THE INTERNATIONAL LUNAR NETWORK. B. A. Cohen, the ILN Science Definition Team, and the MSFC/APL ILN Engineering Team, [1]NASA Marshall Space Flight Center Huntsville AL 35812 (Barbara.A.Cohen@nasa.gov).

Introduction: A new lunar science flight projects line has been introduced within NASA's Science Mission Directorate's (SMD's) proposed 2009 budget, including two new robotic missions designed to accomplish key scientific objectives and, when possible, provide results useful to the Exploration Systems Mission Directorate (ESMD) and the Space Operations Mission Directorate (SOMD) as those organizations grapple with the challenges of returning humans to the Moon. The first mission in this line will be the Lunar Reconnaissance Orbiter, an ESMD mission that will acquire key information for human return to the moon activities, which will transition after one year of operations to the SMD Lunar Science Program for a 2-year nominal science mission. The second mission, the Lunar Atmosphere and Dust Environment Explorer (LADEE) will be launch in 2011 along with the GRAIL Discovery mission to the moon. The third is delivery of two landed payloads as part of the International Lunar Network (ILN). This flight projects line provides a robust robotic lunar science program for the next 8 years and beyond, complements SMD's initiatives to build a robust lunar science community through R&A lines, and increases international participation in NASA's robotic exploration plans.

The International Lunar Network is envisioned as a global lunar geophysical network, which fulfills many of the stated recommendations of the recent National Research Council report on The Scientific Context for Exploration of the Moon [2], but is difficult for any single space agency to accomplish on its own. The ILN would provide the necessary global coverage by involving US and international landed missions as individual nodes working together. Ultimately, this network could comprise 8-10 or more nodes operating simultaneously, while minimizing the required contribution from each space agency. Indian, Russian, Japanese, and British landed missions are currently being formulated and SMD is actively seeking partnership with these and other space agencies to establish the ILN.

Mission Science: A global geophysical network has been a lunar science community desire since the Apollo seismic stations were turned off in 1977. The science motivation has been detailed in numerous community and independent reviews, reports and recommendations [most recently, 1-4]. Several mission proposals/concepts have been developed by the science community for similar network missions to the moon and Mars (e.g. Lunar-A, NetLander, ExoMars, MoonLite, LuSeN, ALGEP, etc.), including science drivers and options for deployment, instrumentation, and operations, though none have yet successfully flown.

The goal of a lunar geophysical network is to understand the interior structure and composition of the moon. As a differentiated body, the moon provides fundamental information to our understanding of the evolution of terrestrial planets. The current structure on the moon arises from its bulk composition, formation via crystallization of a magma ocean, and subsequent loss of heat produced by radiogenic elements. The narrow extent and instrumental limitations of the Apollo seismic network resulted in very little information about crustal variations, limited resolution of upper mantle mineralogy, and no details about the lower mantle or the lunar core. Therefore, the major goals of a lunar geophysical network include:

- Determine the thickness of the lunar crust (upper and lower) and characterize its lateral variability on regional and global scales.
- Characterize the chemical/physical stratification in the mantle, particularly the nature of the putative 500-km discontinuity and the composition of the lower mantle.
- Determine the size, composition, and state (solid/liquid) of the core of the moon.
- Characterize the thermal state of the interior and elucidate the workings of the planetary heat engine.

A Science Definition Team (SDT) is working to set science objectives and measurement goals to accomplish lunar surface and interior science uniquely enabled by the availability of multiple sites for the Anchor Nodes. The charter of the SDT is to define and prioritize the scientific objectives for the ILN Anchor Nodes, define measurements required to address the scientific objectives, and define instrumentation required to obtain the measurements (e.g. seismometry, heat-low probes, EM sounding laser retroreflectors, etc.). Because of the stringent cost cap, the SDT understands that this mission must be highly focused and will se its priorities accordingly.

The SDT will also address implementational issues such as criteria for selection of the initial two sites and technical challenges to deployment and operations. SDT findings and recommendations will be reported to the Planetary Science Division Director, and to the Associate Administrator for the Science Mission Directorate as final report in mid-September.

International Participation: Representatives from space agencies in Canada, France, Germany, India, Italy, Japan, the Republic of Korea, the United Kingdom, and the United States agreed on a statement of intent in July. The statement marked an expression of interest by the agencies to study options for participating in a series of international lunar missions as part of the ILN. The statement of intent does not completely define the ILN concept, but leaves open the possibility for near and long-term evolution and implementation. Initially, participants intend to establish potential landing sites, interoperable spectrum and communications standards, and a set of scientifically equivalent core instrumentation to carry out specific measurements.

US Participation: NASA's Science Mission Directorate and Exploration Systems Mission Directorate (ESMD) have partnered to provide two so-called Anchor Nodes of the ILN. These two US stations may not necessarily be the first to become operational on the lunar surface, but are the first committed and planned missions to contribute to the ILN, flying no later than 2014 (with a possibility of sending two more, identical nodes in the 2016 timeframe).

The ILN Anchor Nodes mission is a cost-capped, $200M mission to deliver two geophysical instrument packages to different places on the lunar surface. The nominal mission length is for 2 years of surface operations, including operating the instruments through lunar night. The two nodes will launch between 2012 (goal) and 2014 (threshold), depending on resource availability. The mission is a Class-D, directed mission jointly implemented by NASA Marshall Space Flight Center (MSFC) and the Johns Hopkins University Applied Physics Laboratory (APL). The mission will leverage use of previous concept designs and studies from MSFC, APL, JPL, ARC and DOD, as well as industry. Acquisition strategy will be formulated during the Pre-Phase A studies and submitted to HQ/SMD for approval.

This mission is technically and programmatically challenging, including a not-to-exceed cap of $200 million (including launch vehicle and reserves), the placement of multiple nodes with one delivery system, and powering instruments through tens of day/night cycles. Because nodes may be desired on the lunar far side, NASA SOMD is studying a lunar communications relay satellite capability as part of its contribution to this endeavor. Currently, the project is operating in a "skunk works" philosophy at MSFC and APL, involving a very small number of key personnel in Pre-Phase A study.

Summary: The concept of an International Lunar Network provides an organizing theme for US and International landed science missions in the next decade by involving each landed station as a node in a geophysical network. Each ILN node will be a core set of instrument to make measurements requiring broad geographical distribution on the Moon, but these instruments may be flown on any lunar lander, thus making the ILN mission more than the sum of its parts. Creation of such a network will dramatically enhance our knowledge regarding the internal structure and composition of the Moon, as well as yield important knowledge for the safe and efficient construction and maintenance of a permanent lunar habitat.

References: [1] M. A. Wieczorek, et al. (2006) The Constitution and Structure of the Lunar Interior. Reviews in Mineralogy and Geochemistry 60, 221-364. [2] The Scientific Context for Exploration of the Moon: Final Report, National Research Council, Space Studies Board, 2007.[3] Workshop on Science Associated with the Lunar Exploration Architecture, February 27 to March 2, 2007, Tempe, Arizona. [4] Opening New Frontiers in Space: Choices for the Next New Frontiers Announcement of Opportunity, National Research Council, Space Studies Board, 2008.