RESOLVE: REAL-TIME SCIENCE OPERATIONS TO SUPPORT A LUNAR POLAR VOLATILES ROVER MISSION.
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Introduction: The Regolith and Environment Science and Oxygen & Lunar Volatile Extraction (RESOLVE) project aims to demonstrate the utility of in situ resource utilization (ISRU). ISRU is a way to rebalance the economics of spaceflight by reducing or eliminating materials that must be brought up from Earth and placed on the surface of the Moon (or Mars) for human use. RESOLVE is developing a rover-borne payload that (1) can locate near subsurface volatiles, (2) excavate and analyze samples of the volatile-bearing regolith, and (3) demonstrate the form, extractability and usefulness of the materials. Such investigations are important not only for ISRU but are also critically relevant for understanding the scientific nature of these intriguing lunar polar volatile deposits.

Temperature models and orbital data suggest near surface volatile concentrations may exist at briefly lit lunar polar locations outside persistently shadowed regions. A lunar rover could be remotely operated at some of these locations for the 7-10 days of expected sunlight at relatively low cost. Such a mission is unique and requires a new concept of operations. Due to the limited operational time available, both science and rover operations decisions must be made in real time, requiring immediate situational awareness, data analysis, and decision support tools.

RESOLVE Field Test: In July 2012 the RESOLVE project conducted a full-scale field demonstration for testing of both technologies required to enable this mission and concepts of operations. With help from the Pacific International Space Center for Exploration Systems (PISCES), a lunar rover prototype (provided by the Canadian Space Agency) was equipped with a suite of prospecting instruments (neutron spectrometer and near-infrared spectrometer) and volatile characterization instruments (drill and auger for subsurface sample collection plus the ISRU-specific instruments LAVA (Lunar Advanced Volatile Analysis) and OVEN (Oxygen and Volatile Extraction Node)). The rover was operated at a lunar analog site on the upper slopes of Mauna Kea, Hawaii with a mission operations center co-located in Hawaii, rover navigation center in Canada, and a Science Backroom at NASA Ames Research Center in California.

Real-time Science Operations: In Hawaii, several console positions within the flight mission operations hierarchy reflected the need for timely science decision-making including an overall Science Lead, a Real-Time Science Lead, and Neutron and Near-infrared Spectrometer Leads. Supporting these console positions was the Science Backroom that was tasked with monitoring the data, conducting in-depth data analysis to support mission decision-making, and conducting any rover traverse replanning as required (Figure 1).

Strict communications protocols were invoked to ensure efficient and effective communication in real-time. For example, the Science Backroom at NASA Ames conversed with the two Spectrometer Leads (located in the flight control center in Hawaii) on a dedicated voice loop, Spectrometer Leads and the Real-Time Science position conversed with the overall Science Lead, and the Science Lead relayed all science-related operational information to the Flight Director responsible for the overall mission. RESOLVE also utilized customized exploration ground data system software (xGDS) to monitor navigation telemetry, spectrometer data feeds, etc. in real-time to support mission decision-making.

Conclusions: The envisoned lunar mission requires highly efficient, real time, remotely operated rover operations to enable low cost, scientifically relevant exploration of the distribution and nature of lunar polar volatiles. The RESOLVE field demonstration illustrated the need for science operations personnel in constant communictions with the flight mission operators and the Science Backroom to provide immediate and continual science support and validation throughout the mission. The RESOLVE field campaign demonstrated that this novel methodology of real-time science operations is possible and applicable to providing important new insights regarding lunar polar volatiles for both science and exploration.

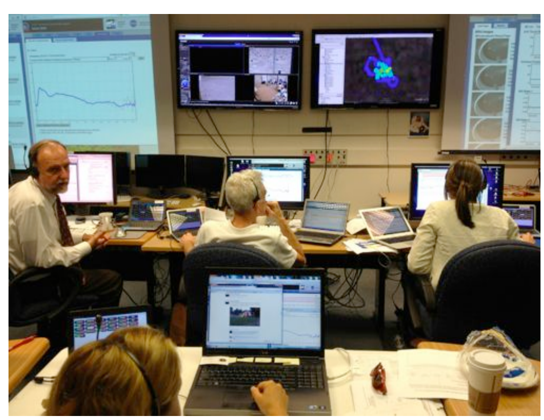

Figure 1. RESOLVE Science Backroom at NASA Ames Research Center during the July 2012 campaign.