THE CORNERSTONE MISSION: A THIRD EXTENSION OF THE LUNAR RECONNAISSANCE ORBITER MISSION. J. W. Keller[1] and N. E. Petro[1], [1]NASA Goddard Space Flight Center, Solar System Exploration Division, Greenbelt, MD 20771, USA (John.W.Keller@nasa.gov).

Introduction: The Lunar Reconnaissance Orbiter mission (LRO) is in the second year of a three-year extension, through September 2019, to study fundamental planetary processes recorded on the Moon. LRO was originally extended for two years but NASA is aligning its planetary mission portfolio with a new 3-year extended mission cadence, following a recommendation from National Academy of Sciences. LRO's instruments are measuring processes that operate not only at the Moon but also generally throughout the Solar System, especially on bodies without a significant atmosphere. The LRO "Cornerstone Mission" (CM) employs all seven instruments on board (including the return of Mini-RF to operational status) to constrain newly identified science questions. This synergistic approach allows processes to be constrained at distinct spatial (both lateral and vertical) and temporal scales. These processes are divided into three distinct eras of lunar history (Figure 1). Major milestones from the mission are listed in Figure 2.

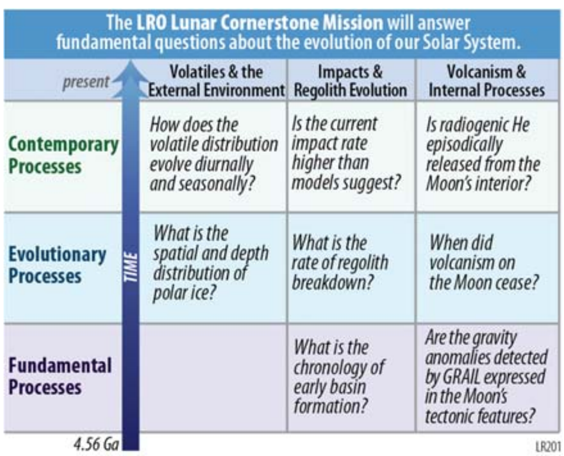

Figure 1. During LRO's CM, the science teams a will address a number of science questions directly related to fundamental Solar System science, which cover processes that have acted over billions of years.

Contemporary Processes (2009-today): LRO has been at the Moon for over 8 years, making it NASA's longest duration lunar and airless body orbital mission. This unprecedented baseline of observations enables fundamentally new science, especially in observations of subtle changes to the lunar surface and its environment [e.g., 1].

Evolutionary Processes (~<1 Ga): LRO will look to the recent geologic past to study processes taking place within the interior and their reflection on the surface, such as those that provide evidence of the Moon's recent volcanism, tectonism, and the evolution of the regolith [2, 3].

Fundamental Processes (~<4.0 Ga): Reaching farther back in time, LRO will employ new observations to determine the relative timing and duration of basin-forming impacts during the proposed period of Late Heavy Bombardment [4], the formation and evolution of the early crust, and the styles and extent of early volcanism.

LRO Key Dates – Eight Years of Successful Operations	
Launch	18-Jun-09
Commissioning Orbit (30 x 216 km) established	27-Jun-09
Insert into Mapping Orbit (50 ±15 km)	16-Sep-09
LCROSS Impact	9-Oct-09
First Public Release of LRO Data From Planetary Data System	3/15/2010 and every 3 months
Begin Science Phase (Under NASA's SMD)	17-Sep-10
Begin First Extended Mission (ESM1)	17-Sep-12
Complete ESM1 begin ESM2	16-Sep-14
Complete ESM2 begin ESM3, The Cornerstone Mission	16-Sep-16

Figure 2 Milestones from the Lunar Reconnaissance Orbiter Mission

Science Focus During the CM: The LRO science teams identified three broad science themes for the CM, which build on Decadal-relevant science questions: 1) Volatiles and the Space Environment, 2) Volcanism and Interior Processes, and Impacts and 3) Regolith Evolution. A few examples of the science questions we address during the CM are illustrated in Figure 1.

LRO's Orbit Enables Fundamental New Science: LRO has maximized its science return by employing a quasi-stable orbit for more than 5 years, which has minimized fuel consumption. In this configuration, which has LRO with a periapsis over the southern hemisphere (Figure 4), enables focused investigations on the region surrounding the South Pole [e.g., 5, 6]. Going forward, the LRO mission team is evaluating options for future orbits that will maximize science collection capability for the remainder of the CM and future potential extended missions.

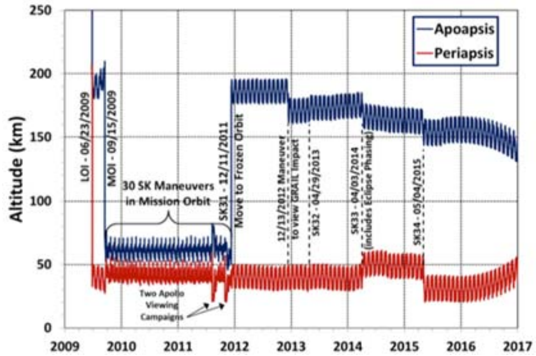

Figure 3 Plot showing the evolution of the LRO orbit since arriving at the Moon in 2009. Since late 2011 LRO has been in a quasi-stable elliptical orbit that allows for a significant reduction in fuel consumption.

LRO As An Asset for Future Lunar Exploration: Beyond the capabilities of LRO as an observatory collecting high-impact science data, LRO is critical from collecting data of possible lunar landing sites [e.g., 7, 8]. As the only resource available to collect new data for landing site assessments, LRO serves as method for assessing landing sites for possible US or international landed missions. In addition, LRO can assess the landing site of missions post-landing [9] providing critical context for surface measurements and observations [4]. As such these pre- and post-mission observations provide unique observations that improve the value of the surface measurements.

Requests for landing site assessments by international partners should be made *via* NASA Headquarters and the Planetary Science Division. At that point the requests are passed on to the mission, and data may be collected, processed, and delivered to the Planetary Data System for use by any interested party. For example, the LROC team can collect multiple views of a possible landing site, and prepare a Digital Terrain Model (DTM) [7] of the potential site (Figure 4).

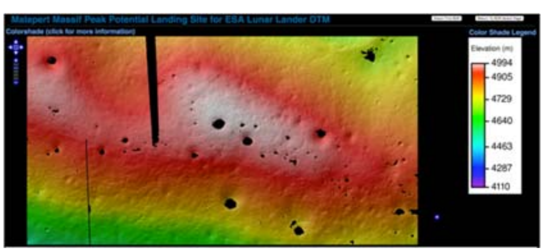
Figure 4 Example of a DTM produced from LROC NAC images [7] for a Possible ISRO landing site at the Malapert Massif [10]

Scientific Productivity: The LRO instrument teams remain highly productive, publishing over 240 peer-reviewed manuscripts since launch. Recently, a three-volume special issue of Icarus (Figure 5) has been published featuring manuscripts from each of the instruments, cross-instrument collaborations, as well as from outside the LRO teams [11-13]. This special issue is the largest produced by Icarus, and illustrate the continuing contributions to lunar and planetary science by the LRO teams.

Figure 5 The LRO mission has yielded numerous results relevant to the planetary science community. The work has led to a number of special issues including a three-volume special issue in the journal Icarus

Conclusions: LRO remains a highly productive, scientifically compelling mission [13]. During its Cornerstone Mission LRO will continue to advance the leading edge of lunar and Solar System science (Figure 3). The LRO mission looks forward to many more years of providing critical data for the revolution in our understanding of the Moon, and by association the Solar System.

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