ESTABLISHING LUNAR RESOURCE VIABILITY
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Introduction: Recent research has highlighted the potential of lunar resources as an important element of space exploration but their viability has not been demonstrated. Establishing whether or not they can be considered in future plans is a multidisciplinary effort, requiring scientific expertise and delivering scientific results.

To this end various space agencies and private entities are looking to lunar resources, extracted and processed in situ, as a potentially game changing element in future space architectures, with the potential to increase scale and reduce cost. However, before any decisions can be made on the inclusion of resources in exploration roadmaps or future scenarios some big questions need to be answered about the viability of different resource deposits and the processes for extraction and utilisation. The missions and measurements that will be required to answer these questions, and which are being prepared by agencies and others, can only be performed through the engagement and support of the science community.

In answering questions about resources, data and knowledge will be generated that is of fundamental scientific importance. In supporting resource prospecting missions the science community will de facto generate new scientific knowledge. Science enables exploration and exploration enables science.

Whether the resource in question is cold trapped polar ice or something else, there are a number of steps that need to be taken to establish their viability as a source of resources, that the capability exists to extract and store those resources, and that their utilisation will bring benefits over and above resupply from Earth. These steps can be summarised as:

- Find and characterise the resource deposits
- Validate the required technologies
- Demonstrate extraction and utilisation

Characterise the resource deposits: The first step in establishing the viability of a resource is to find where it is located and then to characterise the extent of a deposit and the physical and chemical properties of the ore or bulk material from which it is to be extracted. While comprehensive measurements have been made of the physical and chemical properties of lunar regolith in the past, and samples of lunar regolith are available from the Apollo missions, these samples may have limited direct applicability to previously unexplored landing sites such as those in the polar regions.

In the case of lunar polar ice deposits characterisation on both regional and local scales surface is required, which may be performed by different mission types with different strengths. For example:

- Comprehensive single point measurements as planned by PROSPECT on Luna-27 or sample return.
- Regionally distributed point measurements with small missions with limited but focussed measurement capabilities such as penetrators or impactors.
- Local deposit characterisation with mobile platforms as proposed for Resource Prospector and ESA’s Lunar Volatile Prospector study.

Validate the required technologies: Having defined the extent and properties of a given deposit the specific challenges associated with extracting and processing the resource can be identified. These challenges may be associated with the environment in which those resources are located the mechanical properties of the feedstock to be extracted; the process by which the feedstock is to be converted into a resource or the process by which a resource is stored, preserved and later delivered for use. Each of these steps poses its own challenges and may require new developments, which may need to be tailored to the specific deposit or resource and may require demonstration in the lunar environment.

Demonstrate extraction and utilisation: A final step is to demonstrate the end to end process associated with a resource using what may be termed as a pilot plant. In this scenario a feedstock must be extracted from its environment. The feedstock must then be processed and converted into a usable resource. The resource must then be made available and utilised directly or stored for future use. Waste products must also be handled appropriately. Ideally the resource should be used, in a demonstrative way, in an early human mission to show for the first time that lunar resources can be used and enabling a transition to resource dependency.

Reference: