Lunar Precursor Robotic Program

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Primary responsibility of the NASA Lunar Precursor Robotic Program is to develop and execute missions to achieve NASA’s robotic lunar exploration objectives.

This will be accomplished by:

- Defining specific requirements for each precursor mission
- Identifying key assumptions and guidelines
- Defining a robust and sustainable architecture for robotic precursor missions that accomplish defined objectives
- Identifying system interfaces
- Building constituencies in the lunar exploration community
- Establishing and overseeing projects to execute mission design, development, integration, test and operation
- Reduce risk for human missions (Constellation) with technology validation
Lunar Precursor Robotic Program Structure

*Note: Contingent upon LAT output.
“Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare for and support future human exploration activities” (NSPD-31)

Robotic missions:
Provide early strategic information for human missions
- Key knowledge needed for human safety and mission success
- Infrastructure elements for eventual human use
- Data will be used to plan and execute human exploration of the Moon

Resolve the unknowns of the lunar polar regions
- Knowledge of the environment – temperature, lighting, etc.
- Resources/deposits – composition and physical nature
- Terrain and surface properties - dust characterization
- Emplace support infrastructure – navigation/communication, beacons, teleoperated robots

Make exploration more capable and sustainable
- Emplace surface systems
- Demonstrate new technologies that will enable settlement
- Operational experience in lunar environment
- Create new opportunities for scientific investigation
Apollo had three robotic exploration programs with 21 precursor missions from 1961-68

Ranger, Lunar Orbiter and Surveyor

Ranger took the first close-up photos of the lunar surface (hard impact)
Lunar Orbiter provided medium & high resolution imagery (1-2 m resolution) to support selection of Apollo and Surveyor landing sites
Surveyor soft landers made surface environmental measurements including physical characteristics and chemical composition
**Lunar Reconnaissance Orbiter (LRO)**

Lunar mapping, topography, radiation characterization, and volatile identification

50 km circular polar orbit

Critical Design Review: October 2006

Launch: Late October 2008

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**Lunar CRater Observation and Sensing Satellite (LCROSS)**

Investigate the presence of water at one of the lunar poles via a kinetic impactor and shepherding spacecraft

Preliminary Design Review: August 2006

Launch: With LRO
Objectives:
Find and characterize resources that make exploration affordable and sustainable
- Volatiles (e.g., H)
- Sunlight
- Landing site morphology
- Physical properties
- Dust
- Oxidation potential
- Radiation environment / shielding

Field test new equipment, technologies and approaches (e.g., dust and radiation mitigation)
Support demonstration, validation, and establishment of heritage of systems for use on human missions
Gain operational experience in lunar environments
Provide opportunities for industry, educational and international partners
Architecture Background - Resources

LP Neutron Spectrometer data indicate polar H content of ~150 ppm
  LP NS pixels are large
  H could be of solar wind origin and uniformly distribution
  H could be of solar wind or cometary origin and cold trapped in permanent shadows
Pyroclastic deposits suggested to have high H content
  Apollo 17 orange glass and Apollo 15 green glass highly enriched in volatile elements
Oxygen can be found globally – H is the resource driver
Lunar Precursor Robotic Program
Polar Volatiles: Shadows, Neutrons, Radar, Imagination
Lunar Precursor Robotic Program
Polar Volatiles: Shadows, Neutrons, Radar, Imagination
Architectural Approach

Polar Lander in illuminated area (e.g., rim of Shackleton)
Measure H content of illuminated regolith
If H content = 150 ppm -> H of solar wind origin and uniformly distribution
No need to explore shadowed areas
if H content <<150 ppm -> H is segregated in cold traps
Need to explore shadowed areas to understand form and distribution
Understand polar environment
Pyroclastic Lander (e.g., Sulpicius Gallus)
Measure H content of pyroclastic material

Resource Ore Decision Option
Polar Shadowed Rover
Determine the form and distribution of H

Resource Ore Decision
Overview
Develop common lander to land in sunlight near lunar pole to characterize environment and deposits
Lander becomes standard design for delivery of future payloads
Sunlight mission answers first-order questions about poles and provides ground truth for orbital sensing

Concept of Operations
Precision landing & hazard avoidance
Characterize sun illumination over a seasonal cycle
Direct measurement of neutron flux, soil hydrogen concentration in sunlit area for correlation with orbital mapping
Biological radiation response characterization
Characterize lunar dust and charging environment
Possible micro-rover for near-field investigation (if funded separately)
Lunar Precursor Robotic Program  
Small Satellite Mission – Notional

Options
- Orbital observation / infrastructure
- Short-lived surface mission

Orbiter microsat bus
- 3-axis stabilized platform
- 100-200 kg-class bus
- 30-40 kg payload capacity
- Communications
  - 5 hour dwell over region in 8 hour orbit
- Remote sensing

Limited life lander
- 130 Kg Lander (four tanks) on a Minotaur V
  - 50 Kg science payload to surface, 200 Watts
- 65 Kg Lander (two tanks) on a Falcon 1
  - 10 Kg science payload to surface, 133 Watts
- Surface volatiles analysis
- Chemistry / Mineralogy
Overview
Reference concept: fuel cell-powered rover, ranging >25 km and obtaining >22 subsurface measurements to map and analyze polar volatiles
Navigation by integration of coherent ranging with an overhead relay satellite, IMU, and perhaps terrain relative navigation
Navigation by flash lamps and MER style hazard avoidance or 3-D scanning LIDAR
RTG-powered options are lighter and offer extended life, but are more costly

Concept of Operations
Rover delivered directly to the crater floor by the lander (which expires shortly after rover egress)
Rover traverses to selected sites obtaining ground penetrating radar and neutron spectrometer profiles along the way
Sampling at predetermined site, rover drills and samples material approximately every 50 cm to a maximum depth of 2 m
On-board analysis of volatile content and composition
Shadow in Earth-based radar images is Earth-shadow; entire crater floor is in **sun**-shadow.

Green – NS pixels
Red – High Radar CPR
Orange – “Permanent” sunlight
Blue line – Rover traverse
Monday December 4
Lunar Architecture Team Report

NASA Exploration Strategy and Lunar Architecture Briefing 1 PM CST Press Conference

AIAA Meeting in Houston
THIS IS THE END OF THE BEGINNING