LUNAR GEOPHYSICAL INSTRUMENT PACKAGE AS A PAYLOAD FOR THE INTERNATIONAL LUNAR NETWORK. C. R. Neal (neal.1@nd.edu)[1], J. D. Weinberg (jweinber@ball.com)[2], P. Lognonné[3], L. Hood[4], D. Mimoun[5], R. Wawrzaszek[6], and M. Banaszkiewicz[6] and the LGIP Team. [1]Dept. of Civil Eng. & Geo. Sci., 156 Fitzpatrick Hall, University of Notre Dame, Notre Dame, IN 46556. [2]Ball Aerospace & Technologies Corp., PO Box 1062, Boulder, CO 80306-1062. [3]Institut de Physique du Globe de Paris (IPGP), Equipe Etudes Spatiales et Planétologie, 4 Avenue de Neptune, 94100 Saint Maur des Fossés, France. [4]The University of Arizona, Lunar and Planetary Laboratory (LPL), Tucson, AZ 85721. [5]Université de Toulouse / ISAE - SUPAERO (10 avenue Edouard Belin - BP 54032 - 31055 Toulouse cedex 4). [6]Space Research Centre PAS, 00-716 Warsaw, Poland.

Introduction: The International Lunar Network (ILN) is a network of several globally distributed landers on the surface of the Moon, instrumented to make long term geophysical measurements. Led by NASA, the program is an international effort in which participating countries will provide any number of nodes (landers) in the network. For its part, NASA will be launching the first two nodes in the 2012-2014 timeframe with two additional nodes to be emplaced roughly two years later.

This submission describes the characteristics of the Lunar Geophysical Instrument Package (LGIP), it's suitability as a payload for the ILN and the distinct advantages of using a common integrated suite of instruments.

Lunar Science: A Science Definition Team has established science objectives for the ILN mission based upon high priority investigations as outlined in the NRC Decadal Survey [1] and the Scientific Context for the Exploration of the Moon [2]. The main objective of the U.S. nodes of the ILN is to understand the interior structure and composition of the Moon, including:

1. Determination of the size, composition, and state (solid/liquid) of the core of the Moon;
2. Characterization of the thermal state of the interior and elucidation of the workings of the planetary heat engine;
3. Characterization of the chemical/physical stratification in the mantle, particularly the nature of the putative 500-km discontinuity and the composition of the lower mantle; and
4. Determination of the thickness of the lunar crust (upper and lower) and characterization of its lateral variability on regional and global scales.

To accomplish these objectives, it is necessary to:

- Make spatially distributed lunar geophysical measurements over a long period of time, covering at least one lunar tidal cycle (≥6 years);
- Make simultaneous measurements of seismic events - at least one from a location where waves pass from the origin through the Moon's core and at least one location where they do not;
- Make heat flow measurements below 1 m depth over at least 1-2 years so that both the steady-state thermal gradient and the thermal conductivity of the regolith can be reliably determined; and
- Correlate surface magnetic measurements with seismic events.

The key to successfully meeting these objectives is to make simultaneous measurements from globally distributed probes, each equipped with complementary geophysical instruments. Geophysical data analysis frequently uses spatial data sources (i.e., seismic, topography, magnetic, gravity) to constrain subsurface models of material and structure types and distributions. Although such interpretations are non-unique, using combined (paired or multiple) data types together in cooperative inversion approaches can be particularly effective in limiting the number of acceptable interpretations. For example, magnetic data can provide good constraints on near-surface density (especially if combined with existing gravity data). Seismic models tend to resolve horizontal layers well, while magnetic approaches resolve lateral variations or vertical interfaces in subsurface magnetic susceptibility (and density if gravity data are available). Heat flow data can provide additional lateral and sometimes (coarse) vertical property constraints, but also can provide key model constraints for seismic (velocity) and density models. By making simultaneous measurements, these combined datasets will resolve ambiguities in our understanding of the lunar interior. *This underscores the importance of having a well integrated suite of geophysical instruments for meeting the science goals of the ILN.*

The LGIP Suite: The Lunar Geophysical Instrument Package (LGIP) team is currently funded under a NASA Planetary Instrument Definition and Development Program grant to develop a synergistic integrated lunar geophysical science package from mature instruments and electronics. The LGIP package includes instrumentation, electronics and mechanical packaging that meet all of the ILN science and measurement objectives. It is designed as a complete instrument suite to simplify lander integration and accommodation. The main elements of the LGIP include:

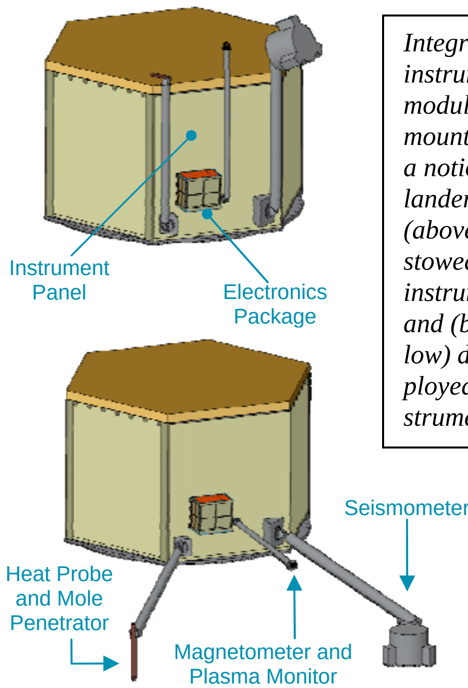
- A highly sensitive *seismometer* to measure lunar seismic events simultaneously from multiple locations;
- A lunar *surface magnetometer* to make measurements at strategic surface locations to test hypotheses on the origin of the lunar crustal magnetic field as well as make complementary measurements with any orbital magnetometer asset that may be available during the life of the ILN;
- A *plasma monitor* to measure solar wind ion bombardment and examine to what extent it is deflected by strong crustal magnetic anomalies;
- A self-penetrating subsurface *heat flow probe* to make long term measurements at multiple new lunar sites, helping to define the global lunar heat flow budget and understand the thermal evolution of the Moon; and
- *Integrated electronics and mechanical packaging* to provide powerful command, control and data handling of the instrument suite, allowing for coordinated instrument operation with maximum science return and simplified spacecraft accommodation

A Suite Advantage: One of the key advantages of an integrated instrument package is that all required instrument accommodations are satisfied by the package itself, including thermal mitigation, deployment, power conditioning, command and data handling, electrical and mechanical integration. The instruments are accommodated on a single structural panel of the spacecraft, which can be integrated before or after system level integration and test (I&T). Instruments are integrated and tested to proto-flight levels as a complete module. An instrument panel mass simulator serves to allow parallel development and testing of both the spacecraft and instrument package. With multiple builds planned, as is the case for ILN, this approach allows for increased schedule flexibility, lower risk, and simplifies mechanical and electrical integration with a single mount and wire harness between the spacecraft and payload.

The total mass of the LGIP suite (without the spacecraft instrument panel) is less than 10 kg, with an average power draw of approximately 6.5 W (~12 W peak). Total mass and complexity of the overall ILN lander may be reduced by accommodating instrument deployments through a common instrument platform. Having an integrated set of payload electronics helps to lower mass even further by reducing the number of wire harnesses and enclosure boxes. This will help reduce cost, especially for the multiple build case of the ILN.

With multiple instruments requiring surface deployment and having specific constraints on proximity and deployment locations, payload accommodation may be one of the most important and complex elements of the ILN mission. There are additional instrument accommodations to consider such as thermal environment and deployment shock levels. *This is where a carefully designed instrument payload suite can have distinct advantages over multiple individual instruments.*

With instrument I&T being performed early in the program, schedule and complexity risk also may be reduced. The flexible and capable architecture of both the instrument panel and integrated electronics package also allows for changes in the instrument suite for future missions without the need to change the spacecraft-to-instrument panel interface.



Integrated instrument module mounted to a notional lander with (above) stowed instruments and (below) deployed instruments.

References: [1] National Research Council, The Scientific Context for Exploration of the Moon: Final Report, *The National Academies Press*, 2007 [2] National Research Council, New Frontiers in the Solar System: An Integrated Exploration Strategy, *The National Academies Press*, 2003.