ROBOTIC EXPLORATION OF THE MOON: PRELUDE TO HUMAN SETTLEMENT AND ISRU EXPLOITATION. J. B. Plescia, Applied Physics Laboratory, The Johns Hopkins University, MP3-E104, 11100 Johns Hopkins Road, Laurel, MD 20723 (jeffrey.plescia@jhuapl.edu).

Introduction: As NASA prepares to return to the Moon, the role of robotic precursors needs to be defined. Robotic precursors play three roles: 1) provide data to enable landing and operations, 2) provide data necessary to settle the Moon and use it as a stepping stone for exploration, and 3) provide data to set the stage for advanced and complex human science activities. The specific objectives of those missions, their targets, payloads and operations are all different.

Raison d'être: This is not the song by the Japanese rock band *Dir en grey* or the American Ale brewed by Dogfish Head Brewery in Delaware. It is the reason NASA is returning to the Moon. Until it is defined and accepted by the agency and the nation, the precursor robotic missions, particularly as they relate to settlement, will be subjective interpretations.

Landing and Surface Operations Missions: To simply land on the surface, few new data lie in the critical path. At present, only geodetic control of high latitude sites would be considered enabling. LRO and the international missions will provide data sufficient to resolve this issue. Depending upon the stay times for the crew, the oxidation potential of lunar regolith fines may require *in situ* analysis. Such analysis requires a mission capable of collecting, sieving and processing samples. Data on the distribution of hazards (craters, rocks, slopes) is enhancing to mission safety and risk reduction, to develop statistics or if they are acquired for the actual outpost site. However, with our current understanding of lunar geologic processes and the technologies being developed by ALHAT, new data may not lie in the critical path.

Settlement Missions: The key to settlement of the Moon is the use of In Situ Resources to minimize the bonds to Earth. Such bonds will never be completely severed, but they can be reduced. It is the nuclear submarine that is perhaps the best analog to lunar settlement rather than Antarctic bases. A nuclear submarine produces its own power and water and recycles air and water; but it remains dependent upon a base for some materials (e.g., food and hardware).

The key to lunar settlement and using it as a stepping stone for continued exploration of the Moon and beyond is the production of fuel and life support volatiles. Hydrogen and oxygen are the two key elements. Oxygen makes up ~45% of lunar materials, it is globally distributed and can be obtained anywhere by any number of processes. Hydrogen, however, is concentrated at the poles, although whether it is in the form of elemental hydrogen or water-ice remains unknown.

Understanding the hydrogen form, concentration, and distribution thus is the key to exploiting lunar resources. To understand that will require missions to the surface having the ability to rove and analyze the regolith to depths of a few meters. Orbital data will never be able to definitively resolve the hydrogen story. The hydrogen may be more or less uniformly distributed over the polar regions or it may be sequestered in areas of permanent shadow. To resolve this, mission(s) that explore the illuminated and shadowed regions are required. The payload might consist of a neutron spectrometer to map the H distribution at high spatial resolution, a drill to acquire material from depth, volatile analysis (e.g., mass spectrometer) to determine the form of the H, and a ground penetrating radar to map its distribution if it is in the form of solid ice. This can be attacked piecemeal or with a comprehensive mission.

Once the volatile resources are located and mapped, an outpost site can be selected. The reason to wait until after such mapping, is that the economics of ISRU involve issues such as transportation between the outpost and the resource ore. Thus, a trade may need to be made between different outpost locations (because of their need for solar power) and the location of different ore bodies to minimize the overall costs.

Other commercial objectives may also have site-specific requirements. The extent to which they become the reason for the outpost may also drive its selection. Missions to assess these requirements might be necessary. However, until the commercial objectives are established, the requirements can not be defined.

Science: Robotic missions that explore different regions and which collect and analyze various data and samples can significantly enhance the potential of humans to conduct scientific exploration. Such missions would require mobility and the ability to collect samples from depth (few meters) and to operate for extended periods of time. They could explore the site and provide the basic information that would allow the humans to focus their attention on the key locations and make the measurements and collect the types of samples that are difficult or impossible for robotic systems.

Summary: Robotic missions are most critical to enable the exploitation of lunar resources. For other aspects, such as landing and nominal surface operations and science, they are enhancing, not enabling.