THE LUNAR POLAR PROSPECTING WORKSHOP, 2018. G. F. Sowers, Colorado School of Mines, 1610 Illinois Street, Golden CO 80401, gsowers@mines.edu.

Introduction: The Lunar Polar Prospecting Workshop was conducted June 14 and 15, 2018 in Golden Colorado. It was conducted in conjunction with the 19th Space Resources Roundtable. The workshop was sponsored by the Space Resources Roundtable and the Lunar Exploration Analysis Group (LEAG). There was a diverse participation of individuals from academia, government and industry and many constructive discussions took place.

The purpose of the workshop was to develop a roadmap for a resource exploration campaign focused on ice deposits at the lunar poles that could lead to industrial scale production of LO_2/LH_2 propellants within ten years. Business case analysis indicates that the availability of lunar propellant can dramatically decrease the costs of transportation beyond low Earth orbit, dramatically decreasing the cost of NASAs Moon and Mars exploration programs and jump starting commercial activity in cislunar space.

The first step in developing lunar ice resources for propellant production is characterizing the resource to the extent that it can be regarded as a proven reserve. This process is well understood for terrestrial resources and those proven processes were the starting point for the workshop. This entails detailed resource mapping as well as identification of economical extraction and processing methods.

The workshop resulted in six findings and six recommendations.

Findings:

1. Use of the term prospecting should be avoided. The process to definitively characterize a space resource such that it becomes a proven reserve should be referred to as space resource exploration.
2. The lunar mining strategic knowledge gaps (SKGs) proposed at this workshop provide a useful guide in developing a space resource exploration campaign.
3. The combination of the LRO and other lunar orbiting spacecraft have provided a solid foundation of remote sensing data of the lunar poles. But the resolution of the data is insufficient to meet the mining SKGs However, proper interpretation of existing and future remote sensing data requires ground truth; i.e. direct confirmation of surface and subsurface conditions corresponding to a particular remote sensing signature.
4. The use of large numbers of mass produced, low cost exploration devices will greatly enhance the cost effectiveness of the lunar resource exploration campaign.
5. Resource exploration must be viewed as an orchestrated campaign, not a set of independent missions. Each mission in the campaign builds off the ones before and provides a foundation for the ones that come later. However, given financial and time constraints, there is great value in rapid and parallel operations in mission development and execution.
6. Any use of high cost, complex rovers should be minimized and employed only as a final verification in a location where there is high confidence an economically viable resource exists.

Recommendations:

1. The first priority for the lunar ice exploration campaign is to obtain ground truth in one or two key locations. This can be obtained by a lander equipped to detect volatile species. Data from this mission will be used to anchor geologic models of the nature and formation of the ice deposits. The data will also be used to calibrate existing remote sensing data for use in site selection for follow-on missions.
2. Geologic models and resource maps should be developed, then refined throughout the exploration campaign.
3. In parallel with the ground truth landers, a cubesat swarm should be employed to gather high resolution remote sensing data at the lunar poles relevant to the existence and characterization of water. The cubesats should fly as low as possible (10-20 km above the surface). The same mission should also deploy a swarm of hundreds of low cost impactors instrumented for volatile detection and quantification.
4. Based on the previous results, a small number of the most promising locations should be selected. For each location, a small lander will be deployed. Each lander is equipped with a number of deployable, tethered sensor packages.
5. Based on the previous results, and if a sufficiently high probability location(s) has been found, a rover/sampler mission should be sent to that location for detailed resource mapping and verification of economic viability. This mission should include an ice extraction technology demonstration. Power options for this mission, which will require long duration operations within the PSR, include an RTG and a separate power beaming lander in an adjacent sunlit region with view into the PSR.
6. NASA should direct the LEAG to convene a Specific Action Team (SAT) to develop the details of the lunar polar ice exploration roadmap sufficient to begin mission planning.