LANDING SITE SELECTION AND EFFECTS ON ROBOTIC RESOURCE PROSPECTING MISSION OPERATIONS. J. L. Heldmann[1], A. C. Colaprete[1], R. C. Elphic[1], and D. R. Andrews[1]. [1]NASA Ames Research Center, Moffett Field, CA 94035.

Introduction: The Moon's polar deposits are considered high priority targets for lunar in situ resource utilization (ISRU) [1]. These resource deposits can enable long term human exploration and settlement of the Moon. Characterization of these resource deposits is critical to verify the form and distribution of volatiles in order to inform future ISRU architectures. Here we discuss optimal robotic mission strategies for resource assessment and verification, and emphasize the importance of site selection and its implications for resource prospecting and ISRU operations.

Robotic Resource Prospecting: Remote sensing data coupled with theoretical modeling has suggested the presence of significant volatile deposits in the lunar polar regions. Verification and characterization of these potential resources is required on the scales of ISRU operations. Such information is required to determine key parameters such as 1) volatile distribution including concentration, lateral and vertical extent and variability, 2) overburden quantities to determine how much material requires excavation to reach the ore, and 3) the working environment including factors such as the fraction of time in sun/shadow, soil mechanics, trafficability, temperatures, etc. [2]. This information is needed to determine if the resource and processing technique present an acceptable risk profile and expected economic return on investment. The in situ measurements are also needed to ground truth models and remote sensing datasets in order to develop robust predictive capabilities for other resource deposits.

The optimal method for robustly obtaining this data is through in situ measurement with a mobile robotic asset(s) [3]. A lunar polar rover mission can characterize the distribution of water and other volatiles at the scales necessary for ISRU. Candidate prospecting instrumentation for such a mission includes a drill for subsurface access and a Neutron Spectrometer System (NSS) and Near InfraRed Volatiles Spectrometer System (NIRVSS). NSS is capable of detecting a water-equivalent hydrogen 40.5 wt% down to about 1 m depth, and thus is sensitive to volumetric hydrogen [4, 5]. NIRVSS is used for identification of surface H2O/OH and other volatiles and near-subsurface sample characterization [5, 6].

Site Selection: Site selection is a key driver of the lunar polar rover prospecting mission duration and hence of the mission concept of operations. Recent work has shown that stable ice may exist outside of permanently shadowed regions (PSRs) near the lunar poles. Thermal modeling coupled with Diviner lunar radiometer measurements from the Lunar Reconnaissance Orbiter (LRO) has shown that cryogenic temperatures exist outside of PSRs in near-surface regions [7]. Figure 1 shows a map of depth to stable ice for the lunar south polar region. Areas where the depth to stable ice is zero meters (white regions in Fig. 1) are primarily regions of permanent shadow. All other regions with a range of depths greater than zero and up to one meter are areas that receive on the order of several days of sunlight per month. The low sun angle coupled with the relative short duration of solar illumination results in the cryogenic subsurface temperatures which enable cold-trapping of water ice and other volatiles, even outside of permanently shadowed regions.

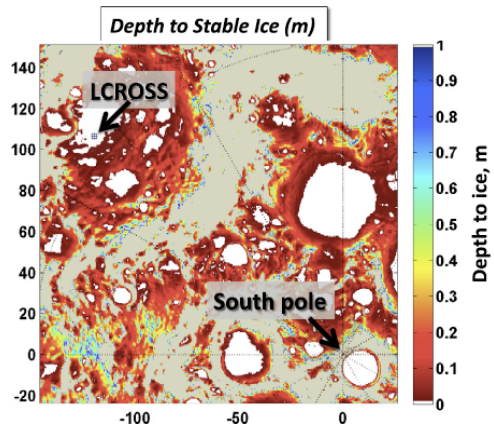

Figure 1. Depth to stable ice. Axes are in km.

Implications for Operations: Lunar polar ISRU activities are not restricted to PSRs. ISRU prospecting and operations can be conducted in sunlight which enhances visual situational awareness during mission operations, subjects hardware to more favorable thermal regimes compared with PSRs, and provides the option of solar power. Also, human settlements on the Moon will not be located in PSRs, thus a resource feedstock outside of a PSR would allow for closer proximity to the human base and avoid the engineering challenges of long-term PSR operations for ISRU.

References:

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