PLANETARY SURFACE SCIENCE OPERATIONS FOR HUMAN MISSIONS: THE 2010 DESERT RESEARCH AND TECHNOLOGY STUDY. D. B. Eppler[1], D. W. Ming[2] and the Desert RATS Science Operations Team, [1, 2]Exploration Sciences Office, Mail Code KX, NASA-Johnson Space Center, 2101 NASA Parkway, Houston, TX, 77058, dean.b.eppler@nasa.gov, [2]doug.w.ming@nasa.gov.

Introduction: Desert Research and Technology Studies (Desert RATS) is a multi-year series of hardware and operations tests carried out annually in the high desert of Arizona on the San Francisco Volcanic Field. Conducted since 1997, these activities are designed to exercise planetary surface hardware and operations in conditions where long-distance, multi-day roving is achievable. Such activities not only test vehicle subsystems through extended rough-terrain driving, they also stress communications and operations systems and allow testing of science operations approaches to advance human and robotic surface capabilities. Desert RATS is a venue where new ideas can be tested, both individually and as part of an operation with multiple elements. By conducting operations over multiple yearly cycles, ideas that “make the cut” can be iterated and tested during follow-on years. This ultimately helps define requirements for future planetary surface operations, and gives the hardware and the personnel experience in the kind of integrated operations that will be necessary in future human planetary exploration.

Desert RATS 2010 tested two crewed rovers designed as first generation prototypes of small pressurized vehicles. Each rover provided the internal volume necessary for crewmembers to live and work for periods up to 14 days, as well as allowing for extravehicular activities (EVAs) through the use of rear-mounted suit ports. The 2010 test was designed to simulate geologic science traverses over a 14-day period through a terrain of cinder cones, lava flows and underlying sedimentary units. Prior to the test, a series of traverses were planned using techniques that were first developed during Apollo [1]. These traverses were based on a photogeologic interpretation of air photo and satellite images conducted by the USGS Branch of Astrogeology in Flagstaff. They were designed to simulate a reconnaissance investigation by 2 rover crews of a planetary surface operating under a variety of communications constraints. Predicted communications coverage was overlaid on the planned traverses [2] and geological stations were adjusted to ensure communications supported the planned test conditions (e.g., continuous communications) during each day of the test. The resulting set of traverses and stations were then field checked by the test team leads to ensure compliance with planned test conditions.

Conduct of the actual test took place between 31 August and 13 September 2010. Two crewmembers lived in and drove each rover for a single week with a “shift change” on day 7, resulting in a total of eight test subjects for the two week period. Each crew consisted of an engineer/commander and an experienced field geologist. Three of the engineer/commanders were experienced astronauts with at least one Space Shuttle flight. The field geologists were drawn from the academic community. Three of the crews were male, with the fourth crew being female.

Operations were tested with different communication states and rover deployment conditions. Three days of each week operated under continuous communications with mission operations team, and three days the rovers were operated with communications only for ≈1 hour in the morning and ≈1 hour at the end of the traverse day (i.e., 2-a-day comm). In addition, portions of the traverses were conducted with the two rovers in mutual support, largely operating as a single entity, while during other periods, the rovers operated out of line-of-site of each other, pursuing independent science objectives.

Science Operations Management Approach: In previous RATS operations, the science support room has operated largely in an advisory role. This approach was driven by the need to provide a loose science mission framework that would underpin the engineering tests, rather than be an element of the operations that was conducting discipline specific test operations. However, the extensive nature of the traverse operations for 2010 drove the decision to expand the role of the science operations and test specific operations approaches as part of the science support for the test. The success of the Apollo mission science support team as well as the science operations approach utilized by the MER missions became the baseline for the science test [3].

Past experience has shown that overseeing manned operations of multiple vehicles requires a separate control room for each (e.g., Space Shuttle and ISS operations prior to docking of the orbiter to ISS or after undocking). Consequently, each rover worked directly with a dedicated Tactical Science Operations Team (TSOT) responsible for managing real-time science operations while each crew was conducting “boots on the ground” geologic field operations. The two TSOTs operated during normal duty days, between ≈7:30 AM and ≈5:30 PM. In addition to the TSOT, independent test operations with two rovers required data analysis and replanning team, termed the Strategic Science Operations Team (SSOT). The SSOT would analyze the results of daily sciences operations from each rover crew and evaluate those operations within the larger objectives of the field traverse plans. In particular, a major function of the SSOT was to evaluate the completion status of a particular day’s objectives and, if necessary, recommend to the Mission Manager variations in the following days’ operations in response to missed objectives or important, serendipitous discoveries. The SSOT operated during the night shift, between ≈8:00PM and ≈4:00 AM. Both the SSOT and TSOT were crewed by scientists with a range of experience levels in both field geology and planetary mission operations.

Each TSOT was housed in a separate trailer in the field that had 7 console positions. The TSOTs were managed by a team lead, responsible for the overall conduct of a particular rovers’ science operations during EVA. Communications with the rover crew were conducted by a Science Communicator (SCICOM), who was the only person on the TSOT that communicated directly with the crew. A Documentarian assisted the TSOT Lead with a real-time, running “war diary” of field operations, describing the operations, identifying specific issues to be resolved downstream, and providing the overall daily reference document for science operations. Two of the remaining console positions (GIGAPAN, MASTCAM) were responsible for managing the operation of a variety of still, panoramic and video cameras and downlinking image products to be utilized in real-time for situational awareness and management of the science operations at a particular station. Lastly, two TSOT members were each responsible for overseeing the science activities of a single crewmember. This activity included downlinking image data from backpack cameras, listening to and conducting real-time science analysis of crewmembers’ verbal descriptions, and providing advice to the TSOT Lead on operations. In addition, each TSOT maintained a team member (OPSLINK) in the primary operations control trailer to act as the liaison between each science team and the overall mission operations team. In particular, OPSLINK managed the control handoff between mission operations team, which controlled the rovers between stations, and the TSOT, which took over when the crewmembers stepped off the rover, i.e., “boots on the ground.”

The SSOT was conducted in a hotel conference room in Flagstaff, separate from the field operations site. Like the TSOT, there were a number of standing positions on the team held by a variety of scientists. The SSOT was managed by a team lead responsible for management and completion of all activities of the SSOT, including replanning of traverses for the following day’s science operations. In addition, the Team Lead was responsible for presenting any changes to the day’s plan to the Mission Management Team following the SSOT’s daily operations. The team also included a Documentarian whose role was similar to the counterpart on the TSOT. An SSOT Strategic Operations Lead was responsible for managing long-term constraints that affected the daily replanning process (e.g. communications constraints), and any items that may affect the mission in light of re-planned science operations. The Activity Planners were responsible for taking the recommendations of the SSOT Team Lead for changes to future tactical plans and preparing the revised daily plan for each rover crew. The Long-Term Planning Lead was responsible for coordinating the science teams that worked on datasets critical to planning the next day’s tactical activities, determining whether there were discoveries or issues that warranted traverse replanning, and revising traverse plans in accordance with new directions. Various geoscience teams were responsible for analyzing data sets produced by the crew Rover imaging and science teams (e.g., Crew Field Notes [4], panoramic or back pack imaging data), making specific recommendations to the Strategic Operations Lead on revising the following day’s geologic traverses, and identifying key samples collected that were candidates for further study.

The 2010 RATS Science Operations Test was extremely successful, testing a variety of old and new operations approaches to managing science data and crew operations on planetary surfaces. In addition to substantive lessons learned that will be discussed in other abstracts (e.g., [5]), the test served to begin training a new generation of scientists in the demands of planetary surface science operations.

References: [1] F. Hörz, et. al. (2011a), *LPSC XVII,* Abstract #XXXX. [2] M. Seibert, et. al et. al. (2011), *LPSC XVII,* Abstract #XXXX. [3] B. Cohen et. al., (2011), *LPSC XVII,* Abstract #XXXX. [4] F; Hörz, et. al. (2011b), *LPSC XVII,* Abstract #XXXX. [5] J. Hurtado, et. al., (2011), *LPSC XVII,* Abstract #XXXX.