**LRO SUPPORT FOR LUNAR SURFACE EXPLORATION.**

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**Introduction:** The Lunar Reconnaissance Orbiter (LRO) is the only US asset at the Moon capable of supporting future lunar landers. The LRO payload was designed to assess future landing sites with an initial objective to complete detailed mapping of regions of interest identified by the Constellation Program Office [1-3]. LRO continues to serve the lunar community and facilitate lunar surface exploration with a wealth of data products and PDS-archived data (data volume of >1.2 PB), and ongoing acquisition of Constellation-site-quality observations.

**Support for current and future lunar surface exploration:** LRO currently supports landing site characterization with observations requested by NASA sponsored payloads flying on landers through NASA's CLPS initiative, and international space agencies (via NASA HQ). Members of the community and public can utilize the LRO/LROC Target Observation Request interface to request site specific observations (http://target.lroc.asu.edu/output/lroc/lroc_page.html).

CLPS deliveries to 10 unique locations on the lunar surface carrying more than 40 science and technology demonstration payloads are already scheduled through September 2025, the duration of a fifth LRO extended mission. This time frame will also see extensive landing site and traverse planning to support Artemis, as well as the landing of Artemis III at the south pole. Additionally, a mixture of technology demonstrations, landers, rovers, and sample return missions are planned by the international community. Even with the wealth of existing LRO observations, the images and data products desired to plan and execute landed missions and detailed traverse planning on the Moon are not yet available for the entire lunar surface. New observations will be essential.

New and existing observations from all seven LRO instruments can be utilized to support landing site analysis and selection, operations planning, and science support. For example, targeted LROC observations can be used for digital terrain models and regional mosaics, while oblique images at differing sun angles enable perspective views of landing sites and facilitate assessment of terrains and hazards. New Diviner and CRaTER observations can enhance temporal coverage, enabling targeted temperature, thermal inertia, H-parameter, and radiation mapping. Observations from the multiple LRO instruments can be used to create specialized landing-site specific predictive models of lighting, thermal radiation, and earth visibility for desired locations and dates to optimize mission operation timelines, and to create regional and local maps of rock abundance and size distribution, surface roughness, slopes, craters, and volatiles. Combining the near-Moon measurements of CRaTER with NASA's Gateway measurements will characterize the full radiation environment (with the exception of the surface) that Artemis astronauts will encounter, and will provide insight into the potential role of small-scale variability. In addition, CRaTER data has been used to predict the strength of the solar cycle during which Artemis will operate. By monitoring the CRaTER measurements through the rising part of this cycle, the team will be able to more accurately predict the galactic cosmic ray environment during the Artemis missions.

In addition to imaging assets on the surface, observations from LRO's instruments during surface operations can provide characterization of the environment and context for surface science investigations such as temperature, lighting, and radiation conditions. Using the science objectives of the >40 payloads already selected to fly on upcoming CLPS deliveries, LRO is designing synergistic investigations to complement findings from the surface, enable comparisons of surface and orbital observations and ground truth where possible, and potentially coordinate observations between the surface and orbit. LOLA is poised to range to Laser Retroreflector Arays (LRAs) flying onboard CLPS landers. Additionally, LRO can monitor the effects of exploration activities on the lunar environment. For example, the LRO instrument LAMP can remotely observe the exhaust of a landing or the plume of an impact [4-6]. Measurements form orbit can provide insight into the associated migration of water and evolution of vapor through the exosphere and deposition of exhaust from descent burns. LRO will use its instruments to subsequently observe the effects of surface operations on the lunar environment over time. For example, LRO observations have previously been used to characterize changes to the regolith as a result of a landing plume [7-9]. Predicting the extent of disturbance from rocket exhaust through a better understanding of the relationship between lander dry mass and the blast zone area will be essential for planning for future high priority landing sites that might be targeted for multiple landings.

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