

Space Human Factors: Research to
Application
Sleep Related Fatigue, Workload and
Circadian Rhythm

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Overview of NSBRI Research Process

- End Users: Constellation, Space Medicine, Space Human Factors Engineering
 - Present the problem and solution parameters: Non-invasive, acceptable, useable in microgravity, volume
- NASA and NSBRI Scientists
 - Define the problem
 - Methods (Lab? Field? Analog?)
 - Results verified, move to next step of applied research until field tested
 - **Knowledge** ---> Inform NASA standards, design handbook
 - **Technology**---> prevent, monitor, feedback, countermeasures
- Iterative Process

NSBRI Response to End Users' Ultimate Questions of Safety & Performance

- Knowledge and mitigation of circadian shifts in astronaut quarters before launch; during flight
- Knowledge of sleep deprivation and effects on performance and safety during critical events
- Non-pharmaceutical mitigation of problem (pharmaceutical / nutrition is not part of this presentation)
- Feedback Loops to crew and ground:
 - Predictive model of sleep related performance fatigue
 - Measurement of performance decrements
- Display, robotic aids

NSBRI Sleep Deliverables- developed with NASA experts and operations

- wavelength and intensity of artificial environmental lighting in the crew habitat
- light-dark schedules for crewmembers; specifications for visor and window light transmission characteristics
- work-rest policies to facilitate maintenance of alertness and performance during extended-duration missions
- mathematical modeling tool to evaluate the impact of actual work-rest/sleep-wake and light-dark schedules on the alertness and performance of crew members
- research and tool development required to fulfill the medical standards on sleep schedules.

Process I– Sleep Related Fatigue, Performance, and Safety Review

- Bonnet and Arrand Review:
 - physicians sleep an average of only 2.8 hours during on-call nights
 - 10% of fatal automobile accidents are due to drowsiness
 - 57% of fatal truck accidents are due to sleep loss
 - Effects of drowsiness on performance: vigilance, selective attention, behavioral output

Process II: From User Need, Review, Lab, Field, Operational

From Lab to Field -- Effective? Acceptable? Feasible?

- Astronaut Quarters and bright, polychromatic light: Charles Czeisler and his team at Harvard
- Blue light as mitigation for circadian adjustment: George Brainard and his team at Thomas Jefferson University
- Work with NASA Johnson Space Center and Kennedy Space Center light experts
- Predictive model of fatigue Elizabeth Klerman and her team at Harvard
- Noninvasive measure of vigilance: David Dinges and his team at the University of Pennsylvania
- Example of Phoenix Mars Lander Fatigue Study, Summer 2008

Conclusions

- NSBRI provides Academic research
 - Specialty expertise
 - An outside voice
 - Ideas expanded to earth based applications
 - Expands the base of civilians interested in space flight
 - Useful for future civilian / commercial applications
- NASA operations, research experts provide
 - Specialty expertise
 - Real life / Operational information and needs
 - Years of experience dealing with spaceflight
 - Provides initiative and feedback
 - Useful for future civilian / commercial applications