520-day Mars simulation: Study looks at impact of stress and fatigue

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Ever wondered what it would be like to go on a mission to Mars? On June 3, a six-man international crew entered an isolation chamber in Moscow for a simulated 520-day Mars mission conducted by the State Scientific Center of the Russian Federation - Institute for Biomedical Problems (IBMP) of the Russian Academy of Sciences. The crew has a mission schedule full of more than 90 experiments and realistic scenarios, including emergency situations, 20-minute communications delays and a trip to the martian surface.

The specialized IBMP facility consists of interconnected modules serving as the mock interplanetary spaceship, including medical and scientific research areas, living quarters, a kitchen, greenhouse and exercise area. The chamber also contains a Mars landing vehicle module and a martian landscape module for simulated extravehicular activities.

Supported by National Space Biomedical Research Institute (NSBRI), the U.S. scientific team participating in the study is monitoring the six crew members' rest-activity cycles, performance and psychological responses to determine the extent to which sleep loss, fatigue, stress, mood changes and conflicts occur during the mission.

"Extensive data from the Russian Mir Space Station, International Space Station and Apollo missions suggest that psychological and behavioral issues will be perhaps the greatest challenge humans will face when they embark on years-long missions to Mars and other locations," said David F. Dinges, Ph.D., leader of NSBRI-funded group and a professor of

psychology in psychiatry at the University of Pennsylvania School of Medicine.

The 520-day Mars Mission, conducted by IMBP under the auspices of the Russian Space Agency (Roscosmos), the Russian Academy of Sciences, and in cooperation with the European Space Agency, is the final phase of the Russian Mars 500 program. Previous phases included a 14-day test of the facility and a 105-day isolation study involving a six-man international crew in 2009. The 520-day mission is broken into 250 days for the trip to Mars, 30 days on the surface, and 240 days for the return to Earth.

During the simulation, Dinges and his colleagues are using miniaturized wristwatch-like devices to measure crew members' sleep-wake patterns and specially programmed computers with brief assessment tests to gather information throughout the mission on crew members' performance and emotions. Dinges is working in collaboration with Matthias Basner, M.D., from Penn, Dimitris Metaxas, Ph.D., of Rutgers University, and Daniel Mollicone, Ph.D., of Pulsar Informatics, Inc. Igor Savelev, Ph.D., NSBRI's International Liaison, oversees the onsite implementation of the study and works in coordination with the Dinges team.

A key component of the computer-based assessment is the Psychomotor Vigilance Task (PVT) Self Test. This three-minute test measures the stability of sustained attention, psychomotor speed and impulsivity. PVT Self Test is also undergoing evaluation on the space station, where it is known as the Reaction Self Test.

"We've learned from laboratory experiments, other mission analogs and the Russian's 105-day isolation study that the PVT is sensitive to fatigue and other factors that degrade the ability to pay attention and respond quickly," said Dinges, who leads NSBRI's Neurobehavioral and

Psychosocial Factors Team.

PVT Self Test was developed through Dinges' work with NSBRI, NASA, the Department of Defense and the National Institutes of Health. The user watches for a signal and responds when it appears, allowing the measurement of reaction times at a high degree of precision. Dinges also implemented PVT in studies involving astronauts in other space analog environments, such as on the ocean floor in NASA's Extreme Environment Mission Operations (NEEMO) program.

"As soon as he completes the PVT Self Test, the crew member receives an assessment of how well the task was performed relative to someone who is fully alert and capable. The report also indicates how many times responses were too slow and how many times responses occurred before the signal came on," Dinges said. "So, there is a measure of impulsivity as well as fatigue."

Crew members do the assessment tests on their own specialized laptops programmed by Pulsar Informatics with built-in cameras to record facial expressions during testing. Facial video data will be evaluated off-line by computer algorithms developed in the Metaxas laboratory, where an optical computer recognition system is being created and validated in collaboration with Dinges for use in space to unobtrusively detect signs of sleepiness, negative moods and stress.

Every seventh day of the Mars 520-day mission simulation, the assessment tests are completed in the morning and before sleep. The tests take 10 minutes, requiring only 20 minutes of the crew member's time on testing day, and include PVT Self Test and other measures of sleep quality/quantity, fatigue, stress, moods, conflict and depression.

"The crew is on a six-day work week. Because they take the test every seven days, we will get data from every day of their work cycle 14 times

throughout the mission," Dinges said.

For Dinges, the need to obtain data in this type of environment is essential.

"This simulated Mars mission is by far the longest-duration study of crew confinement under operating conditions attempted to date. It will have an impact on planning for exploration missions," Dinges said. "It provides something we can't learn from much shorter-duration simulations or from the 180-day stays on the space station: namely, what is the effect on crews of living and working for 520 days in continuous confinement?"

Mars 500 will allow Dinges and others to find out whether the ability to sleep well, attend to tasks, react quickly, maintain positive moods, and feel alert is sustainable across such a long mission, and whether there is evidence of negative moods, depression and an increase in conflicts.

The lessons learned extend to life on Earth.

"These tests and interventions have an impact beyond the space program," said Dinges, a 2007 recipient of the NASA Distinguished Public Service Medal. "Many people, including those in military operations and many first responders, work night shifts and in high-stress, often confined environments that require alertness. The things we are learning about how to objectively and unobtrusively measure changes in performance and psychological status will be useful in many environments, such as power plant control rooms, railroad systems, emergency operations, hospitals, and police, fire and rescue situations."

Provided by National Space Biomedical Research Institute