Moon Express: Lander Capabilities and Initial Payload and Mission. P.D. Spudis, Lunar and Planetary Institute, Houston TX 77058 (spudis@lpi.usra.edu), R. Richards, Moon Express Inc., Moffett Field CA, J.A. Burns, Univ. Colorado, Boulder CO

Moon Express Inc. is developing a common lander design to support the commercial delivery of a wide variety of possible payloads to the lunar surface. Although one of the Google X-Prize contestants, the company is committed to developing a commercial market for delivery of payloads to the lunar surface. Significant recent progress has been made on lander design and configuration. In addition, we have developed a straw man mission concept designed to return significant new scientific and resource utilization data from the first mission. Here we describe the lander concept and a scenario for a low-mass payload and mission scenario.

Spacecraft. The ME lander is derived from designs tested at NASA Ames Research Center over the past decade. It is designed to deliver payload to the lunar surface, with no global restrictions on landing site. The lander can carry an upper stage designed for missions that require Earth-return, such as sample retrieval. The upper stage utilizes a unique toroidal design and can return surface samples back to Earth. The ME lander is powered by a specially designed engine capable of being operated in either monoprop or biprop mode.

First Mission. We have recently examined an initial mission designed to use the ascent stage of the ME lander design as a separate spacecraft to land a limited payload on the Moon. This small payload would be optimized to answer some specific and carefully posed scientific and operational questions. Flying this mission would validate the ascent stage design while at the same time, obtain useful science data relevant to future exploration. As currently envisioned, this mission would also satisfy the requirements of the Google X-Prize competition.

Landing Site Rationale. The mission concept involves a visit to a regional pyroclastic deposit on the lunar near side [1,2]. We know from study of the Apollo samples that solar wind hydrogen is implanted onto the dust grains of the lunar regolith. Moreover, the concentration of this solar wind hydrogen appears to be dependent upon both grain size (smaller grain size fractions being more enriched) and titanium content (higher Ti regolith showing higher H concentrations). Mature, high-Ti regional dark mantle deposits in theory should show the highest concentrations of implanted solar wind hydrogen as they are uniformly small grains (mean size of the glass spheres ~ 50 microns or less) and the black, devitrified glasses have microscopic blades of crystallized ilmenite (the presumed carrier of implanted hydrogen) at their surfaces [1]. Thus, based on current understanding, regional dark mantle deposits should have enhanced amounts of solar wind hydrogen, in some cases approaching several hundred parts per million (typical H abundance in returned regolith is on the order of 20-50 ppm). Mature, regional dark mantle has never been sampled, so these relations are postulated and not certain. A mission to measure the hydrogen concentration of these deposits will help to resolve this issue.

Several possible landing sites for the ME lander are found on the near side of the Moon. We have focused on the Rima Bode dark mantle deposits (east of crater Copernicus, around 13° N, 4° W). These deposits are mature [2], having been exposed to solar wind implantation for at least 3 billion years and have high Ti content; smooth areas near the vent suggest that the ash beds are several tens of meters thick. The dark mantle extends over several hundred square kilometers, requiring low precision for landing point designation. The fine-grained nature of the deposit (which also shows very low diffuse radar backscatter; [2]) indicates that the surface is poor in decimeter-scale rocks and obstacles, thus ensuring a relatively safe landing area over a wide region.

Payloads for Lunar Geoscience and Conops. Our projected payload includes three instruments. An imaging system will document the geological setting of the landing area. Two instruments for compositional analysis are under consideration. An APX instrument (heritage: Mars landers [3]) will provide major element composition of the regolith; we are particularly interested in the surface Ti content, to help calibrate and better understand the remote sensing data from which we infer Ti composition. In addition, we plan to fly a neutron spectrometer [4] (heritage: the RESOLVE lunar prospecting package [5]) to measure the bulk hydrogen composition of the regolith at the landing site. These two parameters are critical to our understanding of solar wind abundance in the lunar regolith and selection of the Rima Bode site assures that we will have documented its occurrence in the end member regolith assumed to retain the most hydrogen of known mid- and low latitude sites.

Measurements of the surface composition would commence immediately upon landing. APX chemical analysis and neutron measurements would be completed with an hour or so. If any propellant remains after landing and a "hop" to another site could be undertaken, we can repeat these analyses at the second site, adding to our confidence that we have obtained representative measurements. Thus, the scientific goals of the first ME mission are satisfied early and easily in the mission profile.

This mission scenario provides significant scientific accomplishment for very little investment in payload or operational time. Although minimally configured, the payload has been chosen to provide the most critical parameters for mapping hydrogen across the entire lunar surface. As hydrogen is a key element to the development of the Moon, understanding its occurrences in both non-polar and polar environments is critical. This mission takes the first step towards lunar presence and permanence.

Lunar Laser Retroreflector. An additional instrument under consideration for the first or second flights of ME is a next generation lunar laser retroreflector. The new design includes a single corner cube, a sunshade, and dust protector to increase efficiency and reduce effects produced by solar heating of dust which settles on the retroreflector. An added retroreflector(s) will markedly improve measurements of lunar librations and, therefore, improve constraints on both the liquid and potential solid inner cores. Also, additional retroreflectors will be helpful in constraining models of gravitational including deviations from General Relativity.

References [1] Heiken G. et al. (1991) *The Lunar Sourcebook*, Cambridge Univ. Press, 971 pp. [2] Gaddis L. et al. (1985) *Icarus* **61**, 461. [3] Campbell et al. (2009) *JGR* **114**, E04006. [4] Elphic R. et al. (2010) *Earth and Space 2010*, 1119. [5] Sanders G. and Larsen W. (2010) *COSPAR* 2010, http://tinyurl.com/kykyrr8