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Mission Operations Design for Lunar Sample Return as field-tested in an Analogue deployment to the Sudbury Impact Structure

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Abstract

A Mission Operations Design will be described for an analogue robotic sample return mission on the far side of the Moon in the South Pole-Aitken Basin. The analogous site will be within the Sudbury Impact Structure. This scenario will use a rover acting alone supported by a single relay spacecraft. The structure established and tested will offer lessons for improving decision making and reducing training time across all similar planetary space missions, including private lunar missions. Differences between our process and the processes used by other recent science-driven Analogue Mission activities [4,6,7] will be discussed.

1. Motivation

The Planetary Decadal Survey has ranked sample return from the South Pole-Aitken basin on the lunar far side as high-priority under the New Frontiers program [1]. As well, there are several dozen private companies who are vying for the Google Lunar X-Prize that will carry out science and exploration objectives on the Moon. As such, we will report on a science-driven Analogue Mission using the UTIAS ROC-6 Rover [2] to investigate a site within the Sudbury Impact Structure in June, 2011. A remote mission control room will be employed in London, ON. We believe that our exercise will provide lessons learned for all groups interested in designing mission operations for the Moon.

2. Scenario Description

The scenario is centred around an exploring/caching rover (not unlike the proposed MAX-C Mission for Mars [1]) which would characterize its landing site and select the best geological samples for return based upon their science potential. A single mapping orbiter assumed to have a 2-hour orbital period similar to the LRO Qualification orbit [3] would support this rover (Fig 1). It is this 2-hour cadence that drives the design of mission operations (Fig. 2). Each command cycle requires two hours to complete with uplink to the field at the start and downlink from the field at the end of the first hour in the middle of each command cycle.

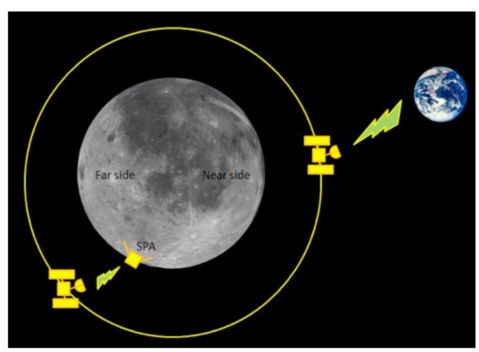

Figure 1: *Cartoon of the communications scheme being tested with a rover at the South Pole-Aitken Basin and Mission Control on Earth.*

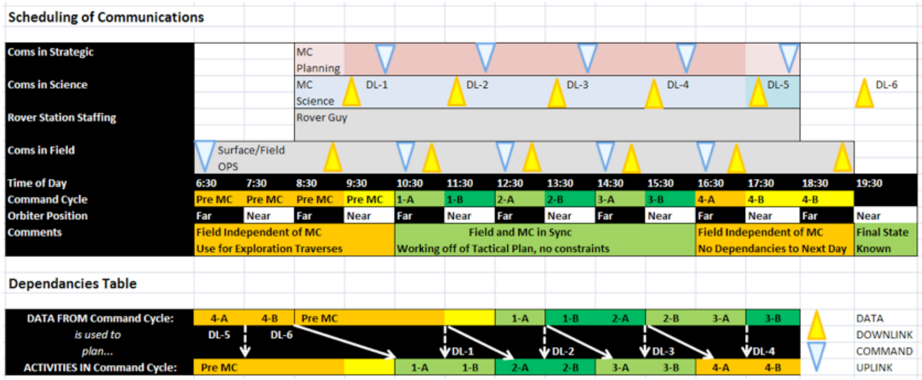

Figure 2: *The Schedule of Communications and staffing necessitated by the 2-hour rolling command cycle.*

3. Process Division

Program Operational Concept used for the Phoenix Mars Lander [5] and adapted it. Over the course of our preparation, changes were made to suit the level of staffing at mission control of 10-20 volunteers and the relatively low amount of training (compared to flight missions) that could be provided. Thus, a structure was developed which played to the existing strengths of the team, many members of which were field geologists (Fig. 3). As such, our process provides a way to rapidly make use of scientists to provide input into a science-driven process.

We have divided up mission control into four separate, yet linked, processes with each, in turn, contributing to the final product. First, Science Processing takes in downlinked data and converts it into science data products. Next, Science Processing works with Science Interpretation to update a list of desired specific prioritized future observations that respond to the new data products and is in keeping with Science Interpretation's Long Term Plan for the mission.

Next, the Planning process takes the prioritized science objectives and balances these against the available resources and rover capabilities to create a schedule of observations and traverses which are uploaded to the field. During this whole sequence, the Mission Evaluation and Facilitation Process fosters inter-process and inter-shift communications and understanding by organizing the data that comes in, recording the decisions made at meetings of each process and maintaining a wiki of reference material available to the entire group.

References

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Figure 3: *Structure of Mission Control showing assigned roles and decision-making processes.*