OPTIMIZING LUNAR SAMPLE RETURN: LESSONS LEARNED FROM A ROBOTIC PRECURSOR LUNAR ANALOGUE MISSION AT THE MISTASTIN IMPACT STRUCTURE, LABRADOR, CANADA.

M. M. Mader [1] I. Antonenko[1], G. R. Osinski[1], M. Battler[1], M. Beauchamp[1], L. Cupelli[1], A. Chanou[1], R. Francis[1], C. Marion[1], E. McCullough[1], L. Preston[1], B. Shankar[1], T. Unrau[1], D. Veillette[1], [1]Centre for Planetary Science and Exploration & Canadian Lunar Research Network, University of Western Ontario, London, ON, Canada, (mmader2@uwo.ca).

Introduction: The return of samples from the South Pole–Aitken (SPA) basin and other regions of of the Moon is a high priority target for the Canadian, U.S., and international scientific communities [1]. In order to prepare and test protocols for future lunar sample return missions, our team is carrying out three “analogue” missions, funded by the Canadian Space Agency. The first analogue mission took place over three weeks in August and September 2010 and aimed to simulate a robotic precursor mission to the SPA. This will be followed by a second analogue mission to the same location in 2011, which will include a human sortie element. The precursor mission involved robotic surveying and prospecting of Sites of Interest (SOIs) in preparation for human field geology operations. The Mistastin impact structure, Canada, which represents an exceptional lunar analogue site [2], was chosen as the target site for this analogue mission.

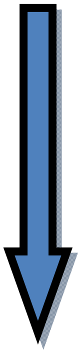
Objectives: The operational goals include: the development of mapping, sample site selection and analysis protocols; and characterizing the scientific decision making processes regarding outcrop mapping and sample site selection. Technical objectives include determining science instrument requirements and limitations of existing off-the-shelf-instrumentation. This analogue mission is driven by the paradigm that the operational and technical objectives are conducted in line with the overarching scientific objectives: to further the understanding of impact chronology, shock processes, and impact ejecta,

Field Approach, Mistastin 2010: The 2010 Mistastin deployment comprised two distinct groups: the mission control team and the field team (“the rover”). The mission control team was based at the University of Western Ontario located in London, Ontario. They directed the “rover” activities and made all science decisions for the deployment based on returned data from the field. No mechanical robot was used on this deployment. Instead, a field team of four to five people acted collectively as the robot - they made traverses with the instruments, collected data as requested by mission control, and sent the data to the remote mission control team using satellite communication. Instruments used in the field included:

- Light detection and ranging (LIDAR) for making 3-D intensity models of the surrounding area (range: up to 1 km);
- Mobile scene modeller (mSM) for making 3-D colour models at outcrop scale (range 2-5 m);
- Ground penetrating radar (GPR) for imaging the subsurface (depth ~10 m);
- Digital camera with Gigapan mount for making panoramic high resolution colour images;
- X-ray fluorescence spectrometer (XRF) for measuring major and trace elemental abundance in rocks.

Operations: A general sequence of activities for this field deployment was based on the principals of mapping the geology of an unknown area: by first providing a regional context and then progressively focusing the geographic area of study.

Large scale



- Remote Sensing Data
- Landing Site Survey (LIDAR, digital camera and Gigapan mount)
- Conduct GPR scan
- Zoom in on Site of Interest (using the following sequence):
    - LIDAR scan and digital panorama
    - mSM
    - Macro digital camera
- Choose specific spot for geochemical and mineralogical analysis (XRF)

Small Scale

Lessons Learned: The focus of this analogue mission was not in testing the capabilities and constraints of a rover, but in testing the scientific instruments that would be carried by a rover and assessing the usefulness of the returned data for future sample return during the 2011 deployment. Initial lessons learned highlight the situational awareness capabilities and limitations of the field instruments. Recommendations emphasize the need to optimize the resolution required for vision system data products for each progressive step (see flow chart above) and to improve visualization software that would allow seamless data integration of different data sets.

References: [1] NRC (2007) *The National Academies Press*, 107. [2] M. Mader et al. (2010), Lunar Science 2010 Forum, Abstract.

Acknowledgments: Canadian Space Agency; Annemarie Pickersgill, UWO; Timothy Barfoot, U of T; Timothy Haltigin, CSA; Ho-Kong, MDA.