The Science of Sleep-Aviation Rest and Fatigue Regulations for Pilots

Noam Alon
United Airlines

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April 1, 2014
Icarus: Northwestern University
Agenda

• Sleep science

• Rationale for the rule

• Key elements of FAR 117

• Q/A

Adapted from and recognition due to Bob Hughes, United Airlines.
The Science of Sleep-Aviation Rest and Fatigue Regulations for Pilots

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Objectives: Why are there RULES?

• The sleep science
  – Impact of Circadian Rhythms
  – Regulation of sleep-wake
  – Consequences of sleep loss
  – Impact of shift work
  – Impact of Jet lag
Duty hours

• Why does the duty hours rule differ by time of day
  – Daily duty hours 8 or 9 hours

• Why is there a cumulative hours rule?
  – Cumulative duty hours 100 or 1000 hours
Circadian Rhythms

Subjective Alertness (deviation from mean)

Cognitive Performance (deviation from mean)

Sleep Latency (minutes)

REM Sleep (% of TST)

Body Temperature (degrees Celsius)

Dijk et al., J. Physiol. 1997, 505:851-858

Dijk & Edgar, 1999, Lung Biology in Health & Disease, vol.133
Circadian Timing System

Retinal Ganglion cells (blue 460-480 nm)

(SCN) "Clock Genes"

OUTPUT RHYTHMS (SLEEP / WAKE)

(Temperature, hormones Performance, mood)
Circadian and Homeostatic Regulation of Sleep

Adapted from Edgar et al. J Neurosci. 1993
How tired is too tired?
Expressing the performance impairment due one night of sleep loss as a Blood Alcohol Equivalent

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Adapted from Dawson & Reid, 1997, Nature Vol 388: 235
Rest Duration

• **10 CONSECUTIVE HOURS** minimum and may not be reduced.
  – This rest must provide a minimum of eight uninterrupted hours of sleep opportunity.
Partial Sleep Debt: Impact on Performance

Belenky et al, 2003
Onboard Crew Rest Facilities

Why do we care?

• To sleep well there are several sleep hygiene rules to follow - those related to the sleep environment include:
  – cool
  – dark
  – quiet
  – Recumbent (lying down)
Further Challenges: Shift work & Jet Lag
Night work

•Circadian misalignment makes working at night and sleeping during the day difficult

**temperature minimum** = time when most sleepy
Major complaints of shift workers

– sleep disruption
– reduced sleep duration & quality
– increased fatigue
– reduced alertness
– reduced performance
– increased psycho-social problems
– increased health problems
– increased risk of accidents
Jet Lag

Acclimation & Theater

- Jet lag is associated with travel across multiple time zones
- Results in misalignment between the internal circadian clock and the external light-dark and sleep-wake cycle
- Results in impairment of daytime function, general malaise, or somatic symptoms such as gastrointestinal disturbance within one to two days after travel.
Jet lag: The Cause

- Misalignment between the circadian clock and local time

<table>
<thead>
<tr>
<th>Time of Day (24 h)</th>
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<tbody>
<tr>
<td>14 15 16 17 18 19 20 21 22 23 24</td>
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</table>

**Boston**

| 19 20 21 22 23 24 | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 |

**London**

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 |

**Boston**
(at home)

**London**
(on arrival)

= when I expect to sleep ok

▼ = temperature minimum
Travelling East

Clock Time in Denver (hours)

Sleep time in Denver

Sleep time in London

Light exposure

Clock Time in London (hours)
Travelling West

Clock Time in London (hours)

Sleep time in London

Light exposure

Sleep time in Denver

Clock Time in Denver (hours)
Thank you