DESERT RESEARCH AND TECHNOLOGY STUDIES (D-RATS) 2011 MISSION OVERVIEW. B. A. Janoiko[1] (barbara.a.janoiko@nasa.gov) and J. E. Johnson (james.e.johnson@nasa.gov)[1], [1]EA, NASA Johnson Space Center, Houston, TX 77058

Introduction: Desert Research and Technology Studies (Desert RATS) is an integrated test activity that exercises advanced technologies and operational concepts in the high desert area of northern Arizona. Conducted since 1997, these activities exercise prototype planetary surface hardware and representative mission operation scenarios. Such activities not only test the subsystems of new vehicle prototypes through exposure to challenging terrain and harsh climatic conditions, 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. Desert 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 tested throughout Desert 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.

2011 was the fourteenth year of Desert RATS analog testing activities and the fourth year in a row at Black Point Lava Flow near Flagstaff, Arizona. The team consisted of about 175 engineers, scientists, and mission operation personnel from nine NASA centers and academia and included support from the European Space Research and Technology Centre in Noordwijk, Netherlands. There were about 75 people deployed in the field during the 9 test days. Four primary hardware elements and about thirty technologies were successfully tested and demonstrated over the course of the mission.

Field Test Overview: The primary focus of Desert RATS 2011 was to exercise several different exploration strategies for a manned near-Earth asteroid (NEA) mission. Instead of conducting long-distance traverses as had been done during previous Desert RATS campaigns, this year’s test explored concentrated areas or test sites analogous in size to a 200-300m asteroid while trying to solve a geologic problem. These sites were based on a photogeologic interpretation of aerial and satellite images conducted by the U.S. Geological Survey Branch of Astrogeology in Flagstaff in a manner designed to simulate a robotic precursor mission to investigate a planetary/NEA surface. Small-scale, localized traverses of each of the chosen test sites were then established by the D-RATS science team to explore the geological features of interest to better understand how the Black Point Lava Flow was formed.

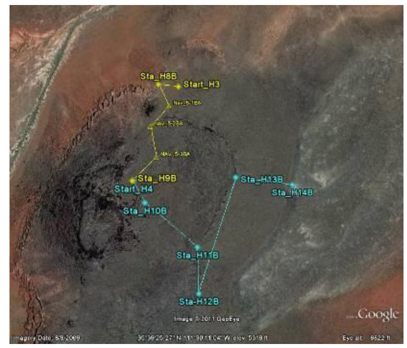

Figure 1. Example of localized traverse to explore geological points of interest. [2]

Although Desert RATS cannot mimic the near-zero gravity conditions experienced at a NEA, the test environment was still beneficial for evaluating key architectural questions regarding exploration and operational productivity using various combinations of vehicles and crew sizes. Four major system elements were used: the first generation Space Exploration Vehicles (SEVs) or rovers, the Habitat Demonstration Unit (HDU) in the Deep Space Habitat (DSH) configuration, instrumented shirt-sleeve backpack assemblies (SBAs), and the Robonaut 2 humanoid robot mounted on the Centaur 2 robotic chassis (R2/C2). Each of the elements supporting the mission also completed standalone engineering evaluations when they weren’t occupied with integrated mission testing so as to help mature their technical designs.

The field test took place between 30 August and 9 September 2011. Two days were devoted to practice/training, and nine test days were held with each day focused on exploring a test site. Two crews, each consisting of two geologists and two astronauts (one of which had spaceflight experience) participated in the test.

This marked the first year of Desert RATS operations where the majority of mission operation and science support personnel participated remotely from Johnson Space Center’s (JSC) Mission Control Center (MCC) in Houston, Texas. A small science team, in collaboration with the European Space Agency, also participated from the Netherlands. All communications between the crew and these teams were conducted over a 50 second one-way time delay to approximate the communications lag expected during a NEA mission.

Primary Test Objectives and Hypotheses: Four primary test objectives were evaluated during the 2011 Desert RATS campaign:

1. Quantitatively compare productivity during NEA-like operations under at least two different Deep Space Network (DSN) communications bandwidths.
2. Quantitatively compare productivity during NEA-like operations with no SEV v. single SEV.
3. Quantify productivity of Education and Public Outreach (EPO) activities from the SEVs and/or DSH using DSN.
4. Quantitatively compare productivity during NEA-like operations with 3 v. 4 crewmembers.

In addition to the stated primary objectives, several secondary and technology demonstration objectives were also assessed. To evaluate these objectives, a total of seven test conditions were formulated; each exercising a different combination of hardware elements and crew compositions. Test conditions one through three evaluated the use of robotic elements (primarily R2/C2) controlled from the MCC, DSH, or SEV and their effectiveness in conducting science operations. The remaining test conditions were used to evaluate the effectiveness of 3 v. 4 person crew sizes and the comparative productivity of using 0, 1, or 2 SEVs in a NEA-like exploration scenario over time-delay. A single day of the test was dedicated to evaluate NEA simulated operations over a reduced bandwidth. Multiple test days were used to conduct EPO events from each major hardware element to evaluate outreach productivity.

Figure 2. Geologist Dr. Hurtado making observations from a simulated robotic arm attached to the SEV.

In executing these seven test conditions and evaluating reduced communications bandwidth and EPO productivity, seven hypotheses were addressed: 1) NEA exploration activities will be rated as acceptable when conducted over a 50 second one-way time delay, 2) scientific data quality, exploration time, and traverse distance will improve with a four person vice three person crew, 3) scientific data quality, exploration time, and traverse distance will improve when operating with 1 SEV v. EVA-only operations, 4) scientific data quality, exploration time, and traverse distance will improve when operating with 2 SEVs v. 1 SEV, 5) scientific data quality, exploration time, and traverse distance for robotic operations improve when the operator is in-situ and can see the robot compared to operation over time delay using onboard cameras, 6) science data quality and acceptability will improve for NEA-like operations when operating with an increased bandwidth, and 7) the human factors of the SEV for single-day traverses will be considered acceptable [3].

Preliminary Results: Results from the nine test days are still being reviewed and published, but preliminary results indicate that effective operations are achievable over a 50 second one-way time delay, reduced data bandwidth did not appear to significantly affect data quality, there is an apparently significant benefit in utilizing 4 v. 3 crewmembers, and that exploration operations are significantly enhanced through use of an SEV (although assessment of the effectiveness of two SEVs for NEA-like operations was not fully addressed due to weather and technical difficulties) [3].

Other Accomplishments: Multiple technologies were also demonstrated and evaluated and collaborative partnerships were established. Two examples of collaboration were the utilization of an inflatable loft added to the DSH by the University of Wisconsin and the partnership with Natick and Hunter Defense Technologies to utilize large airbeam shelters for logistical support of the Desert RATS field mission. At the end of the campaign, both community and VIP visitation days were held in the field to showcase this year's test operations.

Plans for 2012: RATS operations are already underway for 2012 with engineering evaluations already accomplished at JSC this past December and January. This year will focus on habitability and human factors evaluations of a second-generation SEV and the use of a high-fidelity NEA simulation. All operations will be conducted at JSC as the SEV and operational concepts are refined for an anticipated return to field testing in 2013.

References: [1] Romig B. A. and Kosmo J. J. (2010) *Desert Research and Technology Studies (D-RATS) 2010 Mission Overview*, LPSC. [2] Eppler D. B. and Horz F. P. (2011) *D-RATS 2011 Traverses*, NASA. [3] Abercromby A. and Gernhardt M. (2011) *Desert RATS 2011: Evaluation of Human and Robotic Exploration Systems over Communications Delay and Bandwidth Constraints*, NASA.