FUTURE EXPLORATION OF THE MOON ENABLED BY THE LUNAR RECONNAISSANCE ORBITER. J. W. Keller and N. E. Petro, NASA Goddard Space Flight Center, Solar System Exploration Division (John.W.Keller@nasa.gov; Noah.E.Petro@nasa.gov).

Introduction: As initially conceived, one of the primary objectives for the Lunar Reconnaissance Orbiter (LRO) was to identify safe landing sites for future human and robotic exploration. After 6 plus years of operations the data captured by LRO has dramatically altered our view of the lunar surface and environment. With the enormous volume of data from LRO future missions to the Moon should face fewer uncertainties in landing and exploring the lunar surface.

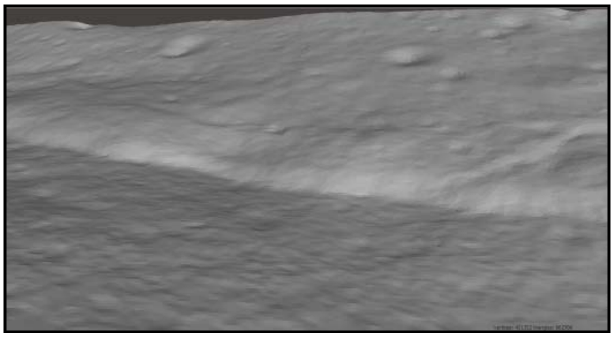

Figure 2. High Resolution LROC NAC DTMs, such as this of a lunar scarp, not only enables significant improvements in our understanding of lunar tectonics, they also enable detailed planning of surface traverses for future surface exploration.

With the cadence of deliveries to the Planetary Data System (PDS) every three months the science community is able to use LRO data within 6 months of acquisition. Accessing LRO data through the PDS (or instrument team websites) is where all data and data products are stored for use by any mission. Interested users can start their search for LRO data at the LRO webpage (http://lunar.gsfc.nasa.gov/resources.html). From there links to the PDS, presentations from the instrument teams on how to access and work with their data, and other resources are available.

The huge data archive that LRO has created will enable a number of future missions. Data from raw counts to higher-level data products are delivered and stored for community use (Figures 1 and 2). Here we explore some of the datasets that are critical to future mission planning as well as examples of possible future missions that have utilized the LRO data.

Resource Prospector: The Resource Prospector instrument suite is targeting a lunar polar region in order to make *in situ* measurements of surface volatiles as well as extract water as a demonstration of In Situ Resource Utilization. Not only does the data from the LEND (Figure 3) and LAMP instruments provide constraints on the location of polar volatiles but topographic data from LOLA (Figure 2) and high-resolution images (<2 meter per pixel) from LROC reveal those safe locations for landing and traversing (Figure 1). LOLA topographic data near the poles is exceptionally densely gridded, due to the number of polar and near-polar passes LRO has made in 6 plus years.

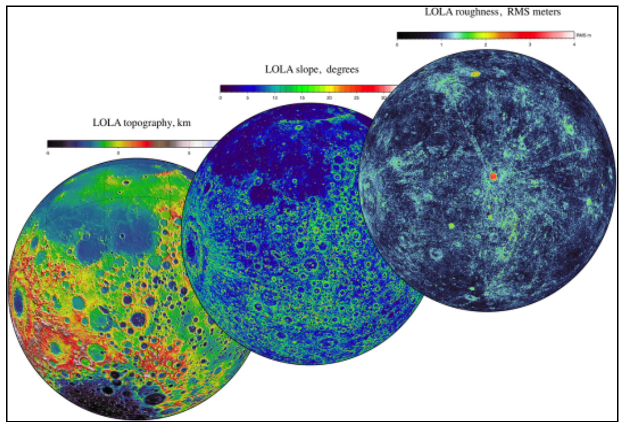

Figure 1 LRO has produced many global data sets typified by the three LOLA products displayed here.

Foreign Mission Support: Formal requests for targeted observations have been made to the LRO project (via NASA HQ) from a number of international space agencies. For example, LROC NAC derived digital terrain maps (DTMs, see Figure 1) of landing sites of interest near the South Pole have been produced and placed in the PDS, thus making it available to ISRO (and the broader community) in support of a possible lander/rover mission.

Additionally, with the public availability of all LRO data, any agency (or individual) can access data for mission support without formal requests.

Future Mission Concepts and Proposals: Between NASA's Discovery and New Frontiers mission opportunities several potential missions have been developed. In the most recent Discovery opportunity at least two missions to the lunar surface were proposed, both of which are enabled by data from LRO. Similarly, a New Frontiers mission to the South Pole-Aitken

Basin is fundamentally enabled by the vast array of data and data products produced by the LRO teams.

Private Exploration of the Moon: With the possibility of a private company landing on the lunar surface (e.g., the Google Lunar X-prize), publically available LRO data is freely available for use by any group planning on landing on the Moon. The LRO project had begun discussions with the X-prize management to offer assistance in accessing data to support landing site validation and identification.

Robotic and Human Exploration: In addition to the missions described above, any number of possible future missions to the lunar surface are enabled by the vast volume of LRO data. Apart from the properties of the lunar surface, the CRaTER instrument provides a unique measure of the radiation environment at and near the Moon. Such data is critical for any future long duration exploration of the Moon, particularly with regards to the safety of Astronauts while at the Moon. CRaTER data has shown that while the current solar minimum has occurred, there is an increase in Galactic Cosmic Rays which present a much more hazardous environment to Astronauts than during solar maximum. Indeed the identification of a number of lunar pits by the LROC team may present a method for protection against radiation hazards as the pits could possibly be used as a shelter during powerful solar storms.

LRO Data Products: In addition to the NAC DTMs (Figure 1), maps of local slope (Figure 2), rock abundance, surface temperature, illumination conditions, neutron albedo, and roughness at a range of baselines are extremely useful for characterizing the surface environment for both landing and navigation (e.g. Figures 2 and 3).

LRO as a Communications Relay: While not intended to serve as a communications relay in lunar orbit, LRO could act as a "bent-pipe" relay of data from the lunar farside. Using the two omni-directional antennas on the spacecraft, LRO could communicate with surface assets and send and receive data from a lander. However, LRO would require revised mission software onboard the spacecraft to do this and this change is not currently planned.

Future Prospects for LRO: Currently in the middle of the second extended science mission, the LRO science team is preparing to propose for 2 additional years of operation. The LRO project is considering approaches to minimize fuel use in order to operate beyond 6 years in lunar orbit and maintain operational flexibility.

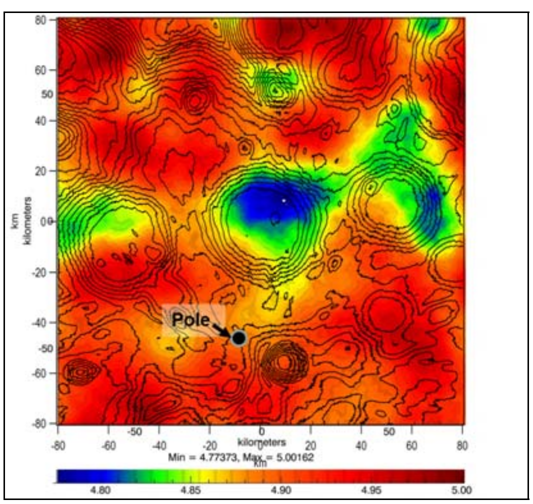

Figure 3 LEND Maps of epithermal neutron suppression regions can guide future explorers in a search for water in and near permanently shadowed regions