April, 2016 – Orlando, FL

Resource Prospector Instrumentation for Lunar Volatiles Prospecting, Sample Acquisition and Processing

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ABSTRACT

Data gathered from lunar missions within the last two decades have significantly enhanced our understanding of the volatile resources available on the lunar surface, specifically focusing on the polar regions. Several orbiting missions such as Clementine and Lunar Prospector have suggested the presence of volatile ices and enhanced hydrogen concentrations in the permanently shadowed regions of the moon. The Lunar Crater Observation and Sensing Satellite (LCROSS) mission was the first to provide direct measurement of water ice in a permanently shadowed region. These missions with other orbiting assets have laid the groundwork for the next step in the exploration of the lunar surface; providing ground truth data of the volatiles by mapping the distribution and processing lunar regolith for resource extraction. This next step is the robotic mission Resource Prospector (RP).

Resource Prospector is a lunar mission to investigate 'strategic knowledge gaps' (SKGs) for in-situ resource utilization (ISRU). The mission is proposed to land in the lunar south pole near a permanently shadowed crater. The landing site will be determined by the science team with input from broader international community as being near traversable landscape that has a high potential of containing elevated concentrations of volatiles such as water while maximizing mission duration. A rover will host the Regolith & Environment Science and Oxygen & Lunar Volatile Extraction (RESOLVE) payload for resource mapping and processing. The science instruments on the payload include a 1-meter drill, neutron spectrometer, a near infrared spectrometer, an operations camera, and a reactor with a gas chromatograph-mass spectrometer for volatile analysis.

After the RP lander safely delivers the rover to the lunar surface, the science team will guide the rover team on the first traverse plan. The neutron spectrometer (NS) and near infrared (NIR) spectrometer instruments will be used as prospecting tools to guide the traverse path. The NS will map the water-equivalent hydrogen

concentration as low as 0.5% by weight to an 80 centimeter depth as the rover traverses the lunar landscape. The NIR spectrometer will measure surficial H_2O/OH as well as general mineralogy. When the prospecting instruments identify a potential volatile-rich area during the course of a traverse, the prospect is then mapped out and the most promising location identified. An augering drill capable of sampling to a depth of 100 centimeters will excavate regolith for analysis. A quick assay of the drill cuttings will be made using an operations camera and NIR spectrometer. With the water depth confirmed by this first auguring activity, a regolith sample may be extracted for processing. The drill will deliver the regolith sample to a crucible that will be sealed and heated. Evolved volatiles will be measured by a gas chromatograph-mass spectrometer and the water will be captured and photographed.

RP is a solar powered mission, which given the polar location translates to a relatively short mission duration on the order of 4-15 days. This short mission duration drives the concept of operations, instrumentation, and data analysis towards critical real time analysis and decision support. Previous payload field tests have increased the fidelity of the hardware, software, and mission operations. Current activities include a mission level field test to optimize interfaces between the payload and rover as well as better understand the interaction of the science and rover teams during the mission timeline.

This paper will include the current status of the science instruments on the payload as well as the integrated field test occurring in fall of 2015. The concept of operations will be discussed, including the real time science and engineering decision-making process based on the critical data from the instrumentation. The path to flight will be discussed with the approach to this ambitious low cost mission.