

**International Coordination of Exploring and Using Lunar Polar Volatiles.** J. E. Gruener<sup>1</sup>, N. H. Suzuki<sup>2</sup>, and J. D. Carpenter<sup>3</sup> <sup>1</sup>NASA Johnson Space Center (Mail Code KX111, 2101 NASA Parkway, Houston, Texas, 77058, john.e.gruener@nasa.gov) <sup>2</sup>NASA Headquarters (Mail Code CQ000, 300 E Street Southwest, Washington, DC, 20546, nantel.h.suzuki@nasa.gov) <sup>3</sup>ESA ESTEC (Keplerlaan 1, 2401 AZ, Noordwijk, The Netherlands, James.Carpenter@esa.int)

**Introduction:** Fourteen international space agencies are participating in the International Space Exploration Coordination Group (ISECG), working together to advance a long-range strategy for human and robotic space exploration beyond low earth orbit. The ISECG is a voluntary, non-binding international coordination mechanism through which individual agencies may exchange information regarding interests, objectives, and plans in space exploration with the goal of strengthening both individual exploration programs as well as the collective effort. The ISECG has developed a Global Exploration Roadmap (GER) that reflects the coordinated international dialog and continued preparation for exploration beyond low-Earth orbit, beginning with the Moon and cis-lunar space, and continuing to near-Earth asteroids, and Mars. The GER can be accessed at <http://www.globalspaceexploration.org>.

The common international goals and objectives of space exploration, documented in the GER, recognize an intention to characterize resources available at exploration destinations including the Moon, and to develop and validate technologies and systems that extract, process, and utilize these resources for the exploration missions of the future. The ISECG has established a study team to coordinate the worldwide interest in lunar polar volatiles, and in particular water ice, in an effort to stimulate cooperation and collaboration, and to maximize the return on individual agency investments.

**ISECG Lunar Polar Volatiles Website:** ISECG has created a website to share information among the global space community, including government, academia, and industry to facilitate ongoing discussion about the exploration and potential utilization of lunar polar volatiles. Focus areas include the current state of knowledge, questions to be answered, and opportunities for collaboration and coordination of relevant studies, capability development, and lunar missions. The ISECG lunar polar volatiles website can be accessed at <http://lunarvolatiles.nasa.gov>.

**Virtual Workshops and Findings:** ISECG also conducts a series of virtual workshops to address key strategic issues, facilitate coordination among the community, and identify possible ways forward for addressing scientific knowledge gaps and advancing technical capabilities for exploration of lunar polar volatiles. Each 2-hour workshop includes a moderator and a panel of international subject matter experts for

the particular discussion topic. These workshops are facilitated by the National Aeronautics and Space Administration's (NASA) Solar System Exploration Research Virtual Institute (SSERVI). Presentations, recordings, and findings from past workshop and a calendar for future workshops are archived on the ISECG lunar polar volatiles website.

*Workshop #1, Lunar Datasets:* The first workshop focused on understanding what remote sensing scientific instruments from lunar orbit or Earth have produced the most beneficial datasets to identify lunar polar volatiles deposits? A primary finding of this workshop is there are sufficient data, without additional new orbital measurements, to support near-term landing site selections for surface missions seeking to provide "ground truth" validation of existing datasets and to further characterize surface and subsurface polar volatiles.

*Workshop #2, Where to Explore, and How:* The second workshop focused on understanding what are the most promising Regions of Interest (ROI) for lunar polar volatile resource prospecting, and how can lunar exploration systems and instrumentation be used to prospect and characterize polar volatiles on the lunar surface. Three broad ROI at the lunar poles were discussed based on a multi-parameter analysis, including the Cabeus crater region; a region near Shoemaker, Faustini, and Nobile; and the Peary crater region.

*Workshop #3, Lunar Surface Prospecting Instruments:* The third workshop focused on understanding what science instruments may be most valuable on the lunar surface to locate and characterize polar volatile deposits and determine their distribution, composition, and abundance? Neutron spectroscopy, near-infrared spectroscopy and mass spectroscopy were identified as proven techniques that are very powerful in locating and characterizing polar volatiles. Other techniques, including ground penetrating radar and laser-induced breakdown spectroscopy may also prove useful.

**Path Forward:** Currently there are several missions at different space agencies that are being developed for lunar polar exploration, including the Russian Space Agency's (RSA) Luna 27 mission with participation from the European Space Agency (ESA), and NASA's Resource Prospector project. However, these missions will only do the important first steps, and further surface missions will be required to undertake comprehensive exploration of high priority areas and

to realize the ability to extract lunar polar volatiles and utilize them on the surface of the Moon.