SCIENCE AND IN-SITU RESOURCE UTILIZATION – BENEFITS OF COLLABORATION.
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Abstract: The release of the Vision for Space Exploration in 2004 and the subsequent Exploration Systems Analysis Study (ESAS), Lunar Architecture Team (LAT), and Synthesis Team efforts by NASA and international space agencies involving scientists and engineers the world round have established not only "how" robots and humans can explore the Moon and beyond, but more importantly "why" humanity is going beyond low Earth orbit by establishing six "Themes" for returning to the Moon, as well as a complete list scientific and exploration objectives for robotic and human exploration of the Moon and beyond. However, even though the products of these efforts are extremely important and beneficial, there is still a disconnect between 'science' and 'exploration' goals and objectives. The Lunar Archicture Team efforts have primarily focused on exploration-related objectives, and the 'Top 40' were presented at the 2nd Space Exploration Conference in Houston in December 2006. In May 2007, the NASA Advisory Council (NAC) released preliminary results from a workshop in February titled "Workshop on Science Associated with the Lunar Exploration Architecture" which has begun the process on prioritizing science goals and objectives. What is clear from the results of both of these efforts is that there is not only significant overlap and synergism between the goals and objectives for science and exploration, but that with proper planning and development, efforts in one can enable new objectives in the other, and vice versa. In particular, exploration-related technology and operation objectives in the area In-Situ Resource Utilization (ISRU) have significant synergism with lunar and Mars science measurement and implementation goals and objectives.

ISRU involves the understanding, collection, manipulation, and processing of local material to provide infrastructure and products for robotic and human exploration, such as leveling areas for landing, building berms for protection, excavating holes for nuclear reactor burial, extracting hydrogen-sources/water from permanently shadowed craters, and/or extracting oxygen from lunar regolith minerals. Successful implementation of ISRU requires detailed knowledge of the type and distribution of resources that may be of interest, understanding of the potential impurities that could foul processing, and knowing the physical attributes of the lunar material to ensure excavation, material transport, and processing systems are designed properly. This requires the development and use of hardware and instruments for orbital and local mineral characterization, access to surface and subsurface materials, material processing to characterize volatiles and make products, and methods for evaluating process efficiency. Hardware, instruments, and operations for ISRU are all common with science goals and objectives associated with determining the physical and geologic composition, structure, origin, and evolution of the lunar crust and subsurface (mGEO-2, mGEO-5, and mGEO-10) as well as the location, distribution, and movement of solar, bombardment, and endogenous lunar volatiles (mGEO-9, mGEO-12, mGEO-13, and mGEO-14). The implementation of ISRU for exploration can support and enable lunar science objectives 'Of the Moon', 'On the Moon', and 'From the Moon', while conversely science instruments and measurements are critical to understanding lunar resources, their distribution, and how to extract and process these resources with the minimum of development and implementation risk for human exploration. Similar synergism exists between ISRU and "Follow the Water" science objectives for Mars.

In the constant reality of limited budgets, it is imperative that science and ISRU objectives, development, and implementation into robotic and human missions be coordinated and executed as soon as possible. However, it is also important to recognize that while overall objectives may be the same, the desired method or hardware to achieve these objectives may be drastically different. One method to promote understanding, coordination, and joint development of instruments and operations in the near term is the use of analog field demonstrations. Analog field demonstrations allow for evaluation of technologies and operations under reasonably realistic conditions. They also allow for independent development of instruments and technologies to common operation and mission needs. Technologies from both science and exploration can be added when available on a continuing basis of evolving overall integrated operations and capabilities that can be utilized in future flight missions. This presentation will provide an overview of ISRU resource characterization needs as well as current technology development and analog field demonstration plans that can promote near-term collaborative efforts leading to joint robotic and human flight mission opportunities.