Lunar Reconnaissance Orbiter

Project Overview & Status

NASA Goddard Space Flight Center
craig.r.tooley@nasa.gov
http://lunar.gsfc.nasa.gov/
Jan. 14 2004 – The President announced a new vision for space exploration that included among its goals “… to return to the moon by 2020, as the launching point for missions beyond. Beginning no later than 2008, we will send a series of robotic missions to the lunar surface to research and prepare for future human exploration.”
**Objective:** The Lunar Reconnaissance Orbiter (LRO) mission objective is to conduct investigations that will be specifically targeted to prepare for and support future human exploration of the Moon.

**Locate Potential Resources**
- Hydrogen/water at the lunar poles
- Continuous solar energy
- Mineralogy

**Safe Landing Sites**
- High resolution imagery
- Global geodetic grid
- Topography
- Rock abundances

**Space Environment**
- Energetic particles
- Neutrons
LRO follows in the footsteps of the Apollo Robotic Precursors

- Apollo had three (Ranger, Lunar Orbiter and Surveyor) robotic exploration programs with 21 precursor missions from 1961-68
  1. Lunar Orbiters provided medium & high resolution imagery (1-2m resolution) which was acquired to support selection of Apollo and Surveyor landing sites.
  2. Surveyor Landers made environmental measurements including surface physical characteristics.
  3. Ranger hard landers took the first close-up photos of the lunar surface

- Exploration needs the above information to go to new sites and resource data to enable sustainable exploration.

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Lunar Orbiter ETU in Smithsonian Air & Space Museum, Washington DC
LRO Enables Global Lunar Surface Access

LRO Global Topography, Imagery and Resource Maps

Current Apollo heritage image set only
Covers 4 of 10 ESAS sites.

Most other high priority sites identified lie outside Apollo heritage area.

LRO extends coverage to entire Moon

Implementing the Vision
LRO Mission Overview

- Launch in late 2008 on an EELV into a direct insertion trajectory to the moon. Co-manifested with LCROSS spacecraft.

- On-board propulsion system used to capture at the moon, insert into and maintain 50 km mean altitude circular polar reconnaissance orbit.

- 1 year mission with extended mission options.

- Orbiter is a 3-axis stabilized, nadir pointed spacecraft designed to operate continuously during the primary mission.

- Investigation data products delivered to Planetary Data Systems (PDS) within 6 months of primary mission completion.
LRO Mission Overview

Launch: October 28, 2008

Minimum Energy Lunar Transfer ~ 4 Days

Lunar Orbit Insertion Sequence, 4-6 Days

Commissioning Phase, 30 x 216 km Altitude Quasi-Frozen Orbit, Up to 60 Days

Polar Mapping Phase, 50 km Altitude Circular Orbit, At least 1 Year

Nominal End of Mission: February 2010
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<tr>
<th>INSTRUMENT</th>
<th>SPONSORSHIP</th>
<th>MEASUREMENT</th>
<th>LVL 1 RQMTS TRACEABILITY</th>
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| CRaTER                           | P.I: Harlan Spence, BU       | Tissue equivalent response to radiation LET energetic particle spectra 200 keV – 1 GeV/nuc | M10 - Radiation Environment  
M20 - Radiation on Human-equivalent tissue |
| Cosmic Ray Telescope for the Effects of Radiation | I.M: Rick Foster, MIT       |                                                                             |                          |
|                                  | I.S.E: Bob Goekke, MIT      |                                                                             |                          |
| DLRE                             | P.I: David Paige, UCLA      | Better than 500m scale maps of temperature, rock abundances, mineralogy     | M50 - Surface Temperatures  
M60 - Images of PSRs  
M70 - Subsurface Ice |
| Diviner Lunar Radiometer Experiment | I.M: Wayne Hartford, JPL    |                                                                             |                          |
|                                  | I.S.E: Marc Foote, JPL      |                                                                             |                          |
| LAMP                             | P.I: Alan Stern, SwRI       | UV Albedo maps of the permanently shadowed areas  
Maps of frosts in permanently shadowed areas, 3km resolution | M60 - Images of PSRs  
M70 - Subsurface Ice |
| Lyman-Alpha Mapping Project      | I.M: Ron Black, SwRI        |                                                                             |                          |
|                                  | I.S.E: Dave Slater, SwRI    |                                                                             |                          |
| LEND                             | P.I: Igor Mitrofanov, IKI   | Maps of hydrogen in upper 2m of Moon at 10km scales  
Global distribution of neutrons around the Moon | M10 – Radiation Environment  
M70 – Subsurface Ice  
M110 – Hydrogen Mapping |
| Lunar Exploration Neutron Detector | Deputy P.I: Roald Sagdeev, UMD |                                                                             |                          |
|                                  | I.M: Anton Sanin, IKI       |                                                                             |                          |
|                                  | I.S.E: Maxim Litvak, IKI    |                                                                             |                          |
| LOLA                             | P.I: David Smith, GSFC      | ~50m scale polar topography at <10cm vertical, and roughness and slope data | M30 - Topography Grid  
M40 - Topography Resolution  
M45 - Images of PSRs  
M80 - Surface Features and Hazards  
M90 - Polar Illumination  
M100 – Regolith Sources |
| Lunar Orbiter Laser Altimeter    | Co-P.I: Maria Zuber, MIT    |                                                                             |                          |
|                                  | I.M: Glenn Jackson, GSFC    |                                                                             |                          |
|                                  | I.S.E: John Cavanaugh, GSFC |                                                                             |                          |
| LROC                             | P.I: Mark Robinson, ASU     | 1000s² of 50cm/pixel images (125km), and entire Moon at 100m visible, 400m UV | M40 - Topography Resolution  
M80 - Surface Features and Hazards  
M90 – Polar Illumination  
M100 – Regolith Sources |
| Lunar Reconnaissance Orbiter Camera | I.M: Scott Brylow, MSSS    |                                                                             |                          |
|                                  | I.S.E: Mike Caplinger, MSSS |                                                                             |                          |
| Mini-RF                          | P.O.C: Keith Raney, JHU/APL | X&S-band Radar imaging and radiometry                                       | P160 - Demonstrate new lightweight SAR Technologies |
| Technology Demonstration         | P.M: Bill Marinelli, NAWC   |                                                                             |                          |
|                                  | D.P.M: Dean Huebert, NAWC   |                                                                             |                          |
LRO Spacecraft

**LRO Orbiter Characteristics**

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<tr>
<th>Feature</th>
<th>Value</th>
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<tr>
<td>Mass (CBE)</td>
<td>1823 kg</td>
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<td>Dry: 924 kg, Fuel: 898 kg (1263 m/sec)</td>
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<td>Orbit Average Bus Power</td>
<td>681 W</td>
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<td>Data Volume, Max Downlink rate</td>
<td>459 Gb/day, 100Mb/sec</td>
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<td>Pointing Accuracy, Knowledge</td>
<td>60, 30 arc-sec</td>
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**Instrument Module** (LOLA, LROC, LAMP)

**ACS Thruster Module** (1 of 4)

**LEND Neutron Instrument**

**High Gain Antenna System**

**Cosmic Ray Telescope for the Effects of Radiation (CRaTER)**

**Diviner Lunar Radiometer Experiment (DLRE)**

**Orbit Average Bus Power**

**Data Volume, Max Downlink rate**

**Pointing Accuracy, Knowledge**

**Mass (CBE)**

**Implementing the Vision**
LRO-LCROSS Launch Segment

- Launch Services Provided by KSC
- Atlas V 401 through NLS Contract
- 2000 kg; Sun Exclusion thru Ascent
- 4m fairing; H/K data thru EELV I/F
- Co-manifested with LCROSS lunar mission
- Launch Site Processing at Astrotech including Fueling & Control Center
LRO Ground Segment Overview

• Mission Operations Center & Flight Dynamics Facility at GSFC

• Primary Ground Station at White Sands (Ka & S-Band)

• Global S-Band TT&C provided by NASA GN & SN.

• Science Operations Centers (SOC) at PI institutions

• S-band tracking augmented by laser ranging system to improve accuracy.
The LRO Mission was confirmed in May 2006 and successfully completed its mission CDR in November 2006.

Instruments completed CDRs during Spring and Summer 2006 and are proceeding with fabrication and testing.

All spacecraft bus avionics are in ETU testing and proceeding toward flight fabrication.

All major procurements (ACS sensors, battery, gimbal actuators, RF systems) are awarded and on schedule for required delivery dates.

Mission Operations Center being outfitted at GSFC.

White Sands 1 (WS1) Ka-S Band primary ground station under construction.

Project Reserves (Budget, Schedule, Mass, Power) are stable and at acceptable levels.