

INITIATING THE SURFACE OPS PHASE OF THE LUNAR EXPLORATION ARCHITECTURE WITH ROBOTIC LANDERS AND ROVERS. D. A. Kring¹ and J. Rademacher², ¹Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, kring@lpi.usra.edu, ²General Dynamics, Advanced Information Systems, 1440 N. Fiesta Blvd., Gilbert, AZ 85233, joel.rademacher@gd-ais.com.

Introduction: Mission parameters and spacecraft systems are rapidly being developed that will return humans to the lunar surface. A test flight of the Ares 1 launch system is scheduled to occur in two years (April 2009) and the first human test flight of Ares 1 with the Crew Exploration Vehicle (CEV) is scheduled to occur in four years (2011). This human exploration effort will be preceded by, and then integrated with, a robotic exploration program. The Lunar Precursor and Robotic Program (LPRP) has identified four missions, including two landers that will begin the surface operations phase of the lunar exploration initiative.

Multiple-Mission Architecture: Robotic surface operations will initially target locations being considered for human operations, but the broader science and exploration objectives of the Lunar Architecture Team (LAT)[1] require global access to the lunar surface (Fig. 1). Many of the LAT objectives and those previously identified by the Lunar Exploration Science Working Group (LExSWG)[2] also require the capability to explore the lunar surface with a mobile science platform. To achieve these objectives we have developed the Lunar Reconnaissance Lander (LRL) series and the Lunar Surface Explorer (LSE), the latter of which is a tracked rover. The landers and rovers can be flown together or individually, depending on specific mission goals (Fig. 2).

The Lunar Reconnaissance Lander has the capability to land and operate anywhere on the lunar surface. This platform can accommodate several power systems (primary battery, secondary battery with solar array, fuel cell, and advanced Stirling radioisotope generator) to facilitate operations in different locations on the lunar surface and survive the appropriate number of lunar nights needed to accomplish a specific set of mission goals. The science payload that it can accommodate is also diverse, including deployables like a rover. A hybrid of this system will be able to return samples to Earth.

The Lunar Surface Explorer is a tracked rover that we previously described [3] and have since continued to develop, including detailed trade studies of rover subsystems and tests of a terrestrial prototype at Meteor Crater. Like the lander, the LSE can accommodate diverse power and payload options to maximize the science and exploration accomplishments achieved at a particular location on the lunar surface.

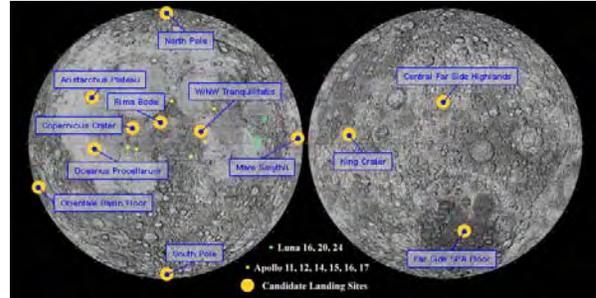


Fig. 1. Representative candidate landing sites.

Polar Operations: Specific elements of the exploration initiative require polar operations [4] and the surface ops of the LPRP are currently planned to begin with (1) a lander and possible rover to a sunlight-rich location, probably on the rim of Shackleton Crater, and (2) a lander and rover to the shadowed floor of a polar crater, probably the floor of Shackleton Crater. Mission (1) can be accomplished with a version of LRL (the Heliopoint Lander mission) that either has an integrated instrument payload or that deploys a rover with a mobile instrument payload. Mission (2), which will provide an important surface measurement of regolith H and potentially water ice, can be accomplished with a version of LRL and LSE (the Polar Express mission) that is designed to land and operate on the floor of a shadowed crater where temperatures approach 40K. Both of these missions will also provide a measure of the behavior of lunar dust in polar conditions and analyses of rocks associated with the South Pole-Aitken basin.

Integrating Robotic Exploration with Sample Return: LAT and LExSWG objectives that require sample return to Earth for analysis can also be accommodated by the spacecraft elements of our multiple-mission architecture. For example, one of the highest priority science goals is to determine the impact flux in the Earth-Moon system, which will require a diverse set of impact samples [e.g., 5]. LRL and LSE can collect and cache samples, prepare samples for robotic sample return, possibly on a hybrid version of LRL with an ascent stage, or survey potential sampling locations in advance of human collection during an astronaut-led sortie.

Integrating Robotic and Human Exploration: The Lunar Surface Explorer can operate in four modes to facilitate human exploration: (1) As a mobile ex-

periment platform that can accomplish the science objectives of the LAT, while also accomplishing exploration objectives that must be met in preparation of future human operations. These rovers can be deployed in advance of human activity to survey a landing site; alternatively, they can be deployed to locations human sorties do not initially target, to enhance the geographic coverage of the overall exploration program. (2) As a transport vehicle that can deploy static science and exploration platforms, both during the robotic and human exploration phases. (3) As an astronaut assistant during the human exploration phase. The goal is to augment surface operations so that an astronaut has more time to explore the geology of the lunar surface and conduct other exploration activities. This strategy will maximize the time available for astronauts to take advantage of their unique human capabilities by assigning mechanical and many analytical tasks to a rover. (4) As an extended mission partner with the human sortie efforts, deployed to further explore the lunar surface around a sortie landing site after astronauts have returned to Earth.

Conclusions: The Lunar Reconnaissance Lander and Lunar Surface Explorer are low-cost, science- and exploration-rich solutions that can address multiple mission scenarios. These solutions include the capability to land and operate in a permanently-shadowed polar crater (the Polar Express mission) and the capability to land and operate in a largely sunlit region (the Heliopoint Lander mission). These spacecraft elements can be used to initiate surface ops on the Moon during the robotic exploration phase, and can also be integrated with the human exploration phase to assist astronauts.

References: [1]

http://www.nasa.gov/pdf/163560main_LunarExplorationObjectives.pdf. [2] LExSWG (1995) Lunar Surface Exploration Strategy, Final Report, 50 p. [3] Kring D. A. et al. (2005) Space Resources Roundtable VII, Abstract #2021. [4] http://www.nasa.gov/pdf/163896main_LAT_GES_1204.pdf. [5] Kring D. A. et al. (2005) Space Resources Roundtable VII, Abstract #2017.

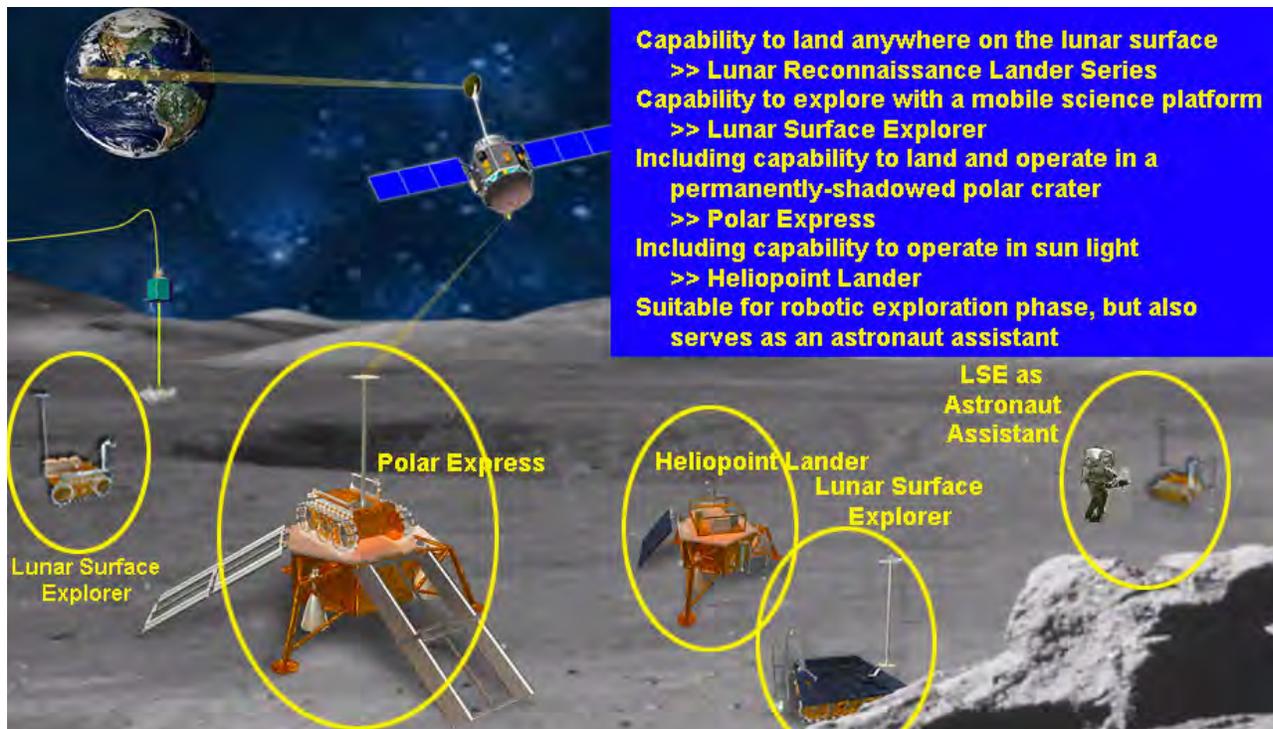


Fig. 2. The Lunar Surface Explorer and Lunar Reconnaissance Lander provide options for multiple mission scenarios.