RESEARCH AND TECHNOLOGY STUDIES (RATS) 2012 MISSION OVERVIEW. B. A. Janoiko[1] (barbara.a.janoiko@nasa.gov), J. E. Johnson[1] (james.e.johnson@nasa.gov), and M. L. Reagan (marcum.l.reagan@nasa.gov), EA/NASA Johnson Space Center, Houston, TX 77058

Introduction: Research and Technology Studies (RATS) is an integrated test activity that has taken place since 1997 to exercise prototype planetary surface hardware in representative mission operation scenarios. Such activities not only test the subsystems of new prototype exploration vehicles, but they also stress communication systems and evaluate science operational concepts that will advance human and robotic surface exploration capabilities for exploration beyond low Earth orbit. RATS is a venue where new ideas and rapidly prototyped technologies can be tested, both individually and as part of an integrated mission operation involving multiple elements. These technologies, elements, and operational concepts are then repeatedly evaluated throughout RATS and other NASA analog missions allowing for continual iteration and improvement upon design. This operationally influenced approach to designing complex human and robotic spaceflight missions enables both the hardware and operational architectures to mature concurrently through hands-on, “lessons learned” experience. It is this very experience that will be necessary to influence future human planetary exploration.

2012 marked the first year of all RATS testing being conducted on-site at Johnson Space Center (JSC) and the fifteenth year of RATS analog testing activities. The team consisted of about 50 engineers, scientists, and mission operation personnel from several NASA centers. The test was conducted over two phases with the first phase evaluating engineering approaches and system performance and the second phase consisting of a simulated operational mission. Three primary hardware elements and multiple operational methodologies were successfully tested and demonstrated over the course of the mission.

Test & Simulation Overview: The primary focus of RATS 2012 was to continue evaluation from 2011 of several different exploration strategies for a manned near-Earth asteroid (NEA) mission. The first phase of testing was dedicated to evaluating the human factors of the new 2nd generation (Gen 2A) Multi-Mission Space Exploration Vehicle (MMSEV) and assess how a simulated asteroid exploration environment could be formulated on-site. This first phase was conducted during the weeks of December 12, 2011 and January 17, 2012 with two different two-person crews consisting of previous Desert RATS participants and one astronaut and geologist. Each week consisted of two days of crew familiarization and training followed by three days and two nights of simulated asteroid mission operations and living in the Gen 2A MMSEV. To effectively provide a simulated asteroid operations environment, RATS leveraged a high-fidelity physics based simulation in concert with JSCs virtual reality (VR) laboratory, a Manned Maneuvering Unit (MMU) trainer, an air-bearing floor (ABF), the Active Response Gravity Offload System (ARGOS), and Mark III mockup space suits. Simulated spacewalks around the virtual spinning asteroid surface were conducted to assess NEA surface exploration operations between an EVA crewmen and the MMSEV. Throughout the first phase of testing, a minimal operations team was leveraged with real-time communications with the crew.

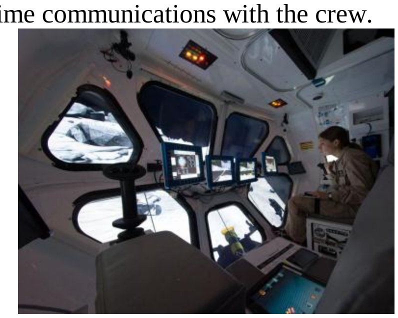

Figure 1. High-fidelity physics based NEA simulation controlled from inside the Gen 2A MMSEV.

After successful completion of the RATS Phase 1 test demonstrated the ability to evaluate NEA operations from JSC, planning for the RATS Phase 2 test got underway. The Phase 2 test occurred August 16th through 31st with a 5-person crew and utilized the same facilities as the engineering evaluation with the exception of the ABF and MMU trainer. The crew rotated among positions as Deep Space Habitat intravehicular crewmembers, MMSEV pilots, and extravehicular activity (EVA) crewmembers. Four of the RATS crewmembers also conducted overnight evaluations of the Gen 2A MMSEV to provide additional human factors data to the Phase 1 assessments. For the first time in recent RATS testing history, this RATS crew consisted of NASA engineers with mission operations experience paired with planetary geologists.

Throughout the test, the NEA simulations were supported by a small operations team located in a room at JSC’s Mission Control Center (MCC). All communications with the crew occurred under a 50-second one-way time latency representative of the time delay that might be experienced during an actual NEA mission.

Primary Test Objectives: Six primary test objectives were evaluated during the 2012 RATS campaign:

1. Execute 10 days of simulated NEA human exploration conditions comparing different operations concepts and combinations of exploration work systems for human exploration of NEAs,
2. Exercise the NEA flight simulation and communications loops from the Gen 2A MMSEV,
3. Evaluate the Mark III mock-up suit & suit port interface plate (SPIP) with Gen 2A MMSEV cabin to evaluate suit port human factors,
4. Use ARGOS and the VR laboratory to test NEA EVA sampling and translation techniques in simulated microgravity,
5. Exercise interaction between EVA simulation(s) & MMSEV IV crewmember(s), and
6. Test Fuel Cell regenerative technology/capabilities.

To assess these objectives, four different test conditions were constructed based off of Desert RATS 2011 testing. Each condition could then be further analyzed under either a 'free-flying' or 'anchored' mode of operation for the MMSEV. These conditions all evaluated a four-person exploration crew and varied the distribution of crew roles among the MMSEV, a simulated Deep Space Habitat (DSH) IV workstation, and on simulated EVA. Each condition was then thoroughly assessed by the crews and the operations team to evaluate overall acceptability.

Figure 2. RATS crewmember Marcum Reagan assisting in NEA operations as a DSH IV crewmember.

In executing these test conditions under a representative time delay, six primary questions were evaluated to specifically help advance the design of the MMSEV:

1. Does the MMSEV need to be a 2-person or 3-person vehicle for NEA operations?
2. How does NEA size, spin rate, and exploration ops concept affect the design of MMSEV guidance, navigation, and control (GN&C) and propellant requirements?
3. How will EVA be used during exploration of a NEA and how does that affect design of the EVA system and the MMSEV?
4. Does the MMSEV need to be capable of anchoring to a NEA? How does anchoring affect crew workload, propellant usage, and exploration productivity?
5. How does increasing earth-to-NEA communications latency affect the software and operational countermeasures that are required?
6. Are the Gen 2A MMSEV prototype cabin human factors acceptable?

In addition to evaluating the primary objectives of NEA operations and questions influencing MMSEV design, a 3 kW regenerative fuel cell was intermittently used to power the Gen 2A MMSEV cabin as a technology demonstration. Product water from the fuel cell was then used to assist in the evaluation of a prototype exploration electrolyzer.

Preliminary Results: Results from the test are still being reviewed and published, but preliminary results indicate that effective operations are achievable over a 50 second one-way time delay utilizing an MMSEV-like exploration platform. Detailed results are compiled by the Exploration Analogs and Mission Development (EAMD) team and will be provided for review at LPSC by the team.

References:

[1] Romig B. A. and Johnson J. E. (2011) *Desert Research and Technology Studies (D-RATS) 2011 Mission Overview*, LPSC. [2] Abercromby, A. F. J. et al. (2012) *Acta Astronautica, doi:10.1016/ j.actaastro. 2012.02.022.* [3] Abercromby A., Gernhardt M., et. Al. (2012) *RATS 2012: MMSEV Gen 2A Testing Post-Test Quicklook Report*, NASA.