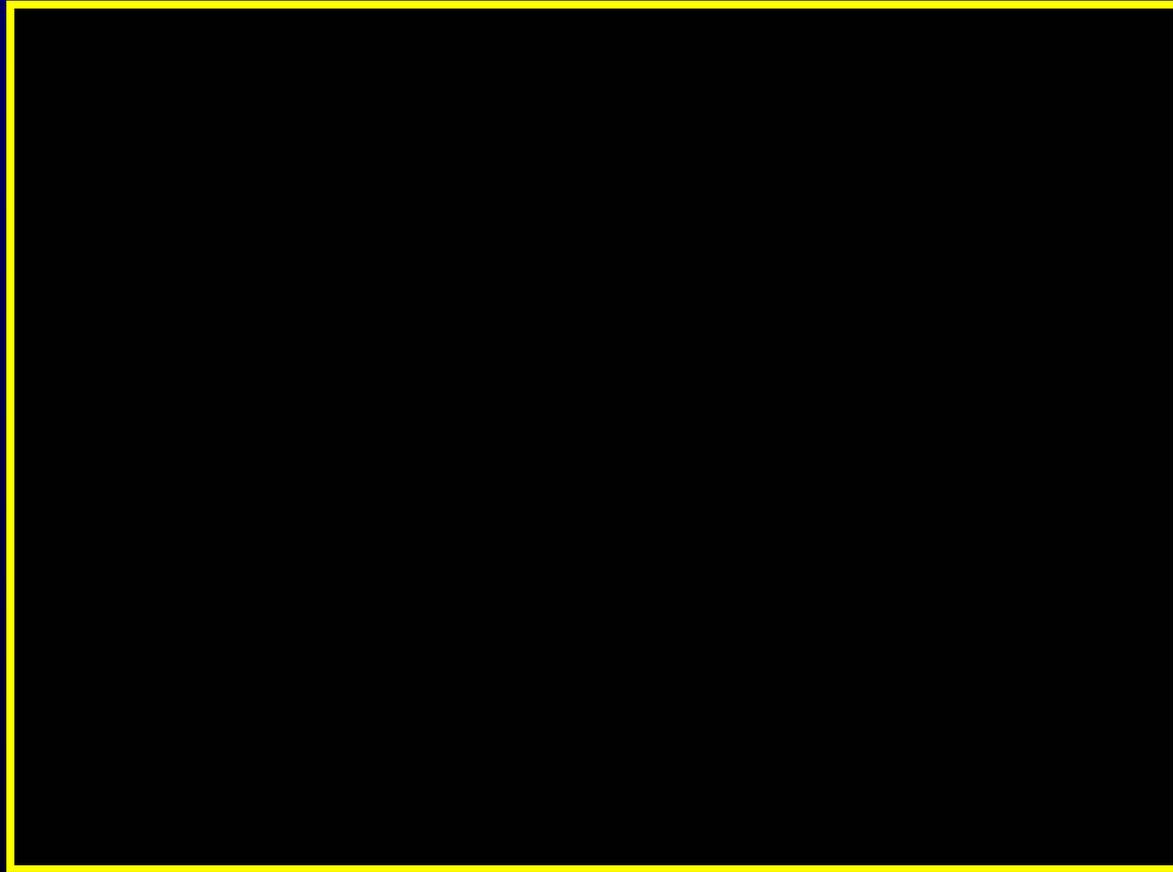
Fatigue degrades performance and mental abilities

- **Accuracy and timing degrade**
- **Lower standards of performance become acceptable**
- **Attentional resources are difficult to divide**
- **A tendency toward perseveration develops**
- **The ability to integrate information is lost**
- **Everything becomes more difficult to perform**
- **Social interactions decline**
- **The ability to logically reason is impaired**
- **Attention wanes**
- **Attitude and mood deteriorates**
- **Involuntary lapses into sleep begin to occur**

Falling asleep on the flight deck is a common result of fatigue

- Objectively-measured crew micro-sleeps have been documented during many revenue flights
- Approximately 50% of military pilots admit to having fallen asleep in the cockpit
- Eighty percent of regional pilots say they have nodded off during a flight
- Seventy-one percent of corporate/executive pilots have made a similar admission
- But remember: *Long before nodding off occurs, performance is already impaired!*

After several hours of continuous wakefulness, alertness decrements in the cockpit are clear



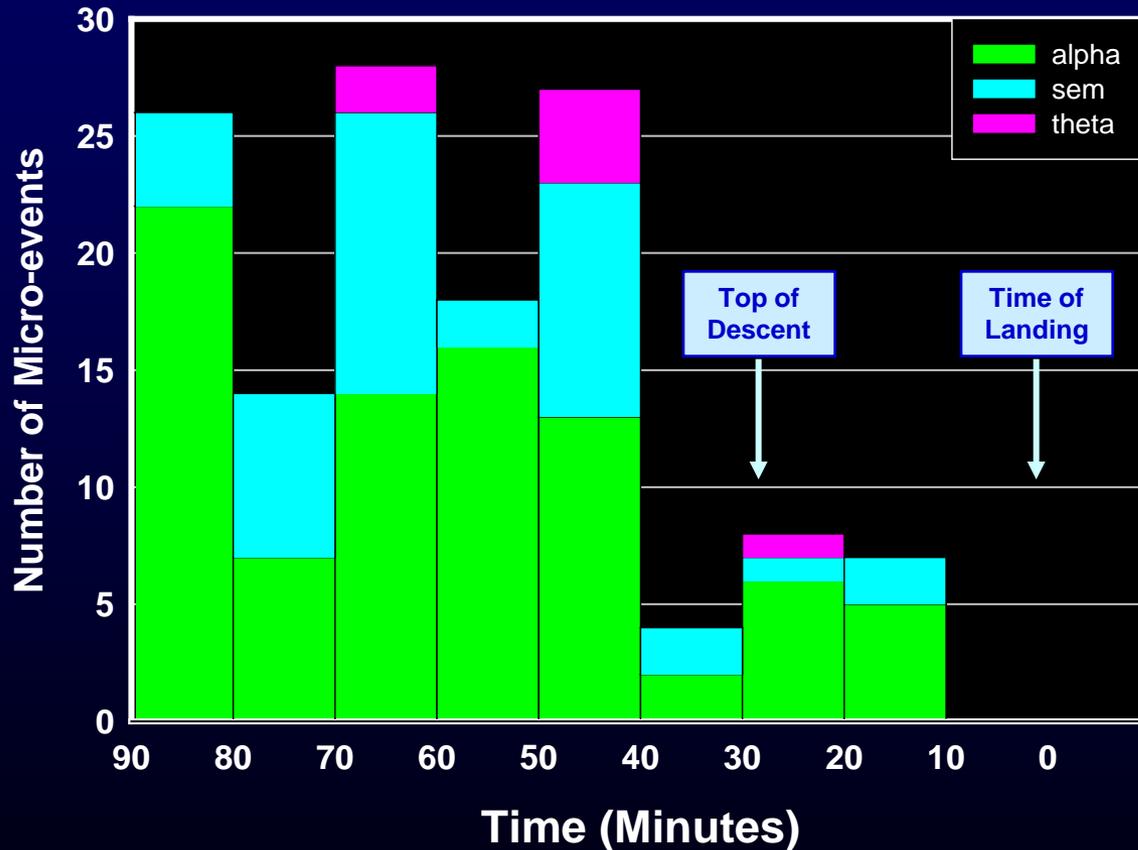
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Fatigue produces clear and dangerous neurophysiological effects

- Long-haul pilots are particularly susceptible to vigilance lapses during cruise segments, but sleepy pilots will lapse anywhere
- Lapses are more pronounced during return trips than during outbound trips
- The longer the flight, the greater the probability of spontaneous micro-sleeps
- Micro-sleeps are 9 times more likely during night flights than day flights
- One night-flight simulation study revealed outright sleep episodes in over half the subjects

Operational research has shown that microsleeps occur even on final

No Nap Group

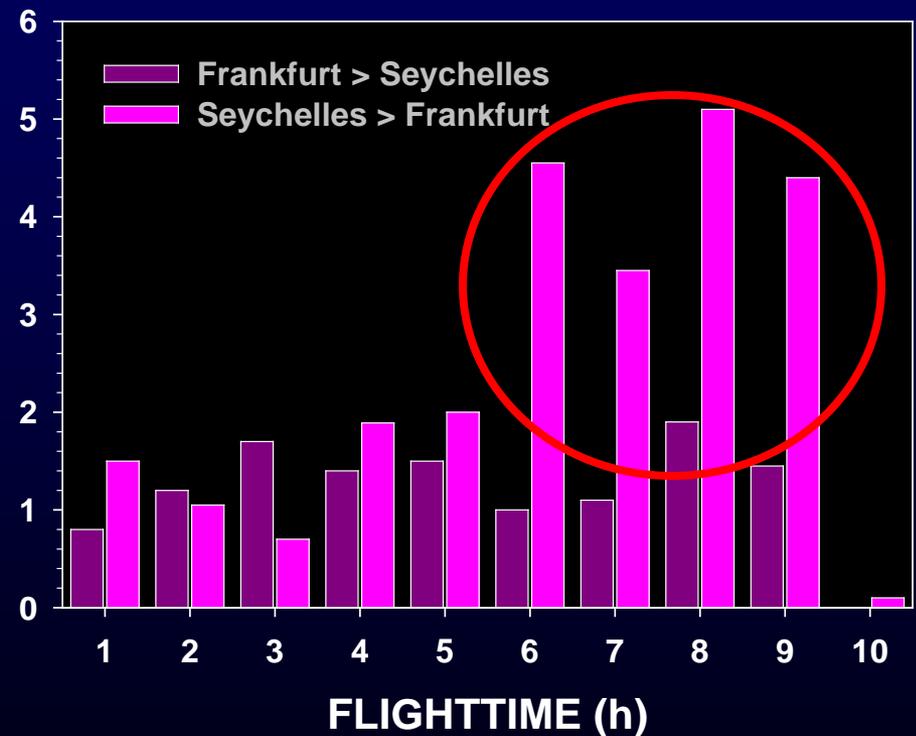


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Fatigue often rears its head more on the return trip than on the outbound leg

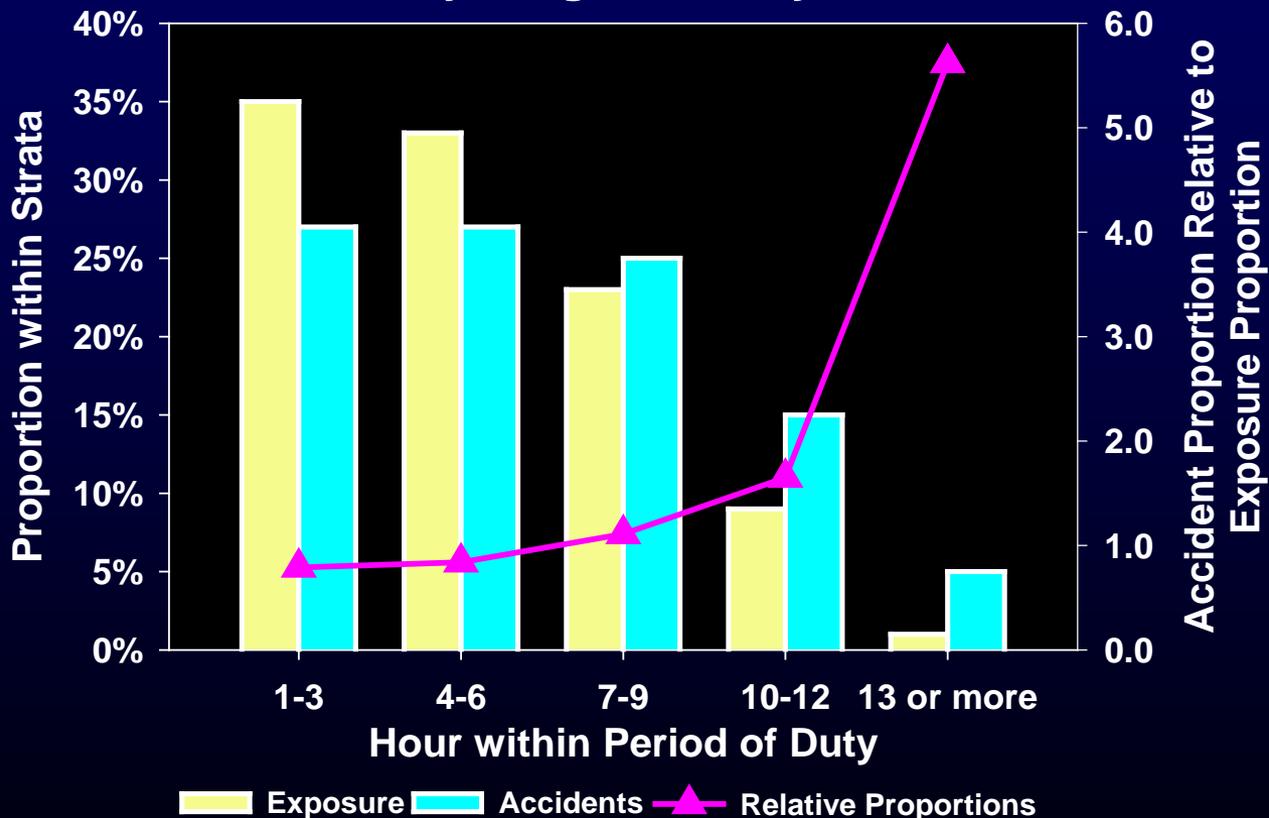
- By the time of landing in Seychelles, the crew had been awake 22 hours
- The layover (with 5 hours of daytime sleep) was 12 hours
- EEG micro-events clearly indicated escalating fatigue on the return trip

In-Flight EEG Micro-Events



Long duty hours (and long wake periods) increase “dozing off” and accident risk

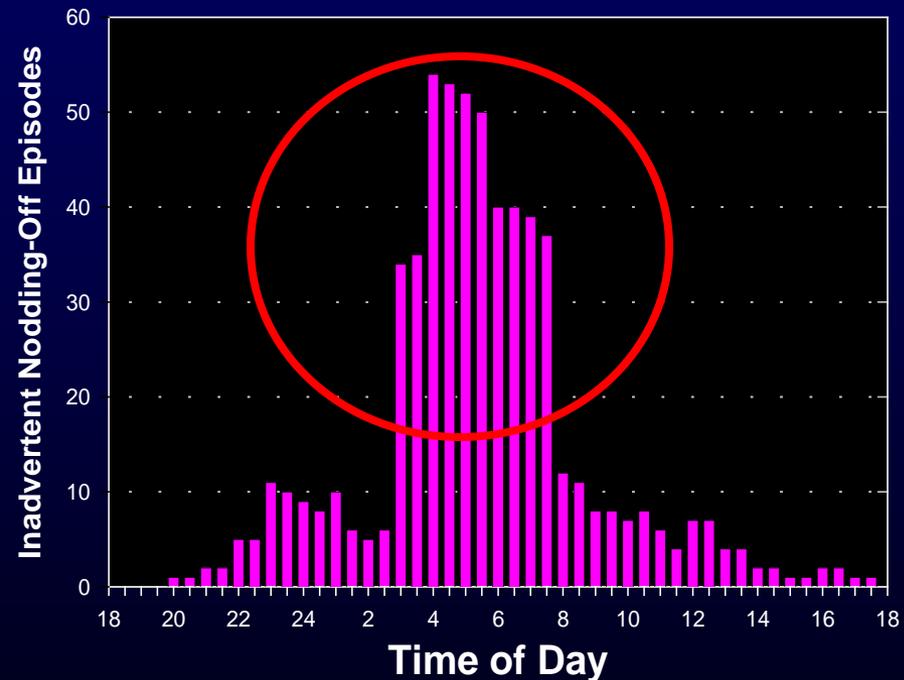
Captains' duty hours and accidents by length of duty



Alertness is especially compromised in the late-night and morning hours

- A study of night flights undertaken in the 1980's revealed numerous instances of nodding off in the cockpit
- In the early morning hours, the frequency of such **lapses increased tenfold**
- Note than many of these occur well after sunrise!

In-Cockpit Nodding Off Episodes



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What are the effects of fatigue on pilot capabilities

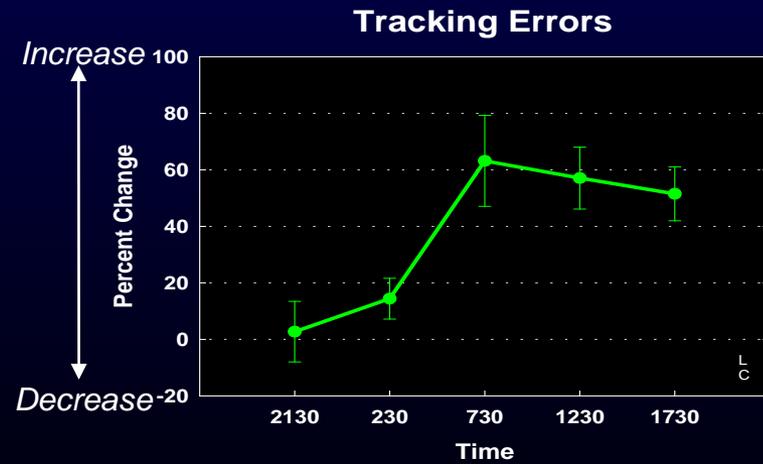
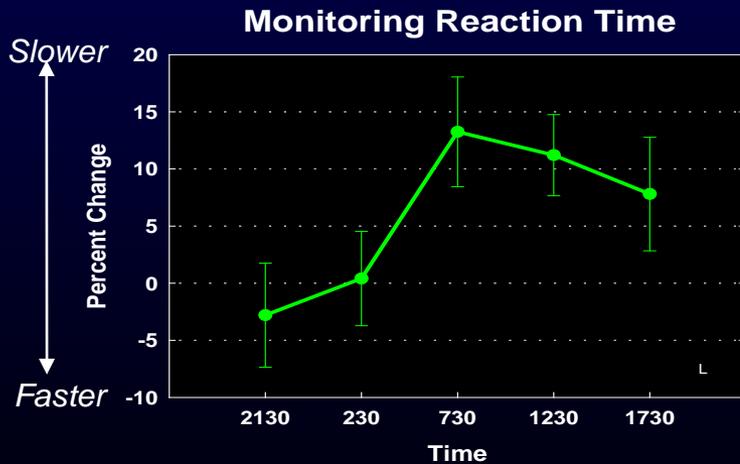
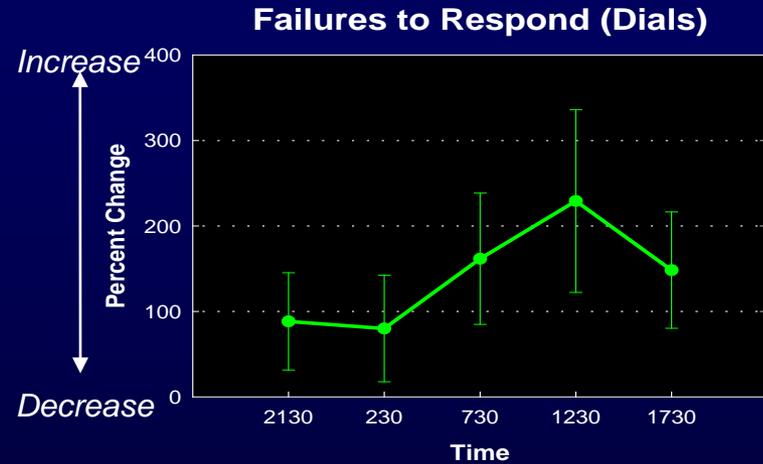
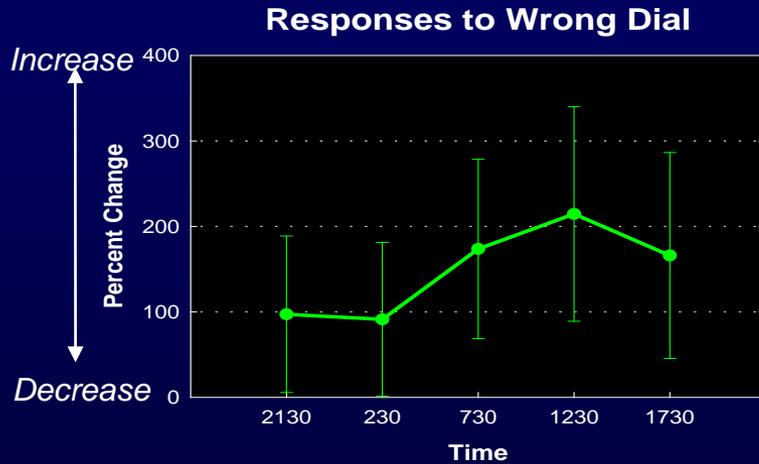


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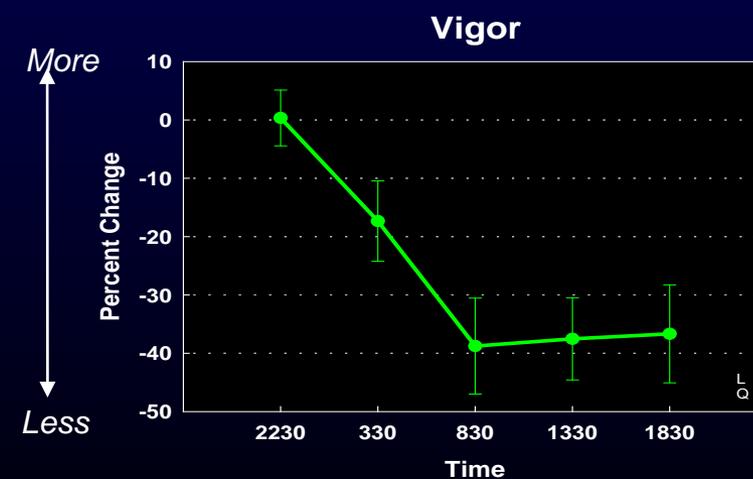
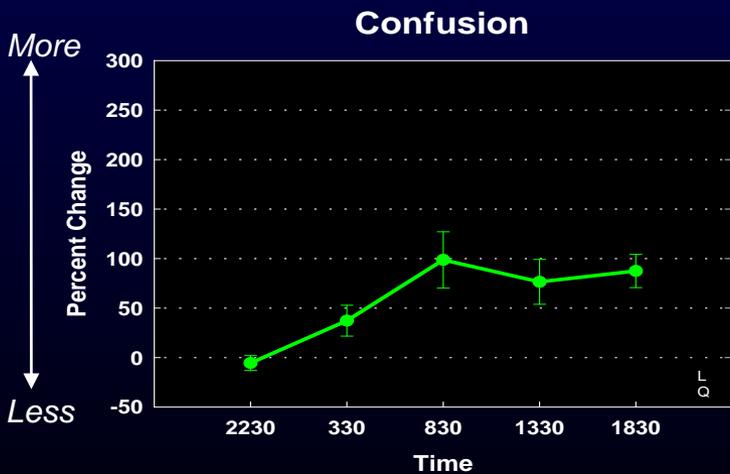
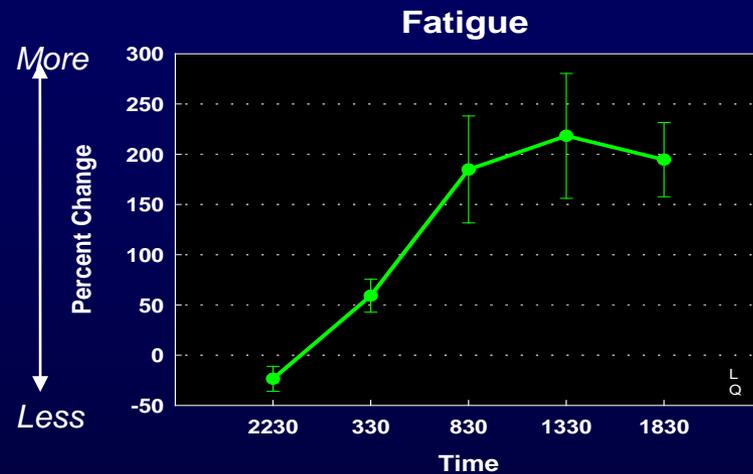
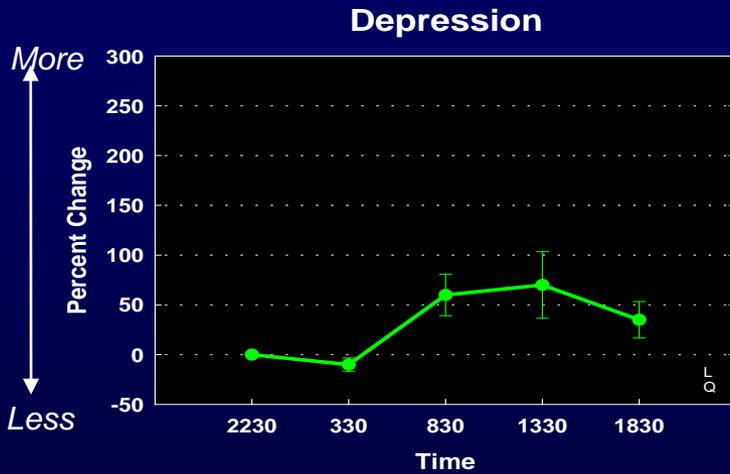
Fatigue degrades basic piloting skills, decision making, and teamwork

- Standardized laboratory tests show decrements in pilots' attention, reaction time, and accuracy
- Fatigue-induced mood changes compromise crew resource management
- Flight simulation and in-flight studies show deteriorations in fundamental flight skills
- *And the group effects fail to highlight the full extent of impairments experienced by some pilots*

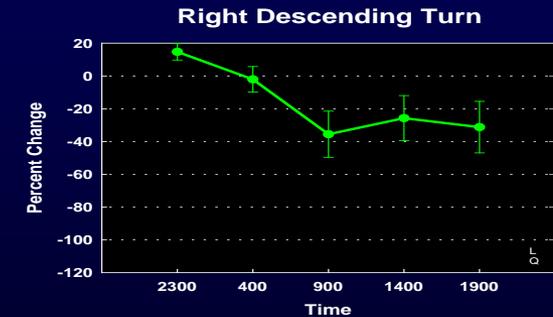
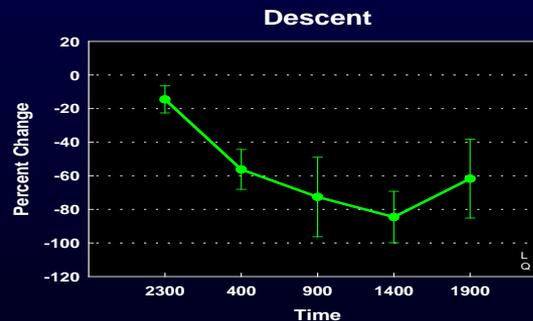
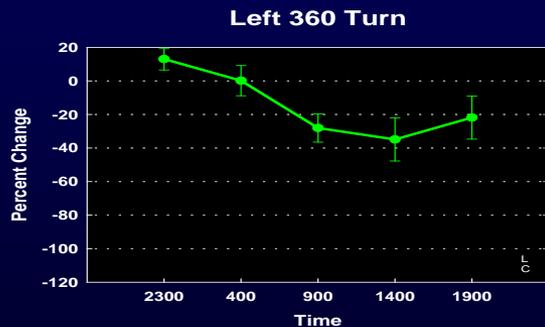
Complex multi-task cognitive performance degrades with one night of sleep loss



Self-reported mood deteriorates as a function of sleep deprivation



Fundamental flight skills suffer after long hours of continuous wakefulness

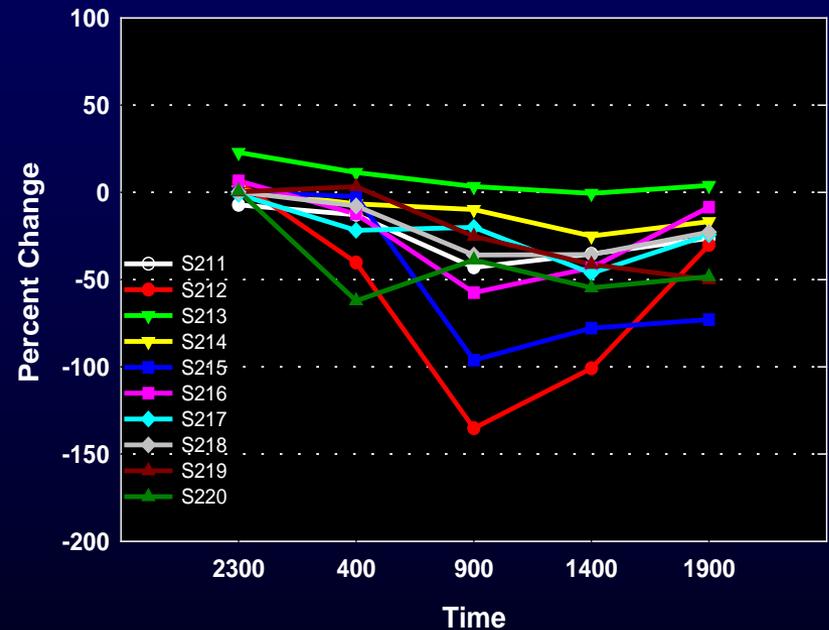


Some pilots are affected more by fatigue than others

Average Response: Ss 211-220
(last training session used as baseline)



Individual Differences: Ss 211-220
(last training session used as baseline)



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What is the impact of fatigue on operational safety



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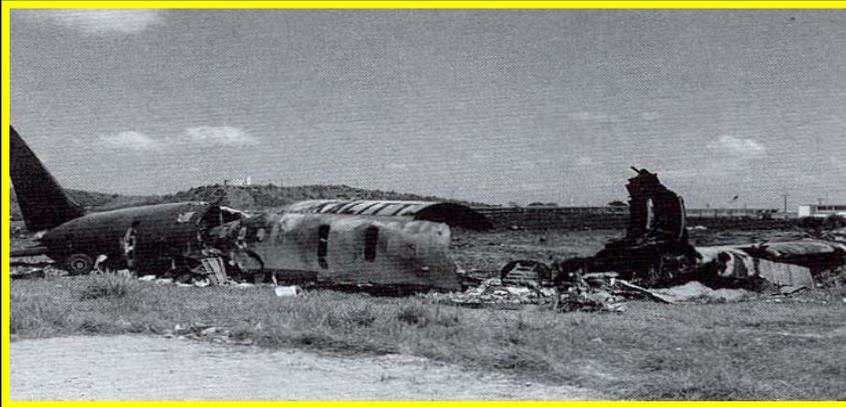
The global effects of fatigue undermine operational performance

- Although “planes aren’t falling out of the sky”, fatigue increases the risk of a mishap and several noteworthy mishaps have been attributed to fatigue
- As they say, *if you think safety programs are expensive, just wait until you get the bill for an accident*



Some infamous aviation examples

Amer. Intl. Flight 808



Korean Air Flight 801



American Flight 1420



FedEx Flight 1478

The NTSB found fatigue to be a factor in each one

- **American International 808 (1993):** *probable cause of this accident was the impaired judgment, decision-making, and flying abilities of the captain and flightcrew **due to the effects of fatigue...***
- **Korea Air 801 (1997):** *probable cause of this accident was the captain's failure to adequately brief and execute the nonprecision approach and the first officer's and flight engineer's failure to effectively monitor and cross-check the approach. **Contributing to these failures were the captain's fatigue***
- **American Airlines 1420 (1999):** *probable causes of this accident were the flight crew's failure to discontinue the approach...and failure to ensure that the spoilers had extended after touchdown. **Contributing to the accident was the flight crew's impaired performance resulting from fatigue ...***
- **FedEx 1478 (2002):** *probable cause of the accident was the captain's and first officer's failure to establish and maintain a proper glidepath during the night visual approach to landing. **Contributing to the accident was a combination of the captain's and first officer's fatigue...***

Internal airline safety reports highlight fatigue's impact on operations

- **In one company, fatigue was found to contribute to 9 percent of FSAP reported events:**
 - 88% of **procedural errors**
 - 42% of **unstable approaches**
 - 41% of **lining up on incorrect runway**
 - 21% of **landing without clearance**
 - 13% of **altitude deviations**
 - 13% of **speed deviations**
 - Etc...

And just last week, pilot fatigue made the news in every major media outlet (again)



NTSB NEWS

NATIONAL TRANSPORTATION SAFETY BOARD • WASHINGTON, D.C. 20594

FOR IMMEDIATE RELEASE **June 10, 2008 SB-08-25**

NTSB RECOMMENDS FAA ADDRESS FATIGUE MANAGEMENT SYSTEMS IN AVIATION

Washington, DC -- The National Transportation Safety Board today made two recommendations to the Federal Aviation Administration (FAA) to address human fatigue within airline operations. The Board recommended that the FAA develop guidance, based on empirical and scientific evidence, for operators to establish fatigue management systems, including information about the content and implementation of these systems.

The Board also made a recommendation to develop and use methodology that will continually assess the effectiveness of fatigue management systems implemented by operators, including their ability to improve sleep and alertness, mitigate performance errors, and prevent incidents and accidents.

"The Safety Board is extremely concerned about the risk and the unnecessary danger that is caused by fatigue in aviation," said NTSB Chairman Mark V. Rosenker. "We have seen too many accidents and incidents where human fatigue is a cause or contributing factor."

The Board's recommendations letter cites three accidents and an incident highlighting the danger of human fatigue within airline operations:

- On October 19, 2004, Kirksville, Missouri, Corporate Airlines flight 5966 struck several trees on its final approach and crashed short of the airport. Both pilots and 11 passengers were killed. Two passengers received serious injuries.
- On February 18, 2007, Delta Connection flight 6488, operated by Shuttle America, Inc., overran the end of the runway as it was landing at Cleveland-Hopkins International Airport. All 72 passengers and a crew of four deplaned without serious injury.
- On April 12, 2007, Pinnacle Airlines flight 4712 ran off the runway after landing at Cherry Capital Airport, Traverse City, Michigan. None of the 49 passengers or crew of three were injured.
- On February 13, 2008, Go! flight 1002, operated by Mesa Airlines, flew past its destination airport, General Lyman Field, Hilo, Hawaii. Air traffic control repeatedly attempted to contact the crew for over 18 minutes, as it flew over Maui, crossed the big island of Hawaii and headed southeast over the Pacific Ocean. The airplane traveled 26 nautical miles beyond its intended destination airport before the flight crew responded. There were no injuries.

"It is imperative that the FAA take action to reduce human fatigue in airline operations," Rosenker said. "Addressing this safety related measure is long overdue. We must and can correct this serious concern."

Summary and conclusions

- Fatigue is a major risk factor in aviation operations
- Scheduling factors are primarily responsible for fatigue-related problems
- Sleep deprivation and circadian disruptions compromise basic pilot functioning and fundamental flight skills
- In-flight and simulation studies have shown the extent of cognitive, mood, and skill decrements
- NASA's ASRS and company FSAP reports have documented the impact of fatigue on operational performance
- Fatigue is a **REAL** issue requiring scientifically-based solutions!



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