INSPIRE (IN situ Solar system Polar Ice Roving Explorer): A MISSION CONCEPT STUDY FROM THE DECADAL SURVEY FOR PLANETARY SCIENCE AND ASTROBIOLOGY 2022-2032. J. L. Heldmann[1], J. O. Elliott[2], A. Colaprete[1], A. Deutsch[1,3], M. Hirabayashi[4], D. Hurley[5], J. T. Keane[2], Y. Liu[2], K. Zacny[6], and the JPL Study Teams[2]. [1]NASA Ames Research Center, Moffett Field, CA, [2]Jet Propulsion Lab, Pasadena, CA, [3]NASA Postdoctoral Program, [4]Auburn Univ., Auburn, AL, [5]Johns Hopkins Univ. / Applied Physics Lab, Laurel, MD, [6]Honeybee Robotics, Pasadena, CA.

Introduction: INSPIRE is a mission concept study conducted through the National Academies National Academies of Sciences, Engineering, and Medicine (NASEM) Planetary Science and Astrobiology Decadal Survey (2022-2032) process. INSPIRE was studied due to the high science priority of understanding lunar polar volatiles for planetary science. INSPIRE underwent a full JPL Team X engineering and cost design as well as evaluation through the Decadal Survey TRACE (Technical Risk and Cost Evaluation) process, although it ultimately was not prioritized for New Frontiers.

Science Motivation: Within the past decade, our understanding of volatiles on airless bodies throughout the Solar System has undergone nothing short of a revolution. These ices are important scientific clues to determining the origins, ages, and evolution of inner Solar System volatiles including the origins of critical species such as water, carbon dioxide, and hydrogen on planet Earth. Addressing these questions will have profound implications for understanding volatile behavior and availability in the inner Solar System, and for understanding volatile delivery and evolution on the Moon, Mercury, and Ceres, with implications for water and other volatile systems on airless bodies throughout the Solar System as well as on exoplanets. Water in particular is also key to enabling sustained human exploration beyond our home planet through in situ resource utilization (ISRU). The quest to determine the origins, ages, and evolution of volatiles in the inner Solar System is motivated by these benefits to both science and exploration.

Mission Overview: The INSPIRE mission focuses on the lunar polar regions as the most accessible inventory of inner Solar System volatiles. The mission concept uses an Intrepid-derived rover based on the mission concept study reported in Robinson et al. 2020 (https://science.nasa.gov/solar-system/documents).

INSPIRE is an RTG-powered, 560 kg rover that carries redundant 2-m drills and an instrument suite of spectrometers, cameras and environmental sensors (Figure 1). INSPIRE traverses ~750 km across the Moon's south polar region within three years, enabled by autonomous day/night traverses along a pre-planned path marked by pre-defined Science Station stops and opportunistic drill holes to be selected in real time (Figure 2). The rover is capable of driving in both sunlight and in darkness and collects science data both along the traverse as well as within targeted Science Stations. INSPIRE measures surface volatiles, subsurface volatiles and stratigraphy, exospheric volatile abundances and distributions, and local environmental conditions (e.g., surface temperatures, ion and electron fluxes, surface geomorphology) to assess the relative contributions of volatile sources and sinks affecting the present-day distribution of volatiles on the meter scale, determine direct relationships between the environment and the presence of volatiles, and establish the timing and origins of volatile deliveries.

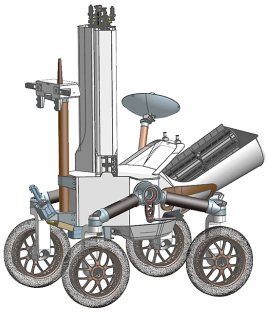

Figure 1. The INSPIRE rover.

INSPIRE investigates multiple lunar PSRs as well as seasonally shadowed regions (SSRs) where each region has unique signatures of volatiles and environmental conditions to provide a system-wide analysis of lunar polar volatiles.

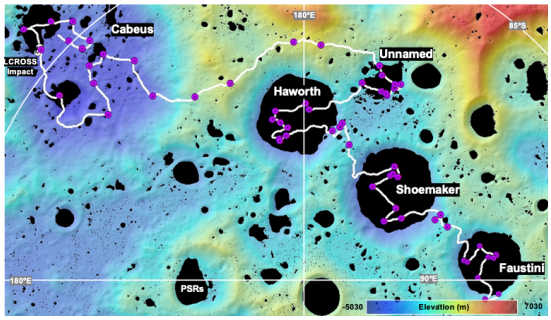

Figure 2. INSPIRE traverse path (white) and Science Stations (purple) in the lunar south polar region.

Mission Cost: The mission development cost (Phases A–D), including 50% development reserves and $70M for the required RTG power source is $1,157M, which is commensurate with a NASA New Frontiers mission class as stated in the Decadal Survey mission concept study ground rules. Using the more conventional costing approach typical of New Frontiers missions with 30% development reserves and including the RTG, INSPIRE has Phase A-D costs of $1,012M.

The full INSPIRE report can be found here: https://drive.google.com/drive/folders/1Qlun6EF0v472eOMXXokHxa6B2tBLNkdv