CREWED MARTIAN TRAVERSES II; LESSONS LEARNED FROM A MARS ANALOG GEOLOGIC FIELD EXPEDITION

M. C. Bouchard[1], [1]Washington University of St. Louis (mcbouchard@wustl.edu)

Introduction: This paper is the second in the Crewed Martian Traverses series. *Crewed Martian Traverses; Building on Lessons Learned from Apollo, Robotic Missions and Planetary Analogs*, was presented at the 45th LPSC. Together they represent a growing body of work in the study of human scientific exploration of the Martian surface. This abstract summarizes the lessons learned by the Crew Geologist during Mission 132, a two week simulation at the Mars Desert Research Station (MDRS), hosted by the Mars Society outside of Hanksville, Utah. MDRS is a medium fidelity simulation which requires delayed communication, limited power, rationed water and food, and "Extra Vehicular Activity (EVA) suits" for external excursions.

The goal for attending the simulation was to study the effect of analog Mars mission environments, procedures, and logistics on geologic field exploration in order to further the body of understanding of traverse planning procedures, science field instruments, and the development of extraterrestrial geologic equipment. While at the simulation the Crew Geologist performed three principal research projects. These included constructing a geologic field map, collecting and analyzing sub-surface samples, and an equipment survey.

Geologic field exploration is characterized by flexible and adaptive execution, two traits that introduce uncertainty and hazards into space missions. Planetary surface exploration, similar to geologic field work, involves making observations, testing hypothesis, and returning to field sites [1]. NASA has spent several years investigating this process their Desert Research Analog Technology Studies (DRATS) [2]. These integrated operational and scientific analog studies must be performed in order to prepare for future human field exploration of Mars.

Operations: During the course of the simulation the seven crew members participated in six EVAs. Each EVA was run by an EVA commander, and consisted of three-four crew members. Every EVA had several mission objectives, which ultimately addressed all seven of the crew member's research needs.

Planning: The process of planning a planetary traverse is a delicate balance between scientific objectives, engineering constraints, and operational logistics [3]. Ultimately the traverse planning fell on the only experienced field scientist of the group, the Crew Geologist, who employed the best practices of NASA's Mars robotic missions, Apollo missions, and analog DRATS [2]. Ultimately the study corroborated the DRATS findings that the inputs of experienced field scientists in traverse planning were invaluable in maximizing the science return [1].

Safety: In any expedition the safety of the participants is of paramount importance. Potential hazards experienced during the simulation were dehydration, minor cuts and sprains, and localized hypothermia; these hazards were exacerbated by significant distance from medical faculties. The crew made every effort to maintain safe operations during the mission to mitigate the risks. Only once during the analog did the crew feel they were in mild danger. This occurred when the crew had hiked up a 30-40 degree slope of a mountain in the EVA suits to survey the surrounding area. The crew was met with difficulty while descending the muddy slope. The decent was made more difficult due to obstructions by fogged up helmets and limited mobility due to the life support backpacks. This highlights limitations of traversable terrain imposed by planetary exploration gear, and was incorporated in following EVA plans.

Sample Collection: A detailed selection, retrieval, and documentation procedure was developed in order to preserve the integrity of the context of sub-surface geologic regolith samples. It was modeled after the Apollo mission and DRATS methods [4]. The documentation procedures involved careful descriptions and photo documentation.

Figure A: Crew members collect regolith

Mobility: For the purpose of the simulation five out of the six EVA's were completed on foot, and so were limited to a <1.6 km radius of the simulated habitat. The limited distance was influenced by the amount of time it took to prepare the EVA team, reach a desired destination, complete given objectives, and return safely before sunset. They were also limited by the speed at which the crew could move on foot and the endurance of the team with EVA's lasting between 3-5 hours. Crews carried in-suit water supplies but were unable to consume any solids once they left the habitat. Working in the EVA suits proved strenuous. The limited radius proved an adequate amount of terrain to explore in a two week simulation; however any mission lasting longer than a month would be greatly limited by this distance. One EVA was completed with the assistance of open-air All Terrain Vehicles (ATVs). This expedition easily reached a target of 2 km distance, and visited several other sites during the traverse. The ATV's greatly boosted the traverse capability of the crew, decreased fatigue incurred from simply reaching destinations, and saved a lot of time. A Mars mission of any duration would benefit from the use of vehicles such as this or the more sophisticated pressurized rovers of the DRATS [4].

Communication: The field crews utilized hand-held two way radios for communication between one another and with the habitat. Every EVA was assigned a Habitat Communication (HabCom) personnel. They acted as a safety link and support personnel. Crew 132 utilized a two-way communication check. The EVA team would contact the habitat when they believed that they had reached one of the four-six waypoints. The HabCom would verify the team's GPS location with the Habitat map and EVA plan. Also every half hour the Habitat would initiate a communication check with the EVA team. This two way communication allowed for both parties to detect issues with communication. The HabCom acted more as mission support, offering logistical and safety support, and not as a science backroom or mission control [3]. The crew suffered from several radio issues, including radio battery failures, loss of communication around hills and beyond 1 km, and general connection issues. On one EVA the Crew Geologist practiced with an active HabCom to whom was relayed the geologist's observations and mission notes. This freed up the field crew's hands and was beneficial, but was subject to loss of information due to communication issues. The EVA would see an increase in science captured if the HabCom had a similar geologic background. These results are similar to the conclusions of the 2010 DRATS mission where science backrooms, given good communication downlinks, helped to maximize the science return of traverses as well as optimize the documentation of data [2].

Equipment: While mapping a geologist carries many different tools into the field. One of the analog studies completed was a survey of seventeen of these typical tools and how their use was affected by the simulated Mars environment and procedures.

Observational: Observational equipment is used by geologists to investigate the features of the rocks they encounter in the field. Some of the classical observational equipment included in the study was a hand lens, a rock hammer, and a compass. More sophisticated observational tools such as hand-held spectrometers or Schmidt hammers were not available. Some of the observational tools were more difficult to use, for example the helmet interfered with the use of the hand lens. Several of these tools will need to be reconfigured to allow for their use in spacesuits.

Documentation: For the purpose of documentation the analog the Crew Geologist relied heavily on the use of a field notebook and camera. Notebooks are excellent for terrestrial applications but prove very problematic for space. Lowered dexterity from gloves, and questionable functionality of writing instruments on paper in the extreme Martian environments will need to be overcome. Cameras offer a more adaptive documentation method but lack on site inferences. An alternative used in both the Apollo program and DRATS is voice recorded transcripts [2]. When verbal logs were radioed back to the HabCom much of the documentation stress was removed from the field crew. However this required more time required for verbal confirmation and was subject to failures in equipment. Future missions should include both a science backroom/ logistical support person as well as field based records.

Logistical: The final set of equipment included non-scientific logistical tools required for the success of the mission such as radios and sun glasses.

Overall the quantity of equipment needs to be centralized and minimized by combining functions. This will greatly increase stow-ability and use of these tools in the field. Minimizing the number of tools will reduce dextral stress and transition time.

Conclusions: The MDRS analog geologic field exploration offered many insights into the challenges and limitations of performing field science on Mars. It highlighted the importance of cross training the crew as field scientists, both in order to perform and support traverses. It showed that equipment should be adapted for the range of motion of space suits, and be streamlined for accessibility. Visibility and fogging of helmets was a serious issue, but will be mitigated by closed environmental controls. Communication continues to be one of the most limiting and essential factors of any traverse. Command and support infrastructure and hands-free reliable communication are a necessity. It also showed the value of increased mobility platforms in the pursuit of exploration.

If the study of these tools and procedures are continued, a better balance of the safety, efficiency, and flexibility required for field science can be achieved.

References: [1] Yingst R.A., et al. (2011) Acta Astronautica 2011.10.001 [2] Eppler D.A., et al. (2012) Acta Astronautica 2012.03.009 [3] Bouchard M.C. (2014) LPS XXXXV, Abstract #1580 [4] Gruener J.E., et al. (2011) Acta Astronautica 2011.12.006. Additional Information: This research would not have been possible without the scholarship and facility support of the Mars Society, and the hard work and commitment of the members of Crew 132.