CONDUCTING PLANETARY FIELD GEOLOGY ON EVA: LESSONS FROM THE 2010 DRATS GEOLOGIST CREWMEMBERS. K.E. Young[1], J.E. Bleacher[2], J.M. Hurtado, Jr.[3], J. Rice[2], W.B. Garry[4], D. Eppler[5]. [1]Arizona State University, School of Earth & Space Exploration (Kelsey.E.Young@asu.edu), Tempe, AZ, 85282, [2]Planetary Geodynamics Laboratory, Code 698, NASA Goddard Space Flight Center, Greenbelt, MD, 20771, [3]University of Texas at El Paso, Department of Geological Sciences & Center for Space Exploration Technology Research, El Paso, TX, 79968, [4]Center for Earth and Planetary Studies, Smithsonian Institution, PO Box 37012, National Air and Space Museum MRC 315, Washington, D.C. 20013, [5]NASA Johnson Space Center, Astromaterials Research & Exploration Sciences Directorate, Houston, TX, 77058.

Introduction: In order to prepare for the next phase of planetary surface exploration, the Desert Research and Technology Studies (DRATS) field program seeks to test the next generation of technology needed to explore other surfaces. The 2010 DRATS 14-day field campaign focused on the simultaneous operation of two habitatable rovers, or Space Exploration Vehicles (SEVs). Each rover was crewed by one astronaut/commander and one geologist, with a change in crews on day seven of the mission. This shift change allowed for eight crew members to test the DRATS technology and operational protocols [1,2]. The insights presented in this abstract represent the crew's thoughts on lessons learned from this field season, as well as potential future testing concepts.

The Importance of EVA: The Apollo missions from 1969-1972 represent the only time that humans have conducted extravehicular activities (EVA), or spacewalks, on another planetary surface. EVAs are Earth-bound scientists' best chance to obtain contextual geologic samples from another body [3]. The geologically-trained Apollo astronauts who collected samples with geologic contextual information proved to be a great asset in developing the scientific history of the Moon we have today. Recognizing this fact, the DRATS team strove to establish a set of technologies and procedures to allow for the maximum science return from the 2010 field test.

EVA Technology: While the greatest asset for scientific data collection on EVA is an astronaut trained in field geology [3], several technologies were tested in the 2010 DRATS field test that proved to be beneficial for sample collection.

Sample Collection Technologies: Sample collection was a large part of scientific data collection in the 2010 DRATS test (4). The development of sample collection technologies are crucial in establishing procedures that allow for maximum efficiency of this process. Each crewmember had their own rock hammer, tool caddy, claw tool (to allow for picking up a sample from the ground without kneeling to obtain it), and sample bags, with access to one shovel and one core tube sampling set. All of these tools were mounted on the aft deck of each rover to allow for easy access by each crewmember.

Each geologist crewmember has extensive terrestrial field experience and therefore has their own opinions about which tools are the most valuable and usable in sample collection [4]. However, many opinions about this technology were unanimous. The tool and sample bag caddy was originally designed to hold tools such as the rock hammer, as well as several sample bags (both empty and full). This caddy could also provide balance as it was tall enough for each crewmember to lean on and sturdy enough that it could bear the weight of a leaning astronaut. However, it proved to be somewhat ungainly and not necessary, as the rock hammer could alternatively be attached to the outside of the shirt-sleeve backpack and a bag to hold collected samples could be clipped to the backpack. The claw tool was not particularly useful to most of the crewmembers as it was often easier to just lean down to pick up the sample. Sample bags were all the same size, which did not prove to be an issue in this year's test as they easily held all soil samples and most hard rock samples, but an option to collect larger hard rock samples should be incorporated in future years.

Audio/Visual Data Collection Technologies: Just as valuable as the hard rock and soil samples observed, described, and returned to Earth on any planetary surface exploration mission are the images, video, and observations of the surrounding terrain taken by any human or robotic explorers. As shown by Apollo 17 geologist Harrison Schmitt, geologist-astronauts bring their expertise to the mission by providing high-fidelity sample and terrain descriptions that astronauts with less field experience may not be able to provide [3]. The DRATS field tests recognize the importance of such observations by providing several avenues by which audio and visual data is transferred back to the scientific backroom on Earth [5].

For the 2010 Desert RATS field test, each crewmember was equipped with a cuff control computer mounted on their left arm that controls data acquisition during EVAs [5]. Each simulated Portable Life Support System (PLSS) had two shoulder-mounted cameras as well as a speaker-headset with the ability to record voice notes. Crew Field Notes (CFNs) were taken on every EVA that included both video and audio information provided by the EVA crewmember

[4,5]. The information recorded in CFNs included both geologic context descriptions as well as documentations of collected samples [4].

The crew noted several problems with the CFN audio/visual data collection technologies. For example, the two shoulder cameras were difficult to maneuver and contextual images of distant objects were difficult to acquire as the crewmember was forced to awkwardly lean backward to get the horizon in the camera's view. In addition to this, the crew had to aim the cameras without the benefit of a viewfinder, so there was no way to determine if the sample or outcrop they were imaging was satisfactorily captured in the field of view of the cameras. The cuff control could be the likely place to station a viewfinder so the crew can see what they're imaging realtime. Similarly, there was no capacity to review images or audio data once they were taken for quality control. Realtime feedback about data collected (both audio and visual) would enable the crew to improve the quality of data collected in the field and minimize the workload for the science support teammembers who otherwise would be faced with poor image data because of poor camera placement.

Despite these difficulties, the crew recognizes that this technology is advancing and that the 2010 experience provides insights into the utility of the cuff control and how to improve it. Thoughts such as the size of the cuff and the time delay between when the crewmember presses the "take picture" button and when the image is acquired are currently being evaluated. A more user-friendly cuff interface is required and is already planned for the 2011 Desert RATS test.

Communication Technologies: All of the technology discussed above is directly related to sample documentation and data collection. Another crucial tool used on EVA is the communications link with the crewmembers and the science backroom. Through a microphone attached the a headset, each crewmember had the ability to talk to both their partner and the backroom while on EVA. During periods where the crews were operating with continuous communications [2], they were capable of communicating directly with the science backroom while on EVA. This proved to be very beneficial for allowing the interactive and realtime development of multiple working hypotheses, the complete documentation of geologic observations, and the cataloging of samples as they were collected. All of the geologist crewmembers agree that multiple minds working on a geologic question are better than one, making the role of the science support room critical. In addition to communications between a rover crew and the science support team and among the individual rover crew, an innovation to be explored for dual-rover operations in the future is a communication link between rover crews during EVA. This would allow valuable discussion between two boots-on-the-ground geologists for real-time EVA plan refinement and synthesis of science observations. This capability must be carefully developed so as not to overwhelm already busy communications loops.

EVA Protocols and Procedures: In order to provide easily accessible and understandable data products in the field, it is crucial to establish a list of protocols and procedures for each crewmember to follow on EVA. The DRATS field campaign sought to establish this procedure, and it is outlined here. Note that Hurtado et al [4] describes sample collection procedures while on EVA and Bleacher et al [2] discusses the communications structure that links each rover to their respective science backrooms. During periods of continuous communications, the crew is able to speak with geologists in the science backroom. This enables the crew to plan each EVA ahead of time with support from the backroom. During times where the crew did not have realtime communications with the backroom, the rovers were responsible for using the pre-designed traverse plans to influence their decisions.

Upon arriving at an EVA station, the geologist crewmember took an IVA (intra-vehicular activity) CFN documenting the plan for the site and any initial observations about the site that they are able to make from within the rover. Egress procedures were then completed, which included getting into the suit (in this case a shirt-sleeve backpack) and conducting communications and safety checks with Mission Control. Once the crew was safely boots-on-the-ground, the geologist recorded a CFN showing where each crewmember was planning on traveling in relation to the rover's parking location. The two crewmembers then completed their individual tasks for the EVA, either together or separately, depending on the EVA plan. EVA activities include geologic observations and sample collection [4] At the end of the allotted time for the EVA, the crewmembers returned to the rover and laid out all collected samples on the aft deck. The geologist would then record a CFN providing a brief geologic description of each sample with sample bag numbers. Upon ingress back into the rover, the geologist would record an IVA CFN to summarize the entire EVA and what was accomplished with relation to the initial goals of the EVA. Any initial hypotheses about the geologic history of the site were also recorded here.

References: [1] Eppler et al. (2011), this volume. [2] Bleacher et al. (2011), this volume. [3] Hodges et al. (2010), A New Approach to Planetary Field Geology, *GSA Abs. w/ Prog.*, v. 42 (5), p. 64. [4] Hurtado et al. (2011), this volume. [5] Horz et al. (2011), this volume.