National Aeronautics and Space Administration

Johnson Space Center (JSC) / White Sands Test Facility (WSTF)

SCREAM: Space-based Cognitive Reliability Error Analysis Method

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Technology Area (TA): 6.3.e-E Human Factors and Habitability **TRL: start 3 / current 4**

CIF IRAD PROJECT OVERVIEW

Given both ground-based performance shaping factors (PSFs) collected by the U.S. Nuclear Regulatory Commission (USNRC) and potential space-based PSFs collected by JSC's HH&P, this year's task is to determine how to combine them for future human reliability analysis (HRA) of space missions. All HRA to date for space missions have been based on ground data (i.e. 1-G environment). There is no space-based HRA approach. **The target of this project to produce a "first of its kind" HRA approach for space missions**. As **humans** go beyond Earth orbit and missions become longer, human performance and reliability is expected to degrade. The questions become by how much, when, and what, **leading to defining** the overall effect on crew risk. Knowing this information earlier rather than later will help us mitigate this risk by vehicle design, crew training, and operational workarounds.

INNOVATION

NASA is leveraging the existing HRA methodology Cognitive Reliability Error Analysis Method (CREAM) to support risk analysis of long-duration spaceflight and human contributions to error and mission risk. Use of this tool is to develop risk models to inform broad mission parameters, but it will also be utilized to assist in the design of the human aspects of the mission by targeting key contributors to error and risk. This effort synthesized ground and space data on fatigue in order to build an empirical foundation to support PSF selection and use.

OUTCOME

This effort resulted in a proof-of-concept application of existing HRA methods to a long-duration spaceflight PSF and demonstrated a meta-analysis-based methodology to derive human error probabilities (HEPs) from other generalizable research. Work will continue to further develop a new method of HRA for long-duration spaceflight in support of future missions.

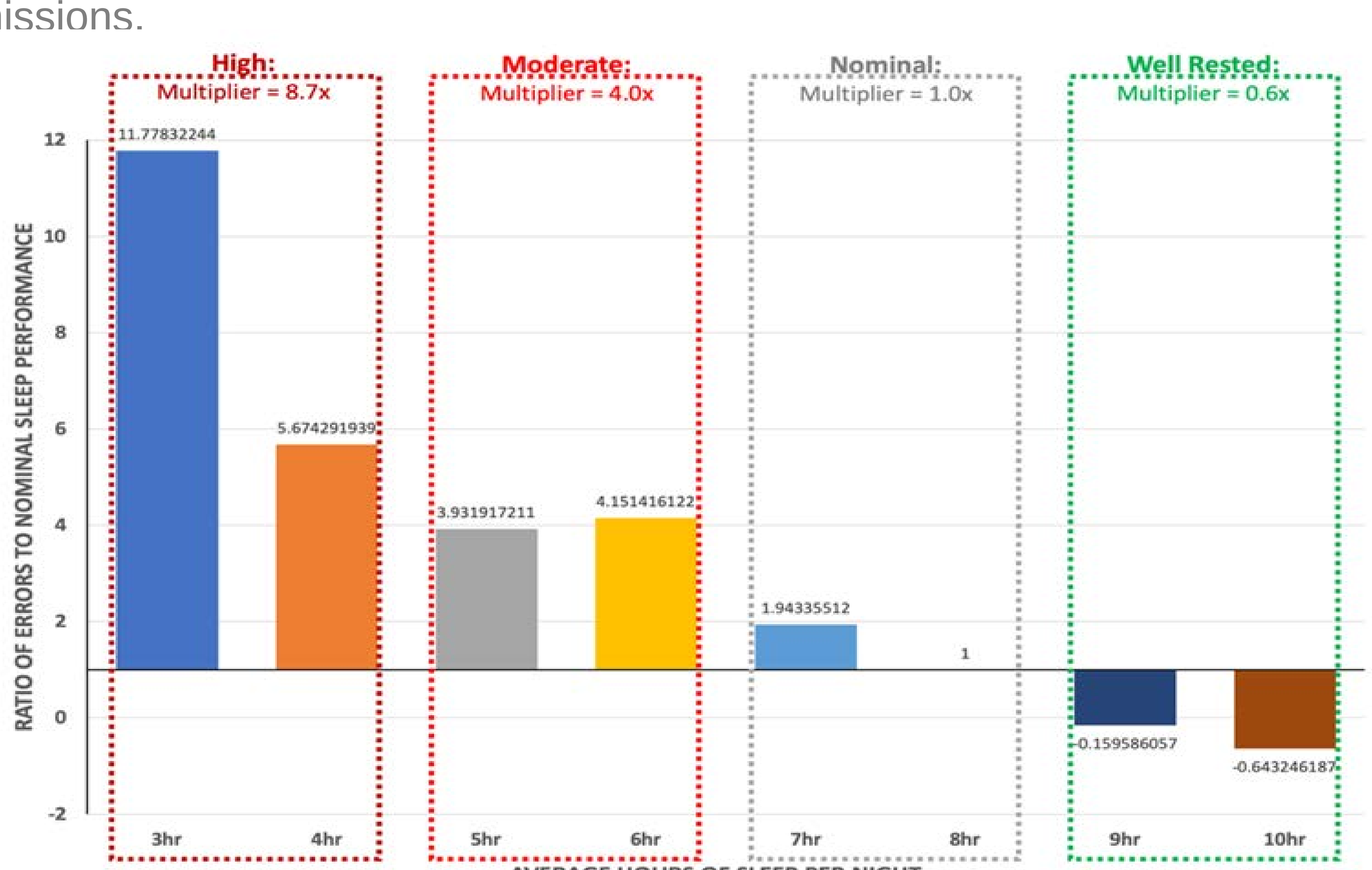
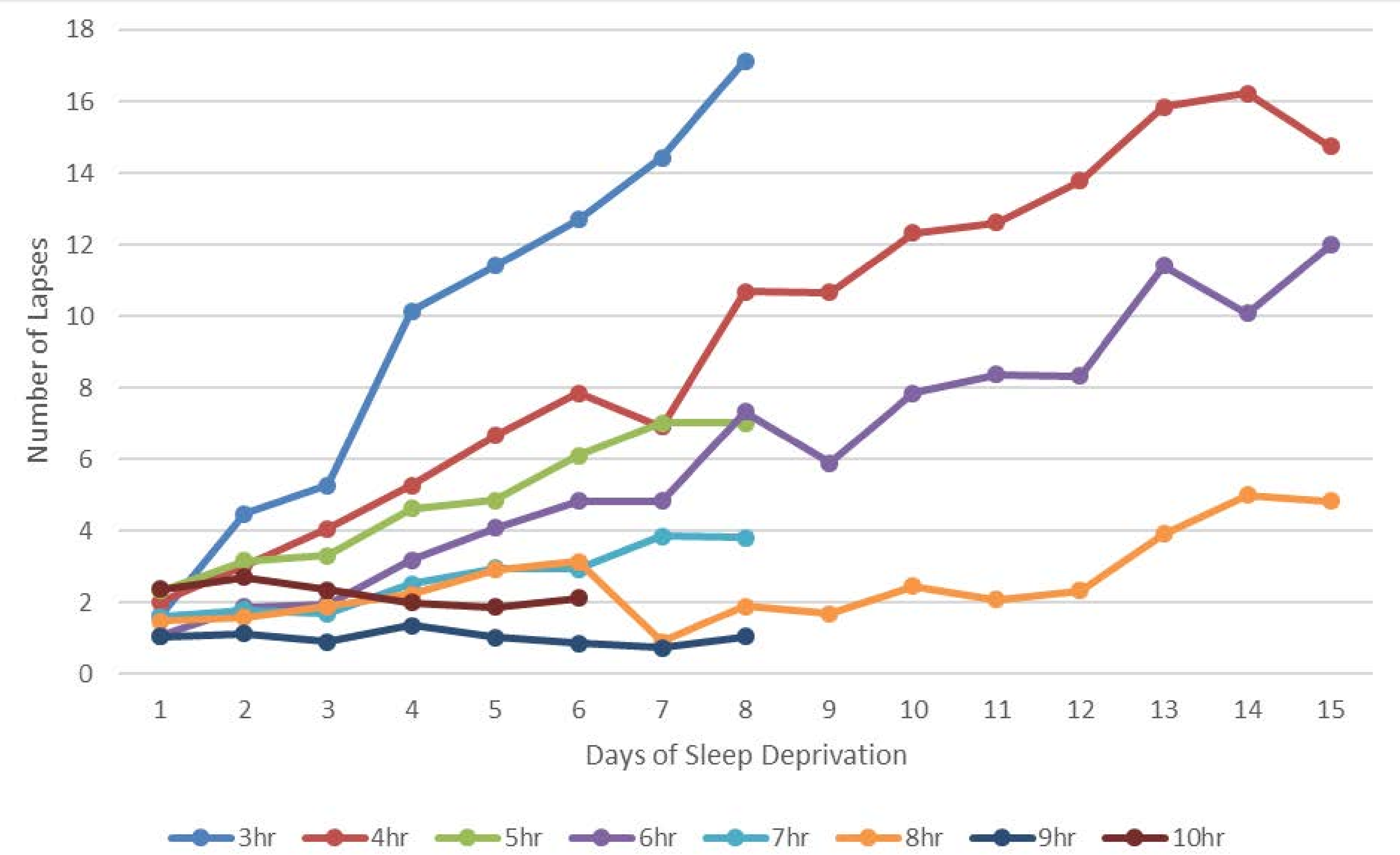


Figure 3. Ratio of Performance Effects at Different Levels of Sleep Deprivation to Performance with Normal Sleep.



Study Author and Year	Sleep Deprivation Conditions (hours per day)	Length (number of consecutive days PVT administered)
(H. P. Van Dongen, Maislin, Mullington, & Dinges, 2003)	4, 6, 8	14
(Hans PA Van Dongen, Rogers, & Dinges, 2003)	4, 6, 8	14
(Banks, Van Dongen, Maislin, & Dinges, 2010)	4, 10	5
(Belenky et al., 2003)	3, 5, 7 9	7
(Basner, Mollicone, & Dinges, 2011)	4	5

Figure 1. Effects of Sleep Deprivation Over Multiple Days on Performance.
Table 5. Studies Investigating Effects of Sleep Loss Over Multiple Days.

Since NASA must contend with astronauts suffering from partial sleep deprivation over longer periods of time, the effort to develop a space-based common performance condition factor focused on partial sleep deprivation studies over longer time spans. A literature search was conducted to identify studies using the psycho-motor vigilance task (PVT), spanning longer than 80 hours, and using partial sleep deprivation defined based on the number of hours of sleep per night during the course of the study. The results of this study yielded a total of 5 studies for inclusion in our meta-analysis (see Table 5 above). From these five studies, a total of 141 data points or means were extracted for the quantitative analysis. A ready comparison of the effects of sleep deprivation are shown in Figure 1.

COLLABORATORS

Further research and development between NASA and HRA experts at the Idaho National Laboratory will be critical to the continued development of a fully-fledged HRA method for long-duration spaceflight.

Idaho National Laboratory INL

FUTURE WORK

Further research will involve continued development of PSF lists, validation of selections, and peer review by other members of the HRA community. Continued work on Bayesian quantification methods may yield alternative processes and actions as well as automation potential of HRA modeling efforts.