

International Coordination of Lunar Polar Volatiles Exploration. J. E. Gruener¹, N. H. Suzuki², and J. D. Carpenter³ ¹NASA Johnson Space Center (Mail Code KX111, 2101 NASA Parkway, Houston, Texas, 77058, john.e.gruener@nasa.gov) ²NASA Headquarters (Mail Code CQ000, 300 E Street Southwest, Washington, DC, 20546, nantel.h.suzuki@nasa.gov) ³ESA 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 [1]. 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.

ISECG Lunar Polar Volatiles Study Team: When it comes to maintaining a longer-term human presence beyond low-Earth orbit, space agencies agree that the use of local resources could significantly benefit operations in the lunar vicinity, and may limit the cost and complexity of bringing all the needed supplies from Earth. For many years, the lunar regolith was seen as the primary source for both oxygen (chemically bound in lunar minerals and glasses) and hydrogen (implanted into the regolith by the solar wind). However, recent discoveries of water on the Moon [2], particularly in polar regions, may lead to less complex methods to create life support consumables and rocket propellants. 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.

Goal: The goal of the study team is to establish an internationally-coordinated effort that addresses exploration and scientific knowledge gaps related to lunar water ice and other polar volatiles by: 1.) advancing the overall state of lunar polar volatiles knowledge by leveraging space agency and private sector interest, 2.) stimulating collaboration and coordination among in-

terested agencies and other stakeholders of relevant studies, capability development, and lunar mission plans, and 3.) if appropriate, and based on findings related to the nature, extent, and distribution of polar volatiles, indentifying initial and affordable small-scale robotic in situ resource utilization (ISRU) demonstrations and experiments to understand whether water ice could be economically extracted and utilized as a resource.

Key Strategic Issues: There are many questions and topics needing discussion and input from the broader lunar science and exploration communities, including but not limited to: 1.) What do we still want to know and how do we answer these questions? (e.g., scientific knowledge gaps; the development of hypotheses that can be tested on the lunar surface; new measurements that can be made from orbit or on the lunar surface; specific regions of interest), 2.) How can we lower the cost of lunar exploration? (e.g., innovative approaches such as impactors, penetrators, cubesats; ride sharing; procuring commercial services, utilizing common infrastructure), and 3.) How can we better coordinate our activities? (e.g., common regions of interest; common measurements and calibration standards; common mechanical, electrical, and communication interfaces; interchangeable surface payload and implements).

Current Agency Activities: Several national space agencies have activities in progress related to exploration of the Moon in general, and lunar polar environments in particular. NASA's activities include Resource Prospector (an advanced exploration systems project involving an instrumented rover targeting lunar polar volatiles), lunar cubesat missions (Flashlight, Icecube), and space act agreements with commercial lunar exploration companies (Astrobotic Technology, Masten Space Systems, Moon Express). The European Space Agency's (ESA) activities include the development of instruments and payloads (PILOT and PROSPECT) for the Russia Space Agency (RSA) Luna 27 mission, and a program involving a human-enhanced robotic architecture and capability for lunar exploration and science (HERACLES). Other agencies are developing mission hardware such as lunar orbiters, landers, and rovers, and conducting mission design studies that could be applied to collaborative international missions.

Website: Included in the ISECG lunar polar volatiles study team's efforts is the development of a website to act as a location for interested organizations and

individuals to obtain information on current lunar polar exploration activities and plans. The website will also be a location for interactive forums for the exchange of information, including live presentations and discussions. In September 2015 the website will be accessible at <http://www.globalspaceexploration.org>.

References: [1] ISECG (2013) http://www.nasa.gov/sites/default/files/files/GER-2013_Small.pdf. [2] Robinson K. L. and Taylor G. J. (2014) *Nature Geoscience*, 7, 401-408.