LUNAR SKGs: WHAT'S REALLY NEEDED AND WHAT DO WE ALREADY KNOW? J. B. Plescia[1],[1] The Johns Hopkins University, Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel MD 20723 (jeffrey.plescia@jhuapl.edu).

Introduction: Strategic Knowledge Gaps (SKGs) consist of information of the environment, characteristics and processes active on a target body that at present are unavailable and that are considered as necessary to conduct specific operations on that target body. Depending upon the operation, the list of SKGs or the detail to which they must be understood vary. Lunar SKGs for different exploration scenarios were established several years ago. Since that time, a variety of international missions have been conducted, including LRO and LCROSS. Given the huge influx of recent data, it is appropriate to evaluate the current list of SKGs and to consider not only those that can be retired, but to consider new SKGs that were not previously identified. Recently, a review of SKGs in light of the new data was conducted by Shearer et al. [1].

SKGs are considered to be *enabling* or *enhancing*. *Enabling* SKGs are those that must be resolved in order to safety and effectively carryout a particular activity. *Enhancing* SKGs are those whose resolution will increase the effectiveness of an activity. Lunar SKGs were divided into three themes: Understand the lunar resource potential, Understand the lunar environment and its effects on human life, and Understand how to work and live on the lunar surface.

With respect to the resolution of SKGs, a somewhat platitudinous analogy is that if one wants to understand annual rainfall in Columbia MD, one can develop a complete understanding the Earth's climate system on the relevant spatial and temporal scales, or one can deploy a rain gauge. It is the *what* that is of consequence with respect to the SKGs, not the *why*.

Understand the lunar resource potential: This theme is associated with the exploitation of *in situ* resources to support exploration at the Moon and beyond. *In situ* resources are those that can be used for life support and fuel – hydrogen and oxygen. While the use of *in situ* resources has been discussed, its economic viability is undemonstrated. It is the use of in situ resources as fuel that present the greatest challenges.

H and O are present everywhere, respectively as trapped solar wind gas and as mineral oxides. Neutron data indicate increased H abundance in polar regions in both permanently shadowed regions (PSRs) and illuminated areas. The H species (e.g., H_2O, H_2, C_2H_6O) remains unknown as well as its form, lateral and vertical distribution. For example, as H_2O, it could be distinct ice lenses, regolith cement, or scattered blocks.

The species, form and distribution of H in polar regions, in terms of fuel production, are enabling and the most critical. Of particular note is enhanced H outside of PSRs. The limit of remote sensing data has probably been reached. Resolution will require *in situ* data. Such data does not require sample return.

Mobile robotic platforms capable of extended traverses (kms) in both sunlight and permanent shadow, acquiring and analyzing samples from depth (1-3 m), and mapping the spatial distribution over km-scales are required to evaluate whether such exploitation is possible and economically viable. Static landers and penetrators can provide some data, but it will not be definitive.

Understand the lunar environment and its effects on human life: The environmental conditions in terms of high-energy particles and radiation as well as the presence of dust are largely understood. The methodology for meliorating these issues with respect to human health and safety remain and must be addressed. However, there are no obvious requirements for additional *in situ* data. Spacecraft radiation sentinel systems (e.g., at L5) would be required during long-term operations but are not necessary as a precursor.

Understand how to work and live on the lunar surface: Once the distribution and form H are established, the extraction and processing for fuel must be demonstrated on the appropriate scale. If H is present is significant quantities in illuminated polar regions, it might make exploitation considerably easier than in PSRs. Transport, storage and use of the fuel must also be demonstrated. Only then would be the economic viability be demonstrated. Significant technology developments are required to conduct such demonstrations.

Conclusions: It is critical that the distinction between *enabling* and *enhancing* SKGs be maintained and understood such that a return to the Moon is not precluded. The role of commercial enterprises in this endeavor is not clear. Establishing the viability of lunar resources would appear to fall to NASA. Once its value is demonstrated and an architecture established that exploits the resources [2], the long-term production could become a commercial activity.

References: [1] Shearer, C., et al. (2016) Lunar Human Exploration Strategic Knowledge Gap, Special Action Team Review, September 2016. [2] Spudis, P., and Lavoie, A., Using the resources of the Moon to create a permanent, cislunar space faring system, AIAA Space 2011 Conf. Exp., AIAA 2011-7185, 2011.