Research and Technology Studies (RATS) 2012 Mission Overview

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Introduction

Research and Technology Studies (RATS) is an integrated test activity that has taken place since 1997 to exercise prototype human exploration 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 advances human and robotic exploration capabilities.

1st generation Space Exploration Vehicles (SEVs) tested during Desert RATS 2010

2nd generation SEV tested at RATS 2012

Test Overview

The primary focus of the 15th RATS mission was to continue evaluation from Desert RATS 2011 of several different exploration strategies for a manned near-Earth asteroid (NEA) mission using a high-fidelity simulation. Following week-long engineering evaluations in December 2011 and January 2012, the final test took place August 16-30, 2012 and for the first time in RATS history, was conducted completely at Johnson Space Center and not in a remote field location.

RATS Motto: "Build a little, test a little".

Engineering assessment of NEA simulation in January 2012

RATS 2012 test configuration at Johnson Space Center's Space Vehicle Mockup Facility (SVMF)

The Team

A team of about 50 engineers, scientists, and mission planners from several NASA centers participated in the 2012 RATS test. The crew consisted of 2 planetary geologists and 3 engineers with mission operations experience rotating across four simulated NEA mission roles.

RATS teamwork drives technological innovation.

RATS 2012 Crew and Support Team Members

RATS mission Support Team monitoring test operations

The Facilities

RATS 2012 leveraged 5 facilities at Johnson Space Center to support the integrated test in August: the Active Response Gravity Offload System (ARGOS), virtual reality (VR) laboratory, simulated Deep Space Habitat (DSH) workstation, Analog Mission Control Center (AMCC), and NEA simulation. The Air Bearing Floor (ABF) and Manned Maneuvering Unit (MMU) trainer were also used during the December and January engineering evaluations.

RATS testing enables integration of unique NASA facilities.

RATS crew Trevor Graff in the VR laboratory

RAT crew practicing translation at ARGOS facility

Multi-Mission Space Exploration Vehicle (MMSEV)

The 2nd generation MMSEV is the third prototype space exploration vehicle to be developed and is an intermediate step between the 1st generation concept development vehicles and the 3rd generation vehicles that will be designed and built as protoflight vehicles capable of being flown in space. In addition to supporting the test as a NEA exploration platform, the 2nd generation MMSEV underwent preliminary habitability and human factors testing with 2-person crews conducting a total of 4 3-day, 2-night stays during both the engineering evaluation and integrated test.

RATS has assisted in maturing MMSEV design over 5 years of testing.

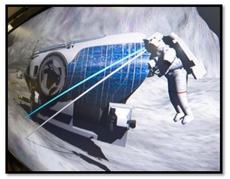
2nd generation MMSEV with Mark III mock-up suit attached to suit port in aft enclosure

Redesigned interior of the 2nd generation MMSEV

NEA Simulation & Virtual Reality Laboratory

The RATS 2012 test utilized a high-fidelity, physics-based human-in-the-loop (HITL) simulation to assess exploration operations of a MMSEV and extravehicular activity (EVA) crew in proximity to the asteroid Itokawa. Asteroid data used in the simulation was provided by JAXA. In order to assess the effectiveness of integrated operations, the simulation was coupled between the MMSEV cabin and the VR Lab.

RATS 2012 was the first analog test to leverage computer-based simulation.



Simulated MMSEV with EVA crew

RATS crew on EVA in the VR Lab

Simulation as viewed from MMSEV cabin

Active Response Gravity Offload System (ARGOS)

ARGOS allows test subjects to be precisely offloaded to simulate weightlessness and the reaction forces that might be encountered during microgravity science operations. This facility was used to support both the RATS test and to provide standalone evaluation of the NEA EVA operations assessed during the NASA Extreme Environment Mission Operations (NEEMO) 16 analog mission using NEEMO crew for cross-comparison of data.

ARGOS supported both RATS and NEEMO analog testing.

Control Center & Deep Space Habitat Workstation

All RATS crew interactions with the Analog Mission Control Center (AMCC) were conducted under a time delay of 50 seconds each way to simulate the communications latency of a NEA mission 1 au from Earth. Operational interaction with the DSH crew was simulated from a workstation configured with representative displays and communications.

All mission communications were delayed 50 seconds each way.

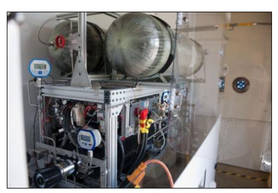
RATS support team member William Moore in the AMCC

RATS crew member Trevor Graff supporting from the simulated DSH workstation

Technology Demonstration

In addition to evaluating the primary objectives of NEA operations and architectural design questions, 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.

RATS advances technology through integrated demonstrations.



3 kW regenerative fuel cell used to periodically power the MMSEV

Fuel Cell unit being transferred to an alternate test facility for electrolyzer test

Outreach

Education and Public Outreach (EPO) activities were conducted throughout the RATS test to inform, educate, and engage the public. In addition to live outreach events on NASA TV and through Challenger Learning Centers, one day of the test was dedicated to media and VIP tours and interviews.

RATS inspires and engages the public in future exploration.

RATS crew member David Coan demonstrates the Mark III mock-up suit for the media

Live Challenger Center interview with fuel cell engineer Abigail Ryan

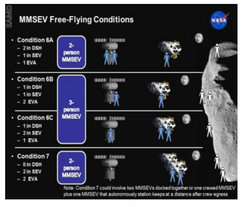
Primary Test Objectives

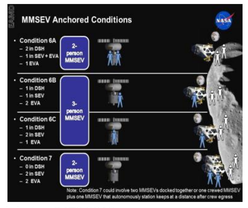
There were six primary objectives for the 2012 RATS mission:

1. Execute 10 days of simulated NEA human exploration conditions comparing combinations of IV and EVA crew over different operational modes with a 50 second each-way communications latency,
2. Exercise the integrated NEA simulation from the Gen 2A MMSEV and VR Lab,
3. Evaluate the Mark III mock-up space 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) and MMSEV and DHS IV crewmember(s), and
6. Test Fuel Cell regenerative technology/capabilities.

Test Conditions

To evaluate the most advantageous approaches to manned NEA surface exploration, four test conditions were created for each of two different operational modes: free-flying operations and anchored operations. Free-flying operations assumed the MMSEV would 'fly' in proximity to the NEA surface while anchored operations assumed the MMSEV would be attached to the NEA surface. For each condition, RATS crew would be assigned a particular role; MMSEV pilot, intravehicular (IV) support from MMSEV or DSH, or EVA crew. The crew evaluated the effectiveness of each condition, the role they served, and the capabilities they utilized (e.g., simulated EVA jet backpack) to identify suitable methods for NEA surface exploration.





Test conditions evaluated during RATS 2012.

Results & Conclusion

Testing results and conclusions are compiled by the Exploration Analogs Mission Development (EAMD) Team and are documented in the *NASA Research and Technology Studies (RATS) 2012: Evaluation of Human and Robotic Systems for Exploration of Near-Earth Asteroids* poster (#1671).

References

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[2] Ross, A. et. al. (2013) *Historical synopses of desert RATS 1997-2010 and a preview of desert RATS 2011*, Acta Astronautica, *doi:10.1016/j.actaastro.2012.02.003.*

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[4] Abercromby, A. F. J. et al. (2011) *Desert RATS 2011: Human and Robotic Exploration of Near-Earth Asteroids*, Acta Astronautica, *Accepted.*

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[6] Abercromby, A. F. J. et al., *NASA Research and Technology Studies (RATS) 2012: Evaluation of Human and Robotic Systems for Exploration of Near-Earth Asteroids*, 44th Lunar and Planetary Science Conference, March 18-22, 2013, The Woodlands, Texas.

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http://www.nasa.gov/exploration/analogs/desert_rats.html

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