

THE LUNAR RECONNAISSANCE ORBITER AT THE MIDPOINT OF THE EXPLORATION MISSION. R. Vondrak*, J. Keller, G. Chin, J. Garvin, Goddard Space Flight Center, Greenbelt, MD 20771

Introduction: The Lunar Reconnaissance Orbiter spacecraft (LRO) was launched on June 18, 2009 and arrived at the Moon 5 days later on June 23. LRO's mission, as part of NASA's Exploration Systems Mission Directorate (ESMD), is to seek safe landing sites for future robotic missions or the return of humans to the Moon. In addition LRO's primary objectives include the search for resources and to investigate the Lunar radiation environment.

Upon arriving at the Moon LRO began a commissioning phase, in which the spacecraft and instruments were fully activated and underwent in-flight calibration. These activities took place while the spacecraft was in a low maintenance polar orbit with peri- and apo-selene of 30 and 216 km from the Lunar surface. After commissioning, the spacecraft was inserted into its Exploration Mission orbit of 50 ± 15 km on Sept. 15, 2009. The spacecraft spends the bulk of its time with the instruments pointed in the nadir direction, however to support the LCROSS mission, on Oct. 9 the instruments were rotated to look above the Lunar limb as the spacecraft passed the launch vehicle upper stage, which had, moments before, impacted a permanently shadowed area within Cabeus crater. The Exploration Mission for ESMD will be completed on September 15, 2010. LRO will then begin a two-year Science Mission.

This presentation updates the status and recent results from the LRO Exploration Mission, as well as the plans for the Science Mission, and gives a brief description of the instrument payload. The payload includes:

Lunar Orbiter Laser Altimeter (LOLA): LOLA is determining the global topography of the lunar surface at high resolution, measuring landing site slopes, surface roughness, and searching for possible polar surface ice in shadowed regions. PI, David Smith, NASA Goddard Space Flight Center, Greenbelt, MD.

LOLA Objectives:

1. Global Geodetic Lunar Topography.
2. Characterize Polar Region Illumination.
3. Image Permanently Shadowed Regions.
4. Contribute to the assessment of meter-scale features to facilitate landing-site selection.
5. Identify surface polar ice, if present.

Lunar Reconnaissance Orbiter Camera (LROC): LROC acquires targeted narrow angle images of the lunar surface capable of resolving meter-scale features to support landing site selection, as well as wide-angle images to characterize polar illumination conditions and to identify po-

tential resources. PI, Mark Robinson, Arizona State University, Tempe, Arizona.

LROC Objectives:

1. Landing site identification and certification, with unambiguous identification of meter-scale hazards.
2. Mapping of permanent shadows and sunlit regions.
3. Meter-scale mapping of polar regions.
4. Repeat observations to enable derivation of meter-scale topography.
5. Global multispectral imaging to map ilmenite and other minerals.
6. Global black and white morphology base map.
7. Characterize regolith properties.
8. Determine recent small impactor rates by re-imaging regions photographed with the Apollo Panoramic Camera (1-2 meter m/pixel).

Lunar Exploration Neutron Detector (LEND): LEND maps the flux of neutrons from the lunar surface to search for evidence of water ice, and provides space radiation environment measurements that may be useful for future human exploration. PI, Igor Mitrofanov, Institute for Space Research, and Federal Space Agency, Moscow.

LEND Objectives:

1. Determine hydrogen content of the subsurface at the polar regions with spatial resolution of 10km and with sensitivity to concentration variations of 100 parts per million (ppm) at the poles.
2. Characterization of surface distribution and column density of possible near-surface water ice deposits in the Moon's polar cold traps.
3. Global mapping of Lunar neutron emissions at an altitude of 30-50 km above Moon's surface, with a spatial resolution of 5 km (pixel radius) at the spectral range of thermal energies up to 15 MeV.

Diviner Lunar Radiometer Experiment (DLRE): DLRE is charting the day and night temperature of the entire lunar surface at approximately 500 meter horizontal scales to identify cold-traps and potential ice deposits. PI, David Paige, University of California, Los Angeles.

DLRE Objectives:

1. Map Global Day/Night Surface Temperature
2. Characterize Thermal Environments for Habitability
3. Determine Rock Abundances Globally and at Landing Sites

4. Identify Potential Polar Ice Reservoirs
5. Map Variations in Silicate Mineralogy

Lyman-Alpha Mapping Project (LAMP): LAMP is mapping the entire lunar surface in the far ultraviolet. LAMP will search for surface ice and frost in the polar regions and provide images of permanently shadowed regions illuminated only by starlight. Acting PI, Randy Gladstone, Southwest Research Institute, Boulder, Colorado.

LAMP Objectives:

1. Identify and pinpoint surface exposed frost in Permanently Shadowed Regions (PSRs).
2. Map all permanently shadowed regions with resolutions down to 260 m.
3. Demonstrate the feasibility of natural starlight and Lyman-Alpha (α) sky-glow illumination for future lunar surface mission applications.
4. Assay the lunar atmosphere and its variability.

Cosmic Ray Telescope for the Effects of Radiation (CRaTER): CRaTER is investigating the effect of galactic cosmic rays on tissue-equivalent plastics as a constraint on models of biological response to background space radiation. PI, Harlan Spence, UNH, New Hampshire.

CRaTER Objectives:

1. Measure and characterize the Linear Energy Transfer (LET) spectra of galactic and solar cosmic rays (particularly above 10 MeV) in the deep space radiation environment most critically important to the engineering and modeling communities to assure safe, long-term human presence in space.
2. Develop a simple, compact, and comparatively low-cost instrument, based on previously flown instruments, with a sufficiently large geometric factor to measure LET spectra and its time variation globally in the lunar orbit.
3. Investigate the effects of shielding by measuring LET spectra behind different amounts and types of

areal density materials, including tissue-equivalent plastic.

4. Test models of radiation effects and shielding by verifying/validating model predictions of LET spectra with LRO measurements, using high-quality galactic cosmic rays (GCR) and solar energetic protons (SEP) spectra available contemporaneously with ongoing/planned NASA (ACE, STEREO, SAMPEX) and other agency spacecraft (NOAA-GOES).

Mini Radio-Frequency Technology Demonstration (Mini-RF): The Mini-RF primary purpose is technical demonstration in the lunar environment of a unique miniaturized multi-mode radar observatory. Its synthetic aperture radar (SAR) imaging modes are most relevant to the scientific and exploratory roles of LRO. P.I. Ben Bussey, Applied Physics Laboratory, Maryland. The mini-RF SAR baseline modes include: two frequencies – S-band (13 cm) and X-band (4 cm); two resolutions – baseline (150 m/75-m pixels) and zoom (15 m/7.5-m pixels); and dual-polarization – transmit on one and receive on like and orthogonal polarizations. The nominal incidence is 45° side-looking; swath widths vary by mode from ~ 4 km to ~ 6 km. The primary data products will be multi-mode Stokes parameters (or their primitives). In addition, there is an experimental two-pass interferometric mode (single polarization), and the possibility of bistatic radar experiments.

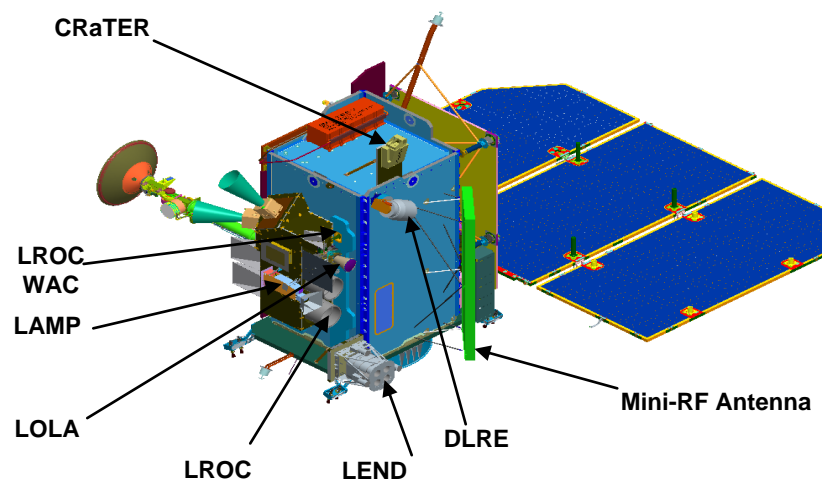


Figure 1 The LRO instrument suite is on an instrument deck and on the body of the LRO spacecraft. The rigid solar arrays are shown deployed.