105-day Mars simulation: US studies focus on improving work performance

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From March 31 to July 14, a six-man international crew called an isolation chamber in Moscow their home. The crew, composed of four Russians and two Europeans, simulated a 105-day Mars mission full of experiments and realistic mission scenarios, including emergency situations and 20-minute communications delays.

U.S. participation in the mission consisted of three research teams with experiments evaluating solutions to conditions that impact work performance. The projects evaluated lighting interventions to counter sleep disruption due to shift work or long hours, tested two objective methods of measuring the impact of stress and fatigue on performance, and assessed interactions between crew members and mission control. The three projects were funded by the Houston-based National Space Biomedical Research Institute (NSBRI).

"The mission allowed us to look at the feasibility of certain technologies developed for improving performance by deploying them in an extremely demanding work environment. In this realistic setting, will crews use the technologies and will we get good data?" said Dr. David F. Dinges, leader of the NSBRI group funded from University of Pennsylvania School of Medicine and Rutgers. "Additional goals were to see how different mission situations affected the various performance measures and to evaluate whether the interventions could indeed improve performance."

The 105-Day Mars Mission, a partnership between the Russia's Institute of Biomedical Problems and the European Space Agency, is the precursor to a 520-Day mission scheduled for 2010. The isolation facility consists of several interconnected, modules containing medical and scientific research areas, living quarters, a kitchen, greenhouse and exercise facility.

For researchers, the opportunity to run experiments in this type of environment was invaluable.

"We've done experiments in the sleep lab to test the efficacy of lighting interventions, but that is a highly controlled environment," said Dr. Charles A. Czeisler, leader of the NSBRI project funded from Harvard Medical School, Brigham and Women's Hospital, and University of Colorado. "By transitioning studies into an operational environment, like the 105-Day Mission, we have the opportunity to learn how to best deploy interventions in a realistic mission setting. This analog is a great intermediate step before implementation on an actual spaceflight."

Participation from the crew and mission controllers was excellent. All three NSBRI projects received data throughout the mission. Final data will be received in the coming weeks, and the teams will begin detailed data analysis.

These tests and interventions have an impact beyond the space program," Dinges said. "Many people work night shifts and in high-stress, confined environments that require alertness, such as power plant control rooms, railroad systems, hospitals, military operations, and fire and rescue situations. The things that we are learning here about how to enhance performance will be useful in many work environments."

NSBRI Project Overviews

Lighting Intervention Study (Dr. Charles A. Czeisler, lead investigator):

The study compared two different wavelengths of light (in the green spectrum) during night-shift work with a control lighting condition (in the red spectrum). Crew members and mission control personnel participated. The experiment, which replicated studies done in sleep laboratories, examined whether exposure to green-enriched light will help sustain job performance in the middle of the night and when participants have been awake for a long time. The study looked at the impact of the light on melatonin, the body's sleep-promoting hormone. Additional data were collected for the study with participants taking performance tests, wearing watch-like devices that track sleep/wake periods, completing sleep and work logs, and submitting urine and saliva samples.

"Based on previous laboratory studies, we anticipate that during exposure to the shorter wavelength green light that melatonin will be significantly suppressed, resulting in better performance during overnight work," Czeisler said. "The findings will have direct application to night-shift workers."

Monitoring the Impact of Fatigue and Stress on Work Performance (Dr. David F. Dinges, lead investigator):
The project tested two novel, unobtrusive, objective methods for monitoring impact of fatigue and stress on work performance. Crew members and mission control personnel participated. One test involved the feasibility of "reading the face" through use of an optical computer recognition system that monitored facial expressions, tracking the shape and movements of the face in three dimensions. Video was taken during brief cognitive tests, to detect the presence of stress, fatigue and negative affect, and will be used to determine the extent to which this approach was feasible during the mission.

The second performance measure used 3- and 10-minute laptop-based Psychomotor Vigilance Tests to detect changes in basic performance involving attention, response speed and impulsivity. The tests require the user to watch for a visual signal and respond quickly and accurately when it appears. Participants took the tests twice daily during day and night work. The tests have been validated in other settings for sensitivity to reduced alertness caused by a variety of factors in spaceflight (e.g., restricted sleep, night-shift work).

Crew Interactions and Autonomy (Dr. Nick Kanas, lead investigator): The study evaluated the mood, interpersonal interactions and performance of crew members and mission control personnel. The groups were studied under two conditions: low crew autonomy (where the work schedule was planned by mission control) and high crew autonomy (where the crew plan and troubleshoot their own work schedule). Through the use of a weekly questionnaire, the project will evaluate the experiment's impact on mission control and on the crew-ground relationship.

"The data gathered on the relative benefits of high versus low autonomy conditions during manned space missions will have relevance not only for future expeditions to the moon and Mars, but also to current on-orbit International Space Station missions," said Dr. Nick Kanas, leader of the NSBRI group funded at University of California, San Francisco.

Source: National Space Biomedical Research Institute

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