THE LUNAR RECONNAISSANCE ORBITER AFTER THIRTEEN YEARS AT THE MOON: GO FOR THREE MORE! N. E. Petro, NASA Goddard Space Flight Center, Greenbelt, MD 20771, Noah.E.Petro@nasa.gov

Introduction: Over the past two decades the planetary science community has led a renaissance in our understanding of planets, small bodies, and moons. This renaissance is driven by new suites of large and detailed datasets, painting an exciting picture of our Solar System. From volcanoes on Ceres, the regolith on Bennu, to the fossae on Mercury the new perspective we have of our solar system is significantly more complex than it was at the start of the century. Planetary scientists have, for some 60 years, applied our knowledge of the Moon to these planetary objects for interpreting and unraveling their geologic history.

The application of such understanding is anchored on what we know about the Moon. However, prior to 2009 our interpretation of the Moon from orbit was limited due to a dearth of high-resolution data. For the last 13 years the Lunar Reconnaissance Orbiter (LRO) has generated the largest volume of data of any NASA planetary science mission and has captured the Moon in unprecedented detail and how the lunar surface changes over time. It is with these data that the planetary science community can both unravel the complex geologic history of the Moon and apply that understanding to our analyses of other planetary objects. Indeed, the interpretations of Ceres, Bennu, Mercury, and many other objects have benefited from our modern understanding of the Moon.

Future of LRO: In this presentation we will describe the three-year mission extension (Extended Science Mission 5 - ESM5) for LRO that maximizes the new lunar science while also collecting valuable data in support of upcoming lunar missions, both crewed and robotic. With ESM5 spanning September 2022 to September 2025 we will perform a rigorous campaign to investigate volatiles, volcanism, tectonics, impact cratering, and regolith development processes. A feature of this mission extension will be the increased degree of coordination, through the identification of targets, across instruments to address our science questions.

We will use the evolving LRO orbit to investigate targets in greater detail than previously possible. ESM5 will occur during a period of unprecedented activity on and around the Moon, including the return of humans to the Moon for the first time since Apollo. We have demonstrated our ability to generate unique datasets when missions visit the Moon, in late 2020 and early 2021 the Chang'E-5 mission provided an opportunity for LRO to document the landing site for the sample return mission, prior to, during, and after the sample return container lifted off the lunar surface providing a view not only of changes to the surface due to the landing, but also providing a near-immediate context for the samples (Figure 1).

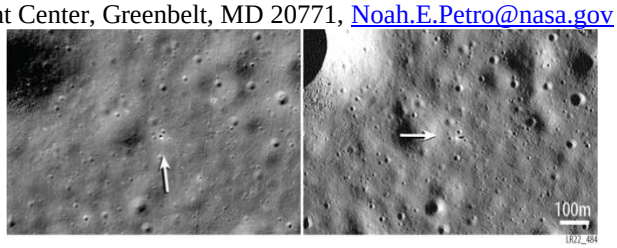

Figure 1. LROC NAC images of the Chang'E 5 landing site immediately after landing on 12/02/20 (M1361560086, left), and after the ascent of the sample-return capsule on 02/07/21 (M136736629, right).

Mission Support: LRO will provide new data to assist with landing site identification, traverse planning, and science support for a myriad of opportunities: Artemis, mission concept studies, Commercial Lunar Payload Services (CLPS) deliveries to locations on the lunar surface, as many as 10 CubeSats/SmallSats that may overlap with ESM5, and a mixture of technology demonstrations, landers, rovers, and sample return missions planned by the international community. In this respect, ESM5 is a new mission that will provide essential observations from the only NASA asset currently positioned to acquire these data.

Spacecraft Status, Orbit, and Fuel: Overall, the spacecraft has performed nearly flawlessly in orbit since launch in June 2009 with a total of 99.04% operational uptime. Only 0.28% of the downtime has been due to spacecraft anomalies, while the remaining 0.68% downtime was due to routine thruster maneuvers and instrument calibration slews.

LRO will complete our current extended mission in September 2022 in an elliptical orbit with periselene of ~78 km and an aposelene of ~110 km. During ESM5 our orbit will be roughly circular at about 95 km, providing for the first time since 2011 nearly uniform spatial resolution over the entire Moon. For the most part since 2011 the LRO orbit has been highly elliptical, with periselene at ~40 km and aposelene > 100 km. We will start ESM5 with an orbital inclination of ~85º, decreasing about 0.5º/yr. Declining orbital inclination results in increased coverage by nadir ground tracks over lower-latitude polar regions compared to the initial mission phases.

As of abstract submission, LRO has ~13 kg of usable propellant, enough for approximately 5 years of regular angular-momentum management, station-keeping maneuvers in the quasi-stable orbit, and for orbital re-phasing for special science operations. The evolution of the LRO orbital altitude and inclination provides exciting opportunities for new science measurements during ESM5.