Investigating Human Fatigue Factors

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NIOSH Working Hours, Sleep and Fatigue Webinar Series

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NTSB Mission

Independently advancing transportation safety

• Investigating accidents
• Determining probable cause
• Issuing safety recommendations
Multi Modal
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Recommendations, Not Regulations

- Recommendations to improve safety
  - Vehicle manufacturers
  - Operators
  - Regulatory agencies
  - State or local governments
  - Associations, labor, others…
- 13,000+ recommendations since 1967
- 82% “acceptance rate”
NTSB 2017-2018 Most Wanted List

- Reduce fatigue-related accidents
- End alcohol and other drug impairment in transportation
- Increase implementation of collision avoidance technologies
- Eliminate distractions
- Require medical fitness for duty
- Strengthen occupant protection
- Ensure the safe shipment of hazardous materials
- Expand recorder use to enhance safety
- Prevent loss of control in flight in general aviation
- Improve rail transit safety oversight
NTSB 2017-2018 Most Wanted List

- Reduce fatigue-related accidents
- 200+ recommendations
- ~67% acceptance
Investigating Human Fatigue Factors

NTSB two-day course

• Was the operator fatigued?
• Did fatigue contribute to the event?
Step 1: Was the Operator Fatigued?

- Determine Operator Sleep/Wake History
- Determine Continuous Time Awake
- Evaluate Circadian Factors
- Evaluate Sleep Loss/Deprivation
- Evaluate Operator Health
- Determine Contribution Operator Health to Sleep Loss
  - Extent Acute?
  - Extent Chronic?
- Was Operator Fatigued?
Operator Sleep/Wake History

1. Determine Operator Sleep/Wake History
2. Determine Continuous Time Awake
3. Evaluate Circadian Factors
4. Evaluate Sleep Loss/Deprivation
5. Evaluate Operator Health
6. Determine Contribution Operator Health to Sleep Loss
7. Extent Acute?
8. Extent Chronic?
9. Was Operator Fatigued?
Key Evidence Sources

- Interviews with the operator or others
- Schedules/logbooks
- Cell phone records
- Audio/video/data recordings
- Other time-stamped records
Operator Interview Topics

- Sleep/wake times (recent and typical)
- Time and duration of ALL activities
- Times/amounts of any drugs/alcohol
- Sleep quality (recent and typical)
- Subjective sleepiness at the time of the accident
Different Ways of Asking Questions

A. Did you get enough sleep last night?
   • Yes.

B. How much sleep did you get last night?
   • About 8 hours.

C. What time did you go to sleep/wake up?
   • I went to sleep around 11:00-11:30.
     I woke up when my alarm went off at 5:00.
Other Interview Tips

• Know as much as you can before you start the interview
• Use a voice recorder or note taker if possible so you can focus on conversation
• Consider filling in a grid or log to document schedule data during interview
• Ask for confirmation sources
Work Schedules

• Work time
• On/off duty
• Shift length
• Rotating?
New York, NY, March 12, 2011
Sleep Quantity and Quality

• Driver self-reported 7.5 hours sleep on workdays; 13–16 hours on days off
• Cell phone and car rental records indicate few sleep opportunities
# Master Activity Log

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:56 a.m.</td>
<td>Arrive casino</td>
<td>Casino video</td>
</tr>
<tr>
<td>2:00 – 6:00 a.m.</td>
<td>Asleep in bus</td>
<td>Driver interview</td>
</tr>
<tr>
<td>6:30 a.m.</td>
<td>Depart casino</td>
<td>Casino video</td>
</tr>
<tr>
<td>9:50 a.m.</td>
<td>Arrive World Wide Travel Terminal</td>
<td>Records</td>
</tr>
<tr>
<td>11:00 a.m. – 4:00 p.m.</td>
<td>Asleep</td>
<td>Driver interview</td>
</tr>
<tr>
<td>10:15 a.m. – 12:03 p.m.</td>
<td>Cell phone used multiple times</td>
<td>Cell phone records</td>
</tr>
<tr>
<td>3:39 p.m.</td>
<td>24-second cell phone call</td>
<td>Cell phone records</td>
</tr>
<tr>
<td>6:15 p.m.</td>
<td>Arrive for duty, World Wide Travel Terminal</td>
<td>Records</td>
</tr>
<tr>
<td>7:40 p.m.</td>
<td>Pickup passengers at Bowery stop</td>
<td>Records</td>
</tr>
</tbody>
</table>
Driver Sleep Opportunities

Time of Day

March 9

March 10

March 11

March 12
Driver Sleep Opportunities

Time of Day

March 9

March 10

March 11

March 12
Driver Sleep Opportunities

Time of Day

March 9

March 10

March 11

March 12
What can sleep/wake history tell you?

Sleep Deprivation
- Acute
- Chronic

Circadian Dysrhythmia
- Time of day
- Schedule inversion
- Jet-lag

Time Awake/On-Task
- Continuous hours awake
- Hours of operation
Evaluate Operator Health

Determine Operator Sleep/Wake History

Determine Continuous Time Awake

Evaluate Circadian Factors

Evaluate Sleep Loss/Deprivation

Evaluate Operator Health

Determine Contribution Operator Health to Sleep Loss

Extent Acute?

Extent Chronic?

Was Operator Fatigued?
What Can Health-Related Evidence Tell You?

- Sleep disorders or risk factors
  - Obstructive sleep apnea
  - Insomnia
  - Restless legs syndrome
- Other health issues that affect alertness
- Presence of sedating drugs and/or alcohol
Diseases and drugs…

- Can impair sleep
- Can cause wake-time sleepiness
- Can have interactive effects with sleep deprivation
Key Evidence Sources

- Toxicology analyses
- Interviews (operator and/or family)
- Medical examiner records
- Personal physician records
- Pharmacy records
Toxicology

- Valuable... yet,
- Challenging to obtain
- Perishable
- Subject to protections
- Requires medical expertise to interpret
School Bus Driver Fatigue Risk Factors

- 5 hours of sleep per night
- History of back, hip, and leg pain
- Alcohol abuse/nightly drinking
- Toxicology:
  - Tramadol
  - Clonazepam
  - Desmethylvenlafaxine
CPAP Treatment Compliance Data

- Cirrus SR-22 crash
- Pilot and 3 passengers died
- Medical certificate documented OSA
- Continuous positive airway pressure (CPAP) device data showed > 4 hours use on 3 nights preceding accident
Step 2: Did Fatigue Contribute to the Event?

Evaluate Operator Performance → Determine Extent Performance Contributed to Accident → Relate Performance to Known Fatigue Effects → Did Fatigue Contribute to Accident?

Identify Pre-Existing Conditions/Known Performance Deficiencies → Consider Alternative Explanations
Evaluating Operator Performance

- Data/voice/video recorders
- Self report
- Interviews with others
- Vehicle/wreckage
Typical Effects of Sleep Deprivation

- Overlooking or skipping tasks
- Unresponsiveness or delayed responses
- Impaired decision making
- “Tunnel vision”
- Inability to adapt to changing information
- Reduced short term memory
Performance Outcomes

- Slow reaction time when braking or steering from obstacles
- Narrowed focus of attention
- Visual or cognitive fixation
- Procedural/tactical decision errors
- Microsleep
New York, NY, March 12, 2011

- Lane excursions
- Shallow angle of departure
- No tire marks
- No evidence of braking
Titan, December 15, 2014

- Captain activated autopilot but not watch alarm
- Boat did not turn at channel
- Nearby boat radioed warning with no response
Step 2: Did Fatigue Contribute to the Event?

Evaluate Operator Performance → Determine Extent Performance Contributed to Accident

Relate Performance to Known Fatigue Effects

Did Fatigue Contribute to Accident?

Identify Pre-Existing Conditions/Known Performance Deficiencies

Consider Alternative Explanations
Clarence Center, NY, February 12, 2009
Documenting Work Environment and Organization
Key Evidence Sources

- Company policies and training materials
- Interviews
- Direct observation
Cleveland, OH, February 18, 2007
Cleveland Environmental Factors

- Heavy flying schedule
- Last flight of day
- Company fatigue policy
- Warning letter
Take Away Messages

• Sleep (or lack thereof) is key
• Gather perishable evidence first
• Use multiple sources of evidence whenever possible
• Operator fatigue that is not causal is still important for safety
Probable Cause

The truck driver’s failure to yield the right of way to the car, combined with the car driver’s inattention due to overreliance on vehicle automation, which resulted in the car driver’s lack of reaction to the presence of the truck. Contributing to the car driver’s overreliance on the vehicle automation was its operational design, which permitted his prolonged disengagement from the driving task and his use of the automation in ways inconsistent with guidance and warnings from the manufacturer.