Resource Prospector: An Update on the Lunar Volatiles Prospecting and ISRU Demonstration Mission A. Colaprete[1], R. Elphic[1], D. Andrews[1], J. Trimble[1], B. Bluethmann[2], J. Quinn[3], G. Chavers[4], [1]NASA Ames Research Center, Moffett Field, CA, [2]NASA Johnson Space Center, Houston, TX, [3]NASA Kennedy Space Center, FL, [4]NASA Marshal Space Flight Center, Hunstville, AL.

Introduction: Over the last two decades a wealth of new observations of the moon have demonstrated a lunar water system dramatically more complex and rich than was deduced following the Apollo era. Lunar water, and other volatiles, have the potential to be a valuable or enabling resource for future exploration. The NASA Human Exploration and Operations Mission Directorate (HEOMD) have selected a lunar volatiles prospecting mission for a concept study and potential flight in CY2021. The mission includes a rover-borne payload that (1) can locate surface and near-subsurface volatiles, (2) excavate and analyze samples of the volatile-bearing regolith, and (3) demonstrate the form, extractability and usefulness of the materials.

Relevance and Goals: While it is now understood that lunar water and other volatiles have a much greater extent of distribution, possible forms, and concentrations than previously believed, to fully understand how viable these volatiles are as a resource to support human exploration of the solar system, the distribution and form needs to be understood at a "human" scale. That is, the "ore body" must be better understood at the scales it would be worked before it can be evaluated as a potential architectural element within any evolvable lunar or Mars campaign. This next step in our evaluation of lunar resources has been captured as a list of Strategic Knowledge Gaps (SKGs) and can provide the next step in evaluating the distribution and form of polar volatiles at scales that may be critical to robotic/human exploration (10s to 1000s of meters).

To address the viability / economics of lunar ISRU the volatile distribution (concentration, including lateral and vertical extent and variability), volatile Form (H_2, OH, H_2O, CO_2, Ice vs bound, etc), and accessibility, incluindg overburden, soil mechanics, and trafficability, must be understood. To this end RP will assess the hydrogen and water distribution across several relevant environments that can be extended to a more regional and global assement. Currently these environnments are defined by their thermal character:

- Dry: Temperatures in the top meter expected to be too warm for ice to be stable
- Deep: Ice expected to be stable between 50-100 cm of the surface
- Shallow: Ice expected to be stable within 50cm of surface
- Surface: Ice expected to be stable at the surface (ie., within a Permanently Shadowed Region, PSR)

Real-time Prospecting and Combined Instrument Measurements: Given the relatively short planned duration of this lunar mission, prospecting for sites of interest needs to occur in near real-time. The two prospecting instruments are the Neutron Spectrometer System (NSS) and the NIR Volatile Spectrometer System (NIRVSS). NSS will be used to sense hydrogen at concentrations as low as 0.5WT% to a depth of approximately 80-100 cm. This instrument is the principle instrument for identifying buried hydrogen bearing materials. NIRVSS, which includes its own calibrated light source, radiometer (for thermal correction) and context camera, will look at surface reflectance for signatures of bound H_2O/OH and general mineralogy. Once an area of interest is identified by the prospecting instruments the option to map the area in more detail (an Area of Interest activity) and/or subsurface extraction via drilling is considered. The RP drill is an auger which can sample from discrete depths using "biting" flutes, deep flutes with shallow pitch which hold material as the drill is extracted. As the drill is extracted a brush can deposit cuttings from the biting flutes to the surface in view of NIRVSS for a "quick assay" of the materials for water or other volatiles. If this quick assay shows indications of water or other volatiles, a regolith sample may be extracted for processing. Processing of the sample is performed by the Oxygen and Volatile Extraction Node (OVEN).

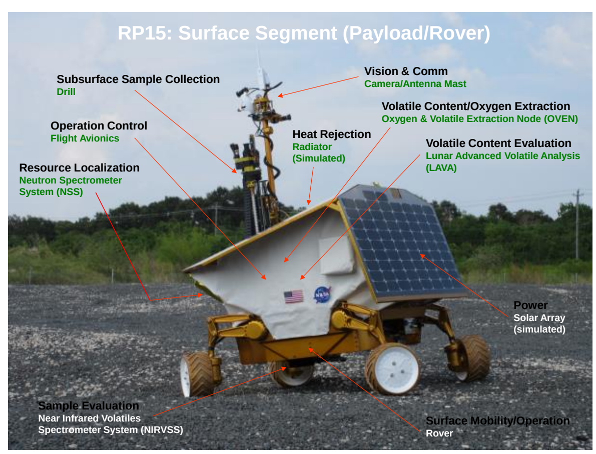

Figure 1. The RP15 rover and payload propotype was designed, built, and operated remotely with distributed operatpions network.

OVEN will heat the sample to first 150C, pause, then to 450C. Any gases evolved from the sample are analyzed by the Lunar Advanced Volatile Analysis (LAVA) system which includes a Gas Chromatograph / Mass Spectrometer system.

As part of efforts to mature mission design and reduce technical risk during fiscal year ‘15 RP designed, built and tested a RP rover/payload prototype, referred to as “RP15”. This effort resembled a “mission in a year” in that initial RP15 requirements and specification were defined at the start of the fiscal year, with interface control documents and initial design review occurring a couple of months later, The effort culminated in a demonstration of distributed operations of the prototype rover/payload as it performed mission related tasks. These efforts worked to reduce a great number of technical risks as well as inform mission design going forward. Additional design efforts and hardware testing, including using the RP15 rover at NASA JSC and the K-Rex Rover at NASA Ames for specific operations/rover simulation tests, have been taking place over the last year. In parallel to these hardware and operational developments, continued effort has been made in lunar surface operation concepts, including detailed analysis of candidate traverse sites , witch required development of new analysis and planning tools. Payload design maturation and testing has also continued, with evaluation of the mass spectrometer performance and testing of the drill, NIRVSS and mass spectometer in lunar-like conditions.

This talk will provide an overview of the RP mission and its current status.