INTREPID: LUNAR ROVING PROSPECTOR PROVIDING KEY GROUND TRUTH MEASUREMENTS AND ENABLING FUTURE EXPLORATION. E. J. Speyerer[1], M. S. Robinson[1], S. J. Lawrence[1], J. D. Stopar[1], School of Earth and Space Exploration, Arizona State University, Tempe, AZ (espeyerer@asu.edu).

Introduction: As described in the Decadal Survey and the Lunar Exploration Roadmap [1,2], the science and exploration communities require critical ground truth measurements to tie orbital remote sensing datasets to physical characteristics on the lunar surface. Given the breadth and diversity of lunar geology, such measurements can best be made from moving platforms (i.e., rovers). We propose a Lunar Roving Prospector, *Intrepid*, to collect essential measurements to address key scientific questions, obtain exploration-enabling datasets for future human activities, and demonstrate technology required for future exploration of the Moon and other terrestrial bodies.

Mission Concept: The *Intrepid* rover concept is devised to be highly mobile, with a baseline traverse of 1000 km over a two-year nominal mission. This long-range rover enables measurement collection and provides ground truth for remotely sensed data products over a wide range of geologic terrains (i.e., mare and highlands). To enable the long traverses, the onboard instrument suite will acquire a majority of the measurements while in motion or during short pauses. This concept is in stark comparison to the rovers studying Mars, which stop frequently for long periods to gather measurements. While this architecture limits time intensive studies of a particular site, the coverage gained by a highly mobile platform will increase the scientific return over wide diversity of geologic materials. An advanced sliding autonomous navigation system will enable the rover to traverse with little interaction from human drivers thus reducing cost of operations, while increasing efficiency. However, humans monitoring the progress of the rover will be able to intervene when sites of opportunity appear in the live feed.

Objectives: The *Intrepid* prospector is capable of investigating twenty major, and hundreds of minor sites over its 1000 km traverse. This mobility enables *Intrepid* to collect key scientific measurements and essential data for future human missions, including the ability to:

+ Provide ground truth for major terrain types measured by orbital datasets
+ Inventory rock type diversity, characterize the impact process, improve the understanding of lunar volcanism, determine volatile abundance and distribution
+ Detect, assay, and map potential resources (identifying and quantifying ISRU potential)
+ Investigate the nature of regolith structure, including mechanical properties
+ Quantify the nature of dust, its environments, and its interactions with systems/humans, and demonstrate dust mitigation strategies and technologies
+ Measure radiation (primary and secondary) hazards to future human explorers
+ Demonstrate precision landing, autonomous navigation, teleoperations, dust mitigation, sampling, and long-duration operations
+ Sample cache

Traverse Options: The architecture of the *Intrepid* prospector enables it to be flexible and handle many lunar traverse plans. One example traverse (**Fig 1**) initiates in southern Oceanus Procellarum and characterizes several high priority exploration targets identified by [3,4], including four Constellation (Cx) Regions of Interest (Reiner Gamma, Marius Hills, Aristarchus 1 and 2). At the landing site, *Intrepid* will characterize the mineralogy and the chemistry of the mare basalt units in southern Oceanus Procellarum as well as the depth and structure of the regolith. *Intrepid* will then travel northward to the Reiner Gamma albedo anomaly where it will investigate the magnetic anomaly, geochemistry and surface properties (soil maturity). The traverse continues through the Marius Hills volcanic vent complex where it then investigates the diversity of volcanic emplacement and characterizes compositional variations and resource potential. Continuing along the northward traverse, *Intrepid* travels through, and scouts out young mare basalt samples south of Aristarchus. The *Intrepid* traverse concludes with an in-depth exploration of the varied Aristarchus plateau where it will assay resources, determine the composition and nature of the dark mantle, and investigate the composition of Aristarchus crater materials. This traverse includes diverse lithologies, albedo, color, magnetic anomalies, as well as a full range of lunar volcanic types and ages thus providing critical data for further scientific study.

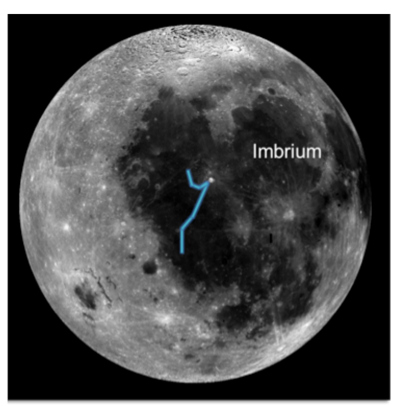

Fig 1-Proposed Oceanus Procellarum traverse includes a variety of geologic materials and four Cx sites.

Notional Instrument Suite: The proposed emphasis on mobility of the *Intrepid* prospector makes short integration time stand-off measurements a critical concept for operations. To maximize the effectiveness of the mission, *Intrepid* will use a high-resolution telephoto reconnaissance imaging system called FARCAM [5]. FARCAM (**Fig 2)** is an adaptation of the 100 mm focal length MSL Mastcam (M-100) instrument modified to meet lunar requirements. The design of FARCAM enables the acquisition of images with a pixel scale of 5 cm from 1 km or 1 m at 20 km. The M-100 on MSL can capture 7.4 cm pixels from 1 km. The increased spatial resolution on FARCAM is achieved by reducing the pixel pitch (5.5 µm vs. Mastcam's 7.4 µm) and slightly increasing the focal length (110 mm vs. Mastcam's 100 mm). The benefits of such a capability on *Intrepid* are threefold:

- En-route reconnaissance of sampling stations
- Rapid remote analysis of distant materials (widening *Intrepid's* footprint along its traverse)
- En-route navigation enabling hazard analysis and determination

In addition to FARCAM, the baseline instrument suite consists of a multispectral stereo imaging system, a Raman spectrometer, an APXS for major element chemistry determinations, a magnetometer, and a radiation environment sensor.

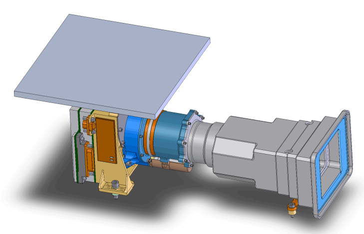

Fig 2-A schematic of the proposed FARCAM with radiator configuration.

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 Lunar Reconnaissance Orbiter (LRO) is to provide datasets to enable future ground-based exploration activities. Research is currently underway to define optimal landing sites, identify traverses, and synthesize a concept of operations for teleoperated spacecraft [6-8]. This study leverages high-resolution and synoptic images provided by Lunar Reconnaissance Orbiter Camera (LROC) as well as datasets provided by other instruments onboard LRO and other satellites (Clementine, Lunar Prospector, Chandrayaan, etc.). Additionally, viewshed analyses for high priority landing sites have been used to determine the best places for broad scale line of site coverage [9]. Such analysis will enhance the use of FARCAM and other long range standoff instruments.

Filling Strategic Knowledge Gaps (SKGs): To implement safe, effective, and efficient human missions to the Moon, gaps in our knowledge of the Moon's surface properties must be addressed. LRO and other recent missions such as Kaguya, Chang'e, Chandrayaan, LCROSS, and GRAIL have answered many key concerns such as characterizing the lighting environment near the lunar poles [10-12]. However, many of the SKGs that remain can only be addressed with assets on the lunar surface. The mobile platform that *Intrepid* provides will enable this single mission to answer a broad range of SKGs, including:

- Quality, quantity, distribution, and form of H species and other volatiles in mare/highlands regolith
- Composition, volume, distribution, and form of pyroclastic/dark mantle deposits and characteristics of associated volatiles
- Resource identification and characterization procedures and technologies to improve ISRU production efficiency
- Monitor the radiation environment at lunar surface
- Improve lunar geodetic control with laser ranging
- Collect high resolution topographic data
- Acquire in-situ measurements to determine lunar surface trafficability
- Test performance of lunar dust mitigation procedures and provide real-time environmental information relevant to daily lunar operations
- Determining near-surface electrical environment and plasma characteristics in multiple localities
- Test micrometeorite protection technologies

Conclusions: 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. Such a broad scale collection of critical ground truth measurements will aid the interpretation of orbital remote sensing datasets, thus strengthening our knowledge of the Moon's past and present state.

References: [1] Committee on the Planetary Science Decadal Survey; National Research Council, 2011 [2] LEAG Exploration Roadmap (2011) [3] Gruener and Joosten (2009) LRO Sci. Targ. Mtg., #6036 [4] Jolliff et al. (2009) LPSC, #2343 [5] Robinson et al. (2012) Int. Workshop on Instrumentation for Planetary Missions, #1064 [6] Lawrence et al., this conference. [7] Speyerer et al. (2012) LEAG Mtg., #3044 [8] Stopar et al., this conference. [9] Mahanti et al. (2012) LEAG Mtg., #3006 [10] Mazarico et al. (2011) Icarus, 1166-1081 [11] Speyerer et al. (2013) Icarus, 122-136 [12] McGovern et al. (2013) Icarus, 566-581.