ispace and the lunar missions ahead R. Ichikawa, ispace inc., 1-3-6 Azabudai, Minato-ku, Tokyo, 106-0041 r-ichikawa@ispace-inc.com

Introduction: This presentation will introduce ispace, a lunar exploration company headquartered in Tokyo, Japan, and Team Hakuto, a front-running team participating in the Google Lunar XPRIZE (GLXP) competition. The presentation will begin by introducing ispace's vision and the technology that ispace is developing for lunar exploration. Next, the presentation will outline ispace's mission plans and rover capabilities. The presentation will conclude by explaining the three-step plan to utilize resources on the lunar surface, while discussing opportunities for the scientific community.

ispace & Water on the Moon: ispace technologies is the commercial arm that manages Team Hakuto in the GLXP Mission. Founded in 2013, its mission is to find the resources necessary to extend human life into outer space. ispace's primary goal is to locate and utilize water on the lunar surface. Observations from the Moon Mineralogy Mapper aboard India's Chandrayaan-1, and measurements from NASA's Lunar Reconnaissance Orbiter, each provide strong evidence for the presence of water ice on the Moon [1]. The water may originate from endogenous sources, delivery by comets or asteroids, or implantation by solar wind [2]. While extracting hydrogen and oxygen from lunar regolith will require significant amounts of energy and infrastructure, the higher concentrations of lunar ice which have been discovered at the Southern Lunar Pole and more recently in the skylight could offer an energy-efficient alternative. In 2009, LCROSS impacted the permanently shadowed crater Cabeus and measured a water ice concentration of 5.6-2.9 wt% [3]. Ground truthing missions are needed in order to further verify the distribution of lunar ice in permanently shadowed and other regions.

ispace has a three-step plan that will demonstrate its technology, locate, map and measure resources, and finally utilize those resources on the lunar surface. ispace will have its first attempt to demonstrate its rover technology during the GLXP mission. Secondly, in the early 2020's, ispace will develop a number of future prospecting missions that will improve our understanding of how and where to mine lunar resources. In this phase ispace plans to partner with space agencies and the scientific community for sensor and technology development to better detect and understand water ice deposits. ispace has been working closely with multiple exploration and science payload developers in the United States, Europe and Japan. In March of 2017, ispace created a new office in Luxembourg under the auspices of the Space Resource Initiative. As a part of this program, ispace is teaming up with the Luxembourg Institute of Science and Technology who will develop a Mass Spectrometer. Finally, depending on the location, distribution, quality and quantity of the lunar ice, ispace will develop extraction, processing, and utilization techniques with interested industrial partners. An ultimate goal is to convert the ice to fuel and deliver it to private companies such as the United Launch Alliance, who recently offered to purchase fuel on the lunar surface for $500/kg [4].

Team Hakuto: ispace owns and operates Team Hakuto, the only Japanese Team competing for the 30M GLXP competition. During this first mission we will join team Indus on a trip to Mare Imbrium. Team Indus's lander will deploy the 4kg rover will attempt to survive one lunar day. The rover will travel at least 500m to achieve the required objectives of the GLXP. In order to further test and demonstrate new technologies, the rover will attempt long distance travel. The traverse will be executed in a flower petal pattern, repeatedly circling back toward the host lander to be photographed. The mission will provide a low cost opportunity to demonstrate our technology. In the future this technology can be further used to investigate promising regions for potential resource deposits.

Supporting Science: 2017 is the beginning of a new era of exploration with cost-efficient opportunities for scientists on commercial missions. Japan Aerospace Exploration Agency is partnering with ispace and Team Hakuto to send a dosimeter to measure cosmic rays and solar wind for future human missions. By decreasing the overall mass of the rover, ispace is able to accommodate future opportunities for scientific payloads and offer the scientific and space technology community unprecedented economical opportunities to gather data and test instruments, algorithms, and equipment during our missions.

References: [1] Delory et al., (2010) The LADDE Mission: The Next Step After the Discovery of Water on the Moon. [2] Hauri et al., (2011) High Pre-Eruptive Water Contents Preserved in Lunar Melt Inclusions, Science 333, 213-215 [3] Colaprete et al., (2010) Detection of Water in the LCROSS Ejecta Plume, Science 330, 463-468 [4] David, L (2015) Inside ULA's Plan to have 1,000 People Working in Space by 2045. Space.com