THE LUNAR RECONNAISSANCE ORBITER MISSION AS A NEW ERA OF LUNAR EXPLORATION BEGINS, PLANS FOR EXTENDED MISSION 5. N. E. Petro[1], M. Banks[1] C. M. Elder[2], J. Keller[1], A. M. Stickle[3], J. Stopar[4], and the LRO Science Team; [1]NASA Goddard Space Flight Center, [2]Jet Propulsion Laboratory, California Institute of Technology, [3]Johns Hopkins University Applied Physics Laboratory, [4]Lunar and Planetary Institute/USRA.

Introduction: The Lunar Reconnaissance Orbiter Extended Science Mission 5 (ESM5) will take place from Sept. 2022 to Oct. 2025 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. LRO will provide new data to assist with landing site identification, traverse planning, and science support for a myriad of opportunities including Artemis, Commercial Lunar Payload Services (CLPS) deliveries to unique 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.

This new role for LRO will be balanced with a vigorous scientific program aligned to NASA Planetary Science controlling documents: The Planetary Science Decadal Survey, Visions and Voyages [NRC, 2011], The Scientific Context for Exploration of the Moon, and the Artemis III Science Definition Team Report. The LRO science objectives are organized around three themes, 1) Volatiles and External Interactions, 2) Interior, Volcanism, and Tectonics, and 3) Regolith and Impacts.

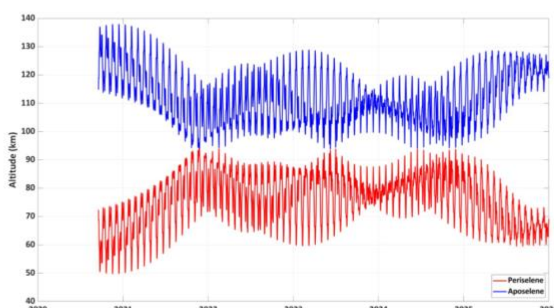

Figure 1. LRO peri- and apoapsis through ESM5. The orbit will be nearly circular for extended periods throughout ESM5, providing uniform coverage of the Moon for the first time since 2011.

Volatiles and External Interactions: The ESM5 will conduct new measurements characterizing regional and seasonal variability in the exosphere and the space environment, as well as focused measurements of regions of high interest in the North and South Pole. The LRO orbit will provide enhanced coverage of Cabeus Crater and so we treat it as an archetypal polar crater to improve our understanding of volatile distribution. We will dedicate observations to Cabeus with a focus on seasonably shadowed regions.

The lunar north pole will come in to focus as well as our orbit will be nearly circular (Figure 1) during this period providing a lower the altitude over the north pole than has been seen since going into a frozen orbit over a decade ago.

We will explore how the new and usual solar cycle (cycle 24) affects the lunar exosphere and space environment of the Moon and conduct a new investigation of lunar dust by comparing two-way laser measurements from the LRO corner-cube reflector array and the Apollo retroreflectors.

Interior, Volcanism, and Tectonics: Large impact structures and corresponding ejecta deposits provide windows into the lunar interior, revealing the composition of the primary crust, and its evolution. The products of volcanism and magmatism making up the secondary crust are derived from partial melting within the interior. Investigations of the full array of lunar mare volcanic landforms can be used to test models of magma generation, ascent, and eruption. We can also assess how eruptions and magma vary in style and composition over time. Tectonic features reflect changes in the lithosphere over time, including mass redistribution from mare eruptions. In ESM5 we will characterize exposures of mantle and deep crustal compositions associated with basins and craters to provide windows into the makeup of the interior at each location. Other focus areas are on how silicic materials inform crustal processes and magma generation on planetary bodies without plate tectonics, and the extent and heterogeneity of the earliest mare eruptions, to help expand current knowledge of cryptomaria distribution and its extent. LRO will explore the distribution, age, and extent of the youngest mare activity to narrow down when the Moon last volcanically active. We will investigate the ages of wrinkle ridges and lobate scarps to explore changes in the Moon's stress state over time and further, attempt to detect current tectonic activity.

Regolith and Impacts: Impact bombardment at all scales has been the primary geologic process modifying the lunar surface for over 1 Gyr. In ESM5 LRO will study regolith formation and evolution by observing the consequences of bombardment at all scales, including crater formation, crater degradation, regolith overturn rates, and space weathering. In ESM5, Mini-RF radar observations in X-band will provide an opportunity to study the degradation of impact craters at a new scale and depth. We will capitalize on the long duration of LRO by (1) searching for space weathering that has occurred over ~10 years by re-observing targets observed early in the mission and (2) continuing to search for new impact craters to improve constraints on the present-day impactor flux and rate of regolith overturn.

LRO Orbit in ESM5: Two aspects of the evolving LRO orbit influence the ESM5 extended mission allowing increased coverage over specific areas of high value. First, as mentioned above the LRO orbit circularizes in ESM5 allowing higher resolution measurements over the north pole than available in ~ 10 years. Second, the declining orbital inclination results in increased coverage by nadir ground tracks over lower-latitude polar regions compared to the initial mission phase. An example is illustrated in Figure 2 that shows orbits over a one-week period will require less than 10-degree slew angles to repeatedly target Cabeus Crater.

Conclusions During ESM5, the LRO mission will be a witness **and** a partner as humans return to the Moon in unprecedented fashion that will define a new era of Solar System Exploration. LRO will assist in landing site characterization, provide scientific context for selecting landing sites and interpreting discoveries all while pursuing a vigorous scientific program of lunar research. It is an exciting time for solar system science and exploration.

The ESM5 may cover one of the great eras in lunar science. We will enter this extended mission phase, if selected, with over 13 years of accumulated experience in lunar orbit, 13 years of discoveries, and 13 years of community use of our data to advance lunar science. With that backdrop, upcoming missions and their corresponding discoveries, will inform LRO science investigations during ESM5 and beyond.

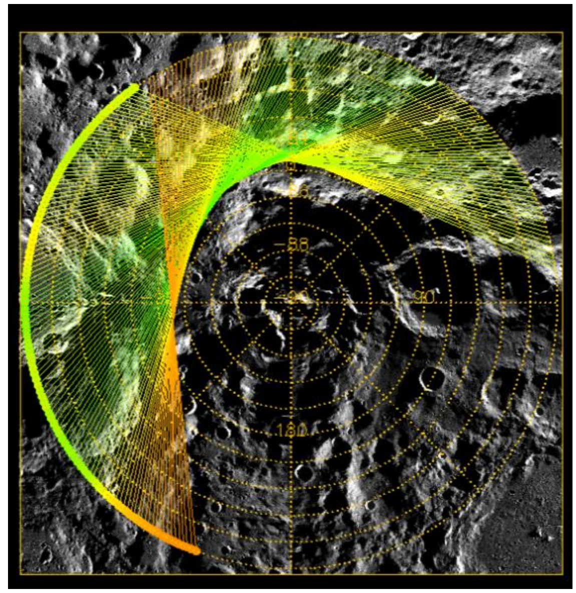

Figure 2. View of the south pole showing the ground track of LRO for a portion of ESM5. The growing orbital inclination of LRO enables repeat coverage of critical targets in ESM5, particularly over targets of interest such as Cabeus Crater.