A ROVER-BASED STRATEGY FOR THE ROBOTIC AND HUMAN PHASES OF THE LUNAR EXPLORATION INITIATIVE.

D. A. Kring[1], J. D. Rademacher[2], and Ben Dobson[3], [1]Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, kring@lpi.usra.edu, [2]General Dynamics, Advanced Information Systems, 1440 N. Fiesta Blvd., Gilbert, AZ 85233, joel.rademacher@gd-ais.com, [3]Aerospace & Deployable Structures Division, Foster-Miller, Inc., 350 Second Ave., Waltham, MA 02451.

Introduction: Science and exploration objectives identified by the Lunar Architecture Team (LAT) [1] and the Lunar Exploration Science Working Group (LExSWG) [2] require global access to the lunar surface. We propose a rover-based strategy that will achieve those objectives and maximize the efficiency of robotic and human exploration.

Lunar Surface Explorer: We have developed a mobile science platform, the Lunar Surface Explorer, that can be deployed and operate anywhere on the lunar surface. It will work both as an independent rover and as an assistant to astronauts. It will provide imaging, in-situ measurements of regolith materials, including dust, monitor radiation at the lunar surface, and conduct chemical, mineralogical, and potentially isotopic analyses of geologic materials, depending on specific mission objectives. This mobile science and exploration platform can accommodate a diverse set of analytical instruments and deploy them, when necessary, on robotic arms. The Lunar Surface Explorer can also accommodate several power systems (primary battery, secondary battery with solar array, fuel cell, and advanced Stirling radioisotope generator) to facilitate operations in diverse terrains, at all latitudes, and survive a sufficient number of lunar nights to accomplish the required mission goals.

LSE operates with two tractive modules, separated by an instrument module and deck from which operations are managed. The tractive system is based on terrestrial field experience with the Talon robot vehicle, which is built by Foster-Miller, Inc. and deployed to hundreds of locations around the world. Tracks provide superior traction, operational efficiency, and operational simplicity, particularly in uneven terrain, as compared to a wheeled rover.

In a terrain analysis of potential science targets, LExSWG concluded [2] that a slope climbing capability of 25° is sufficient for rover operations, which is within the design capabilities of LSE. Commonly, however, slopes on the Moon are limited to 5 to 10°. Even at fresh craters, like the 500 m diameter South Ray Crater of Apollo 16, the slope of the ejecta blanket is only ~7°, although the slopes of interior crater walls that lead to the crater floor grow to 17 to 26°. In tests at Meteor Crater, a terrestrial prototype of LSE climbed a 40 degree slope.

The LSE is scalable in size. Specific designs examined, thus far, deliver 30 to 50 kg of science payload to the lunar surface. The rover can be delivered on our own Lunar Reconnaissance Lander, or as a payload on another lander, including a crewed landing vehicle.

Initial Mission Requirements: To illustrate the capability of a rover-based strategy, we have developed point designs for polar operations, which have been recommended by the LAT [3]. The Lunar Precursor and Robotic Program (LPRP) is studying two notional missions that will provide (1) a lander and rover to the shadowed floor of a polar crater, probably the floor of Shackleton Crater and (2) a lander and possible rover to a sunlight-rich location. For mission (1), Lunar Surface Explorer will be able to survey the floor of a shadowed crater, provide surface measurements of regolith H and potentially water ice, while operating in an environment where temperatures approach 40K. For mission (2), Lunar Surface Explorer will be able to assess the availability of sunlight, evaluate surface roughness and regolith thickness, and other factors that may affect the deployment of outpost components for human exploration. Both of these missions will also provide a measure of the behavior of lunar dust in polar conditions, provide the first structural analysis of the interior and rim of one of the largest (~19 km diameter) simple craters on the Moon, and provide the first in-situ analyses of rocks associated with the South Pole-Aitken basin, one of the largest and oldest impact craters on the lunar surface and potentially the first basin impact involved in the lunar impact cataclysm.

Integrated Robotic and Human Surface Ops: The Lunar Surface Explorer will facilitate lunar surface activities in four different modes:

- As a mobile experiment 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.

- As a transport vehicle that can deploy static science and exploration platforms, both during the robotic and human exploration phases.

- 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.

- 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 Surface Explorer is a low-cost, science- and exploration-rich, solution that can accomplish lunar robotic exploration objectives and assist with the human phase of the lunar exploration initiative. The flexibility of this mobile science platform and its ability to assist with astronaut activities will help maximize the efficiency of lunar surface operations.

References: [1] http://www.nasa.gov/pdf/163560main_LunarExplorationObjectives.pdf. [2] LExSWG (1995) Lunar Surface Exploration Strategy, Final Report, 50 p. [3] http://www.nasa.gov/pdf/163896main_LAT_GES_1204.pdf. [#] Kring D. A. et al. (2005) Space Resources Roundtable VII, Abstract #2017. [#] Kring D. A. et al. (2005) Space Resources Roundtable VII, Abstract #2021.

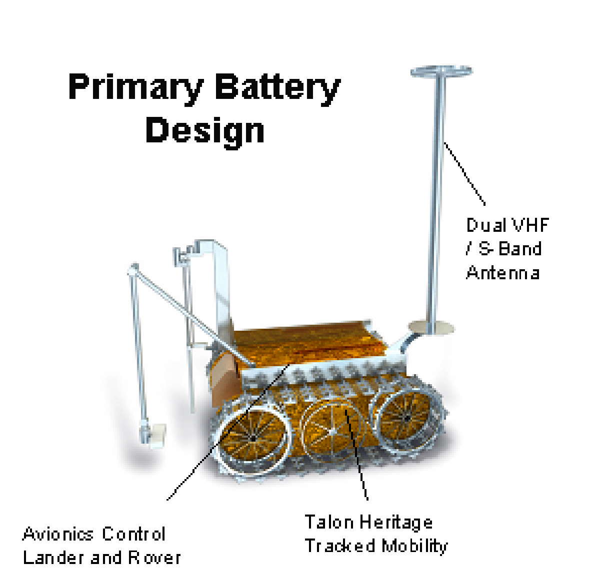

Fig. 1. Lunar Surface Explorer with a primary battery power system. Other power options include a secondary battery with solar array, fuel cell, and advanced Stirling radioisotope generator.

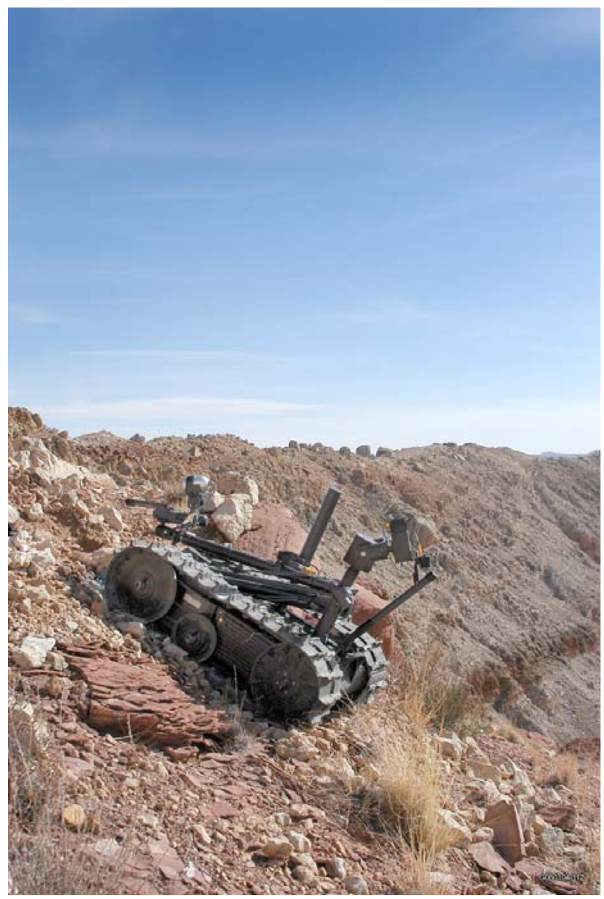

Fig. 2. Field mobility test at Meteor Crater of a terrestrial precursor of Lunar Surface Explorer. This design takes advantage of heritage developed by Foster-Miller for their Talon-series of rovers.