DEVELOPMENT OF MINI-LANDERS FOR VERY SMALL LUNAR SURFACE PAYLOADS. B. A. Cohen, NASA Marshall Space Flight Center, Huntsville AL 35812

Introduction: Over the last 5 years, NASA has invested in development and risk-reduction activities for a new generation of planetary landers capable of carrying instruments and technology demonstrations to the lunar surface and other airless bodies. The Robotic Lunar Lander Development Project (RLLDP) is jointly implemented by NASA Marshall Space Flight Center (MSFC) and the Johns Hopkins University Applied Physics Laboratory (APL). The RLLDP team has produced mission architecture designs for multiple airless body missions to meet both science and human precursor mission needs. The mission architecture concept studies encompass small, medium, and large landers, with payloads from a few kilograms to over 1000 kg, to the Moon and other airless bodies.

The payload and concept of operations for the U.S. contribution to the ILN was guided by an independent Science Definition Team, which required each node to operate for 6 years continuously, including through lunar eclipse periods, and to carry a seismometer, heat-flow probe, retroreflector, and electromagnetic sounding instrument. Some configuration trades using penetrators, hard landers, and soft landers are discussed in [1, 2]; the preferred concept became soft-landing propulsive landers discussed in [3]. The landers were sized primairly according to their power systems: an ASRG lander configuration is estimated at 155 kg dry mass, which includes a payload suite estimated at 23 kg including payload accommodation and deployment; a solar array-battery (SAB) lander configuration is somewhat larger at 265 kg of dry mass including a 19 kg payload suite with payload accommodation.

The ILN mission was the most demanding in terms of lifetime requirements on the lunar surface (6 years) and requirement to survive many 2-week eclipse periods. However, the team developed a mini-lander concept in an effort to design to cost for SMD's initial rquest for a two-lander mission for $200M. This lander concept accommodated the "floor mission" identified in the ILN SDT report. For the floor science mission, the RLLDT developed a concept that would put two landers on the lunar near side via separate launches on a Minotaur V vehicle from Wallops Flight Facility. This vehicles enables delivery of 413 kg to TLI on a direct trajectory. Non-direct trajectories were also investigated, but these longer cruise times would require solar arrays and additional structure/PSE/thermal to keep the vehicle warm during cruise; these lander additions offset propellant savings.

Because of the mission requirements, precision landing was not required and so was not included in the lander GN&C design. The landers would use direct-to-earth S-band communication and operate for 2-3 years in order to ensure two years of overlapping operations. The lander payload consisted only of the SEIS seismometer package, operating continuously through lunar day and night. The payload was 10 kg drawing 2.6W continuously and acquiring 130 Mbit of data per day (including 30% margin on all quantities, plus payload accommodation including blankets, heater, deployment mechanisms, booms, and associated electronics controllers allocated to the instrument). The mini-lander designs were enabled by potential availablility of the Derivative Advanced Sterling Radioiostope Generator (DASRG), essentially a half-powered ASRG concept weighing only 13 kg. Since this technology is no longer being pursued, a small RPS, solar array/battery system, or other power subsystem needs to be investigated.

The complete lander had a wet mass of 143 kg (including 20% margins); when combined with the Star stage for descent and launch vehicle adaptor, the total mass came to 412 kg (including 20% margin), just fitting within the Minotaur V capability. The mini-lander concept was costed for a Class D Mission, where each susbstem was single string and the mission accepted higher risk. The independently-confirmed cost estimates for a 2-lander mission of this scope fell within the $200M scope, in 2010 dollars.

The mini-lander concept developed for the ILN floor mission has exceptional promise for delivering small payloads to the lunar surface for a variety of lunar mission desires. Though the ILN concept is no longer moving forward as a directed mission, the project continues to make significant investments in technology risk reduction in focused subsystems, including the Mighty Eagle warm-gas prototype. These design and testing investments have significantly reduced development risk for airless body landers, thereby reducing overall risk and associated costs for future missions. More information on current maturation work using lander prototypes can be found in [4].

References: [1] B.J. Morse, et al., NASA's International Lunar Network (ILN) Anchor Nodes Mission, in: Proceedings of the International Astronautical Commission Annual Conference IAC-08-A.3.2.B1, 2008. [2] B.J. Morse, et al., NASA's International Lunar Network (ILN) Anchor Nodes Mission Update, in: Proceedings of the International Astronautical Commission Annual Conference IAC-09.A.3.2.B6, 2009. [3] B. A. Cohen, et al. (2012) Acta Astronautica 79, 221-240. [4] D. G. Chavers et al., this meeting.