NEXT-GENERATION STRATEGIES FOR HUMAN LUNAR SORTIES. B. A. Cohen, NASA Marshall Space Flight Center, Huntsville AL 35812

Introduction: The science community has had success in remote field experiences using two distinctly different models for humans-in-the-loop: the Apollo Science Support team (science backroom), and the robotic exploration of Mars. In the Apollo experience, the science team helped train the crew, designed geologic traverses, and made real-time decisions by reviewing audio and video transmissions and providing recommendations for geologic sampling. In contrast, the Mars Exploration Rover (MER) and Mars Science Lab (MSL) missions have been conducted entirely robotically, with significant time delays between science-driven decisions and remote field activities. Distinctive operations methods and field methodologies were developed for MER/MSL [1,2] because of the reliance on the "backroom" science team (rather than astronaut crew members) to understand the surroundings. Additionally, data are relayed to the team once per day, giving the team many hours or even days to assimilate the data and decide on a plan of action.

Experience gained from these models has significant implications for future field protocols involving humans sampling a remote planetary surface. In most models of future human missions, some degree of crew autonomy is likely to be the case, but the opportunity to have a remote team involved in real time science decisions provides the potential of significant increase in science return. In addition, new analytical tools developed for robotic missions may significantly enhance the value of samples selected for return. NASA's Desert-RATS field tests incorporated elements of both MER/MSL and Apollo strategies into crw operations [3]. Lessons leaned emphasize several common themes that should be considered in future human sorties.

Well-trained geologists on the crew and a science backroom with which that crew can interact are both critical components for maximizing science return. Cross-training of scientists in mission operations, as well as training operations personnel and crew in field methods desired on the surface. Such training and integration leads to smoother communications, competency and trust [4], allowing the crew to be more efficient in the field and lessen the desire for backroom coaching. Similarly, the MER science and operations teams are highly integrated and unusually close for science mission teams, leading to improved science return and efficiencies in planning [5].

Sampling protocol are one area where crew need to be specific training in sampling and collection protocol to be able to answer scientiftic hypotheses, rather than just simply landing and collecting a scoop sample or random hand samples. The incorpration of handheld instruments could also significantly enhance the ability of surface crew to target high-priority samples. Such data could flow to the science backroom for quick-look analysis, or threshold values could be built into the handheld instruments.

Sufficient time for analysis must be built into the the tactical operations timeline. The science objectives for short lunar sorties should be clearly articulated and human-unique skills be deployed. Planetary geologic exploration involves observing, testing hypotheses and revisiting locations if appropriate to better understand field relations. This process requires time for evaluation, by the crew or backroom, or both. The ability to interrupt and revise based on improved understanding is critical. Deployment of teleoperated robotic rovers or surface stations could also enhance science return with minimal tending by the surface crew, allowing the longer-lived operation beyond the human mission.

High-fidelity communication and data flow ensure that time is not wasted in repetitive review of acquired datasets. The large amount of real time data being generated to support the scientists requires an efficient and intuitive data plan that streamlines data flow. All spacecraft budget large sums for data pipelining for tactical use and for long-term storage on the PDS, whereas Apollo did not. The results of the 2009 and 2010 D-RATS field tests indicate that funding such a data pipeline is critical to mission science output. A real time mission with human involvement will produce significant amounts of data in many forms, including images, voice transcripts, and data that will need to be refined before it can easily be read (e.g., multispectral data). All these will need to be ingested and made available in a streamlined fashion. Scientists in the backroom and on the ground must have tools and an architecture that allows sufficient time for scientific understanding, so this requires investment in information tools and databases.

References: [1] B. Jolliff, et al. (2000), , J. Geophys. Res doi:10.1029/ 2000JE001470. [2] Yingst, R.A., Cohen, B.A., L. Crumpler, M.S. Schmidt, and C.M. Schrader, (2011), Mars 6, 13-31, doi:10.1555/mars.2011.0002. [3] Yingst, R.A., Cohen, B.A., Ming, D.W., and Eppler, D.B. (2011) Acta Astro., doi:10.1016/j.actaastro.2011.10.001. [4] Love S, and Bleacher J. (2012) Acta Astro. 10.1016/j.actaastro.2011.12.012 [5] J.V. Tollinger, C.D. Schunn, and A.H. Vera (2006) Proc. Conf. Cognitive Science Society 28, 840–845.