INTREPID: LUNAR ROVING PROSPECTOR PROVIDING GROUND TRUTH AND ENABLING FUTURE EXPLORATION.

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Introduction: As noted by the Decadal Survey and the Lunar Exploration Roadmap [1,2], critical science and exploration measurements are needed from the lunar surface. Orbiting spacecraft (i.e. Lunar Reconnaissance Orbiter (LRO), Clementine, Lunar Prospector, and others) and impactors like the Lunar Crater Observation and Sensing Satellite (LCROSS) were designed to provide key information about potential landing sites, identify potential resources, and characterize the lunar regolith. However, these missions cannot provide the ground truth required to tie these remote sensing datasets to physical characteristics on the lunar surface. We propose a Lunar Roving Prospector, *Intrepid*, to collect essential measurements to address key scientific questions, obtain important measurements to enable future human exploration, and demonstrate technology required for future exploration of the Moon and other terrestrial bodies.

Science Measurement Objectives: The Intrepid rover will investigate twenty major (and hundreds of minor) scientific sites over 1000 km during two Earth years. This mobility will enable Intrepid to acquire measurements over a broad areas and address many key scientific objectives, including:

- Provide ground truth for all terrain types measured by orbiting spacecraft.
- Characterize the composition of the components of the lunar regolith in order to provide important constraints on the lithologic diversity of the crust.
- Characterize the lunar surface to investigate volcanic processes and increase our understanding of the evolution of the lunar crust.
- Investigate and quantify possible magnetic anomalies and lunar surface swirls.
- Create a sample cache that could be retrieved by future human and robotic exploration systems.

Exploration Opportunities: In addition to providing key measurements for scientific studies, Intrepid will provide measurements essential for future robotic and human missions to lunar surface, including:

- Detect, assay, and map potential resources (identifying and quantifying ISRU potential).
- Quantify the nature of dust, its environments, and interactions with systems.
- Measure the radiation environment (primary and secondary) present on the lunar surface.

Mission Concept: The *Intrepid* rover is designed to be highly mobile with a baseline traverse of over 1000 km, over a two year nominal mission. This long range rover enables measurements to be collected over a variety of geologic terrains (i.e. mare and highlands). To enable this mobility, Intrepid is designed to acquire measurements in three traverse modes: cruise, roam, and focused investigation. In the cruise mode, in which Intrepid will predominately be traveling to different discrete scientific sites, the rover will mainly take measurements while in motion (for example, passive magnetometer measurements). However, infrequent stops will be made to provide basic measurements that cannot be acquired while the rover is motion (i.e. Pancam, LIBS – ChemCam, etc.). In the roam mode, the rover will make more frequent stops during its traverse to acquire more science measurements. In the focused investigation mode, Intrepid will acquire measurements with a higher frequency (less than every 10 meters) to enable focused analysis of the scientific sites of interest. An advanced sliding autonomous navigation system will enable the rover to traverse in all three operating modes with little interaction with human drivers. However, humans will be able to intervene if sites of opportunities are identified in the live feeds.

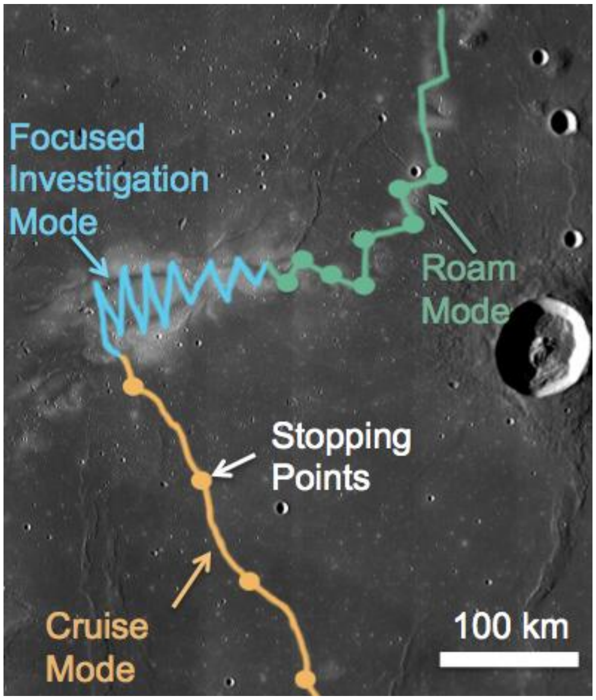

Figure 1. Traverse modes

Notional Instrument Suite: The proposed emphasis on mobility in the Intrepid concept makes stand-off measurements a critical concept for Intrepid operations. We have baselined a notional instrument suite consisting of a multispectral stereo imaging system, a narrow angle FARCAM for long-distance imaging of potential targets, a Raman spectrometer, an APXS for major element chemistry determinations, a magnetometer, and a radiation environment sensor.

Traverse Options: With a range of 1000 km, a series of high-priority targets will answer both scientific and exploration questions in a single mission. Leveraging data returned by the Lunar Reconnaissance Orbiter, we are in the process of defining several high-value scientific traverses on the lunar nearside. For example, one high value traverse initiates in southern Oceanus Procellarum near the Reiner Gamma Constellation Region of Interest, continues through the Marius Hills volcanic complex, proceeds northward along the youngest mare basalts as defined by crater statistics [3], and concludes with an in-depth exploration of the Aristarchus plateau. This traverse would include diverse lithologies, regions of unexplained albedo, color, and magnetic anomalies, a full range of lunar volcanic types and ages, and includes four Constellation Regions of Interest (Reiner Gamma, Marius Hills, Aristarchus 1 and 2), providing critical data for further scientific studies.

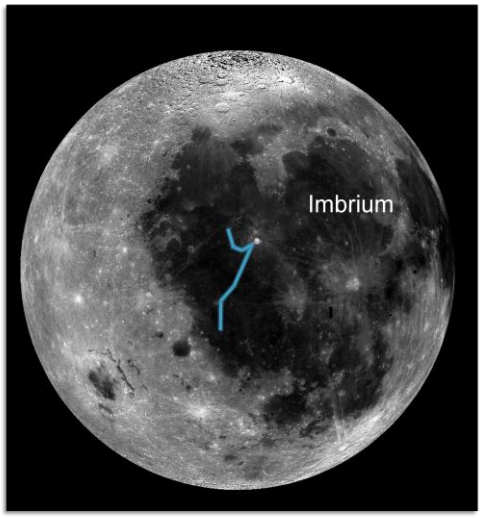

Figure 2. Traverse option for the Intrepid rover

Rovers offer many operational advantages over static landers, which lack the capability to perform investigations beyond a limited distance from the original landing site. Intrepid offers the flexibility and the capability to perform wide-scale investigations that characterize the composition and properties of the lunar regolith over hundreds of square kilometers to address key science and exploration objectives. For example, with respect to studies designed to address in-situ resource utilization assessment, mobility allows assessment of *grade and tonnage* of an ore body – essential information for planning ISRU.

Opportunities to Develop Technologies: Future explorers (to the Moon and beyond) will require new technologies, and the Moon is an ideal location to develop and validate them. One of the highest priorities identified in the decadal survey for near-term multi-mission technology investment is for the completion and validation of the Advanced Stirling Radioisotope Generator (ASRG). An ASRG/solar hybrid rover enables electronics to survive and operate in the extreme lunar environment. In addition, Intrepid offers other opportunities to test technologies essential for future robotic and human exploration, including precision autonomous landing instrumentation, automated precision landing systems and surface navigation, instrument development, and tele-operations.

Leveraging existing remote datasets: In the past two decades, orbital satellites have collected datasets essential for planning future missions to the Moon. One of the main objectives of LRO is to provide datasets to enable future ground based exploration activities. The Lunar Reconnaissance Orbiter Camera (LROC) acquires high-resolution and synoptic images that provide high resolution maps, digital elevation models, and illumination maps. Datasets from other instruments onboard LRO and other satellites (Clementine, Lunar Prospector, Chandrayaan, Chang'e, SMART-1, and future orbiters) will be used in traverse planning and identifying features of scientific and exploration interest and potential hazards that could disrupt rover operations.

Participatory Exploration: The proposed Intrepid rover has outstanding opportunities for immersive public engagement with both passive (live high-definition video streams, 3-D surface panoramas, and daily views of Earth) and participatory (remote rover driving and imaging, collective data analysis, and communication via social media) participation throughout the two-year nominal mission. Intrepid operations and data analysis will also contribute to developing NASA's future workforce (undergraduates, graduates, and postdocs).

References: [1]Committee on the Planetary Science Decadal Survey; National Research Council, 2011 [2] LEAG Exploration Roadmap (2011) [3] Hiesenger et al. (2010), *J. Geophys. Res., 115, E03003.*