Recent Results from the Lunar Reconnaissance Orbiter Mission and Plans for a Second Extended Science Mission,
J. W. Keller, N. E. Petro, T. P. McClanahan, R. R. Vondrak, J. B. Garvin, Goddard Space Flight Center, Greenbelt MD 20771.

Introduction: The Lunar Reconnaissance Orbiter (LRO) mission remains poised to take advantage recent extraordinary discoveries on the Moon by this and other missions to advance lunar and planetary science with new, targeted investigations that focus on geologically recent and even contemporaneous changes on the Moon. We present recent results for the mission and describe plans for a second two-year extension of the science mission, ESM2. LRO has been in orbit for nearly 5 years, in that time it has been a witness to, and participant in, a remarkable era of lunar science where a paradigm shift is taking place from the view of the Moon as a static planet to one with active processes.

The case for an extended mission is very strong with compelling new science that could justify a completely new Discovery class mission focused on any one of several topics that the LRO mission will investigate, whether, for example, it is the discovery of new impact craters recording the flux of small objects near the Earth-Moon system or the transport of lunar volatiles at the poles. The use of existing assets such as LRO to achieve new Discovery class science objectives represent the highest possible return on science investment, critical in an era of reduced resources. The ESM2 objectives are tightly coupled to scientific recommendations in the NRC Planetary Science Decadal Survey (Visions and Voyages, 2011). The new science objectives will advance our understanding to the moon and solar system while we complete a legacy data set that will serve future explorers and scientists for decades to come.

History of Operations: LRO launched on June 18, 2009, and began with the goal of seeking safe landing sites for future robotic missions or the return of humans to the Moon as part of NASAȻs Exploration Systems Mission Directorate (ESMD). In addition, LROȻs objectives included the search for surface resources and the measurement of the lunar radiation environment. After spacecraft commissioning, the ESMD phase of the mission began on September 15, 2009 and was completed on September 15, 2010 when operational responsibility for LRO was transferred to NASAȻs Science Mission Directorate (SMD). The SMD mission was scheduled for 2 years and completed in September of 2012. Under SMD, the Science Mission focused on a new set of goals related to understanding the history of the Moon, its current state, and what it can tell us about the evolution of the Solar System.

First Extended Mission: LRO is currently in itȻs first extended mission, ESM1, which will be completed in September of 2014. LRO maintains a ~200 x 30 km polar orbit with periselene near the lunar south pole. This orbit requires yearly maneuvers which require small amounts of fuel; LRO currently has enough fuel onboard to maintain its current orbit for as long as 11 years. As we approach the end of ESM1 we review here the major results from the LRO. LRO has: enabled the development of comprehensive high resolution maps and digital terrain models of the lunar surface; discoveries on the nature of hydrogen distribution, and by extension water, at the lunar poles; measured of the daytime and nighttime temperature of the lunar surface including temperature down below 30 K in permanently shadowed regions (PSRs); direct measurement of Hg, H_2, and CO deposits in the Cabeus PSR; evidence for recent tectonic activity on the Moon; and high resolution maps of the illumination conditions at the poles. The objectives for the first Extended Science Mission under SMD address four themes: 1) The nature of polar volatiles, 2) Lunar differentiation and early evolution, 3) The lunar impact record, 4) The MoonȻs interaction with its external environment.

Instrument Suite: All instruments remain operating in their nominal states and continue to prodcuce excellent science data. The instruments, which were described in detail previously [1], are:

Lunar Orbiter Laser Altimeter (LOLA), PI, David Smith, Massachusets Institute of Technology, Boston, MA

Lunar Reconnaissance Orbiter Camera (LROC), PI, Mark Robinson, Arizona State University, Tempe, Arizona

Lunar Exploration Neutron Detector (LEND), PI, Igor Mitrofanov, Institute for Space Research, and Federal Space Agency, Moscow

Diviner Lunar Radiometer Experiment (DLRE), PI, David Paige, University of California, Los Angeles

Lyman-Alpha Mapping Project (LAMP), PI, Kurt Retherford, Southwest Research Institute, San Antonio, Texas

Cosmic Ray Telescope for the Effects of Radiation (CRaTER), PI, Nathan Schwadron, University of New Hampshire, New Hampshire

Mini Radio-Frequency (Mini-RF), P.I. Ben Bussey, Applied Physics Laboratory, Maryland.

PDS Deliveries: The LRO instrument teams make quarterly deliveries to the PDS and to date (January 7, 2014) have delivered nearly 485Tb of data to the PDS. In addition to raw and calibrated data, the teams have also delivered a number of higher level data products, including maps and derived products (e.g., surface slope, rock abundance).

Data can be accessed in a number of ways; the PDS maintains a website [2] that posts dataset updates as well as links to the PDS archives; and some teams have direct access to their data and derived products through their websites [e.g., 3, 4, 5]. For quick access to the LRO Camera Narrow Angle Camera data, the QuickMap interface [6] provides easy access to the data as well as a tool for projecting data on top of 3D renderings.

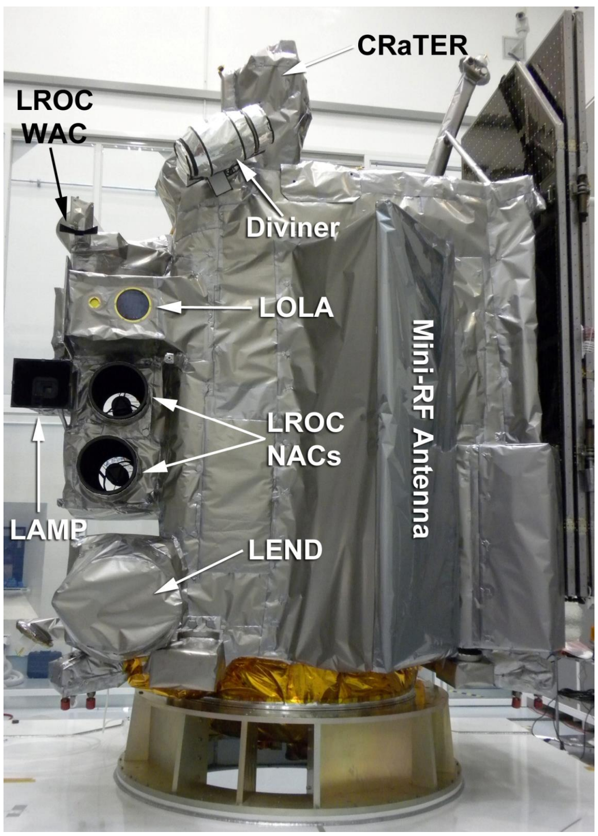

Figure 1 The fully assembled and thermal blanketed spacecraft.

References: [1] Vondrak, R.R., Keller, J.W., and Russell, C.T., (Ed.s), 2010, Lunar Reconnaissance Orbiter Mission, New York, Springer. [2] http://wwwpds.wustl.edu/missions/lro/default.htm [3] http://imbrium.mit.edu/ [4] http://lroc.sese.asu.edu/ [5] http://diviner.ucla.edu/ [6] http://target.lroc.asu.edu/q3/