Lunar Precursor Robotic Program

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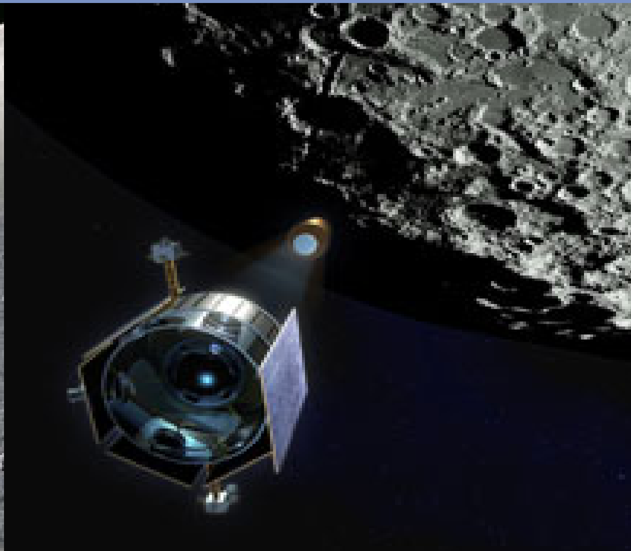
Lunar Reconnaissance Orbiter PSG Meeting
Honolulu, HI
November 30, 2006



Brief Description of LPRP

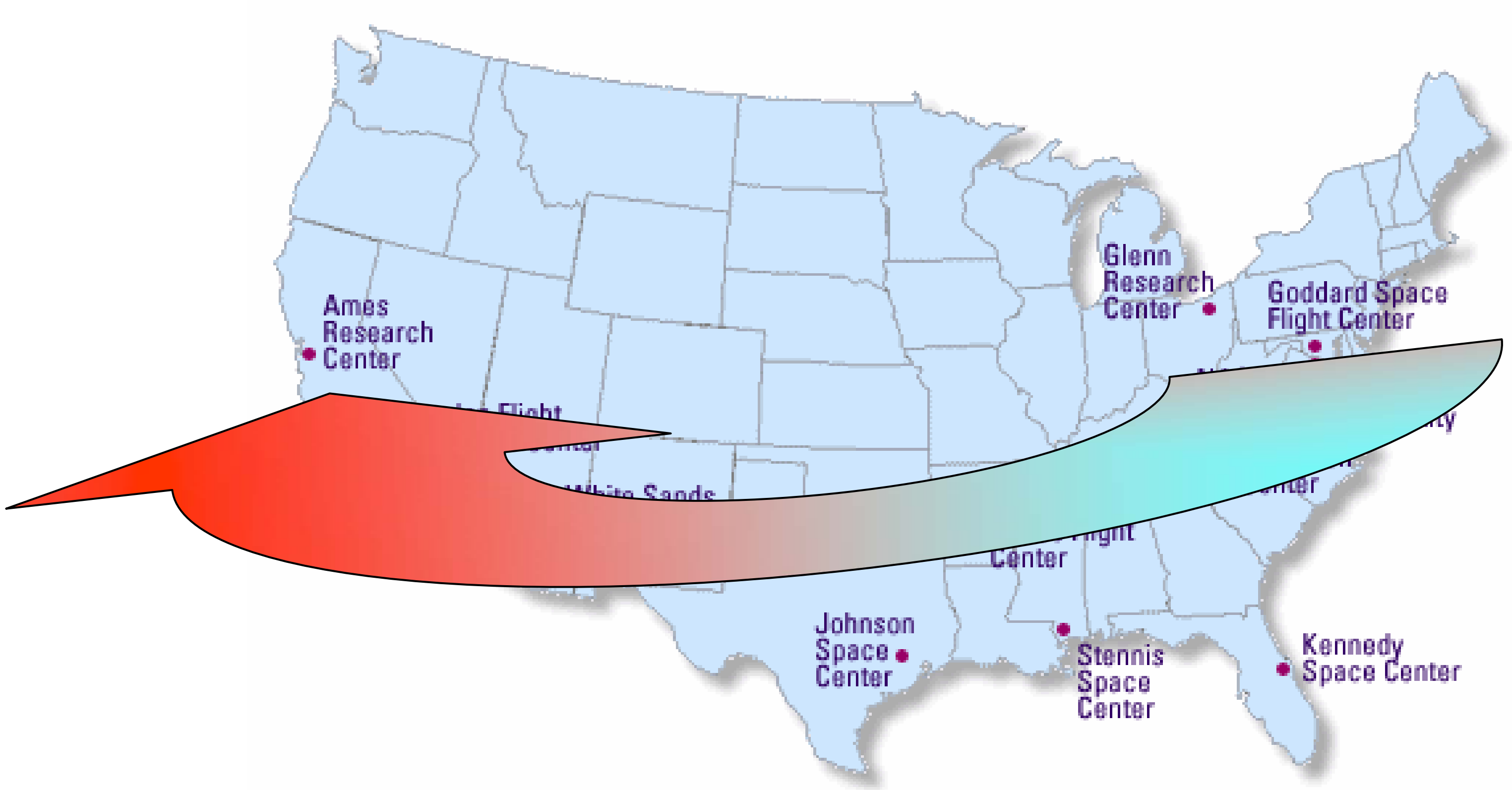
Primary responsibility of the NASA Lunar Precursor Robotic Program is to develop and execute missions to achieve NASA's robotic lunar exploration objectives.

This will be accomplished by:

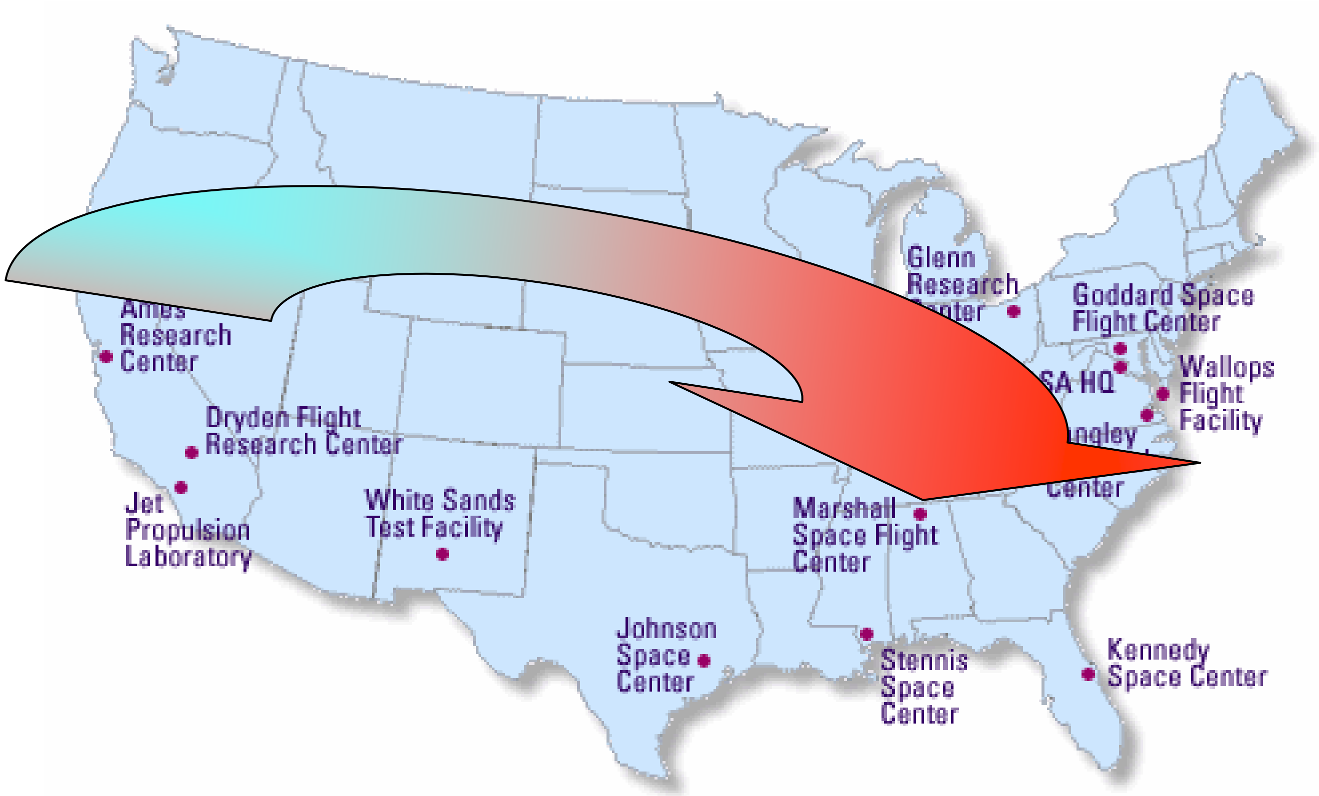
- Defining specific requirements for each precursor mission
- Identifying key assumptions and guidelines
- Defining a robust and sustainable architecture for robotic precursor missions that accomplish defined objectives
- Identifying system interfaces
- Building constituencies in the lunar exploration 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

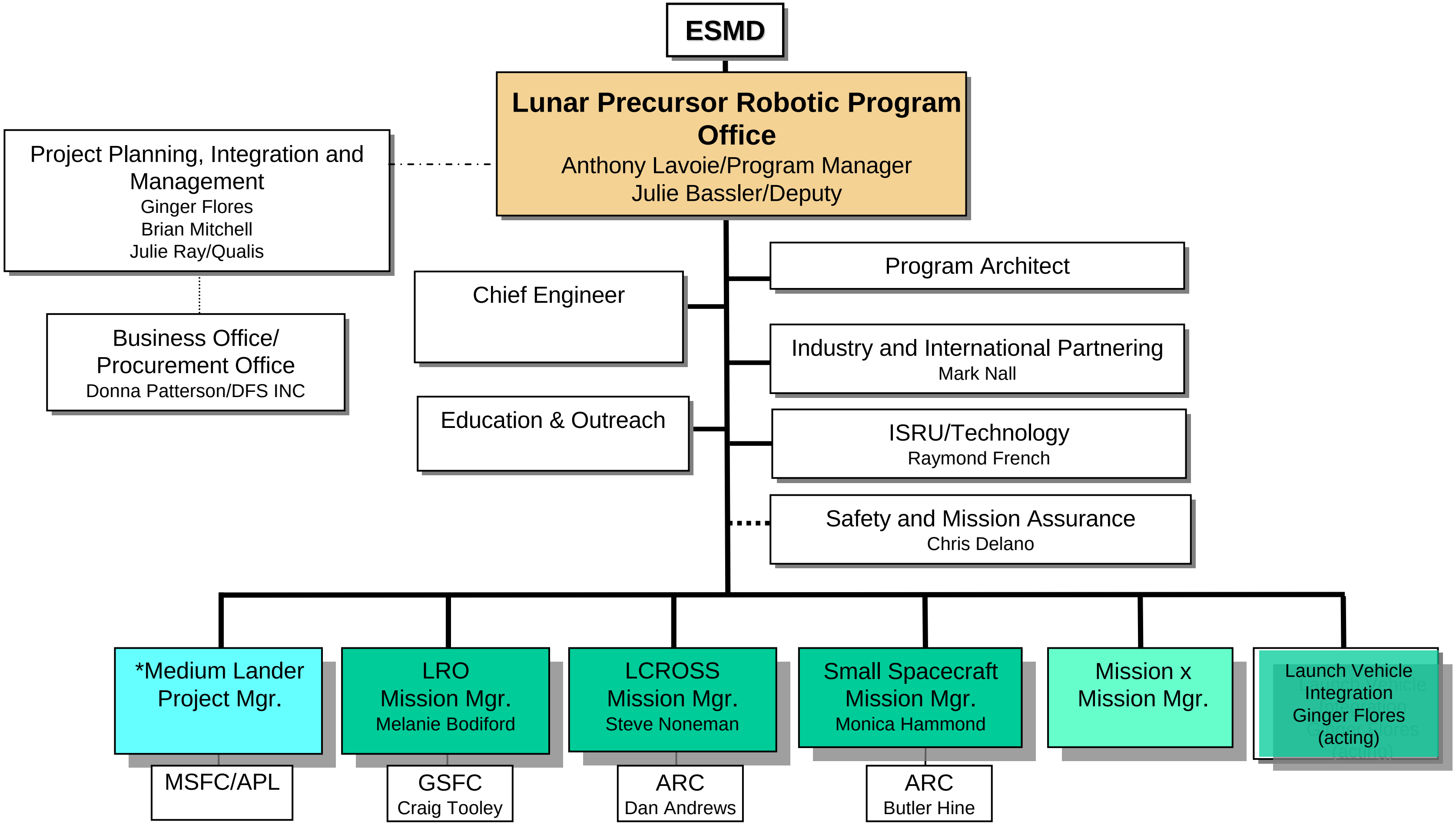
Where's Waldo?



Lunar Precursor Robotic Program
Where's Waldo?



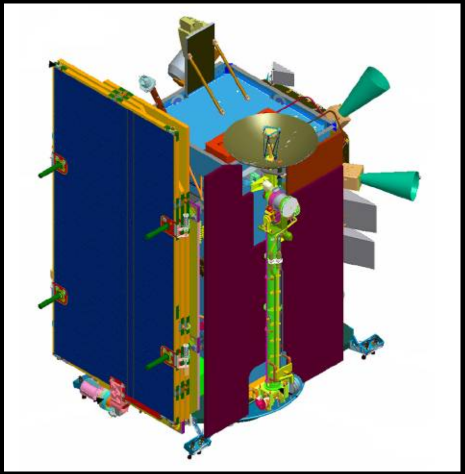
Lunar Precursor Robotic Program Structure



- Mission objectives/requirements
- Budget allocation to all elements
- Risk-based insight
- Integration of Payloads onto Lander
- Launch Vehicle Budget control and Integration of hardware
- Mission Operations

*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)



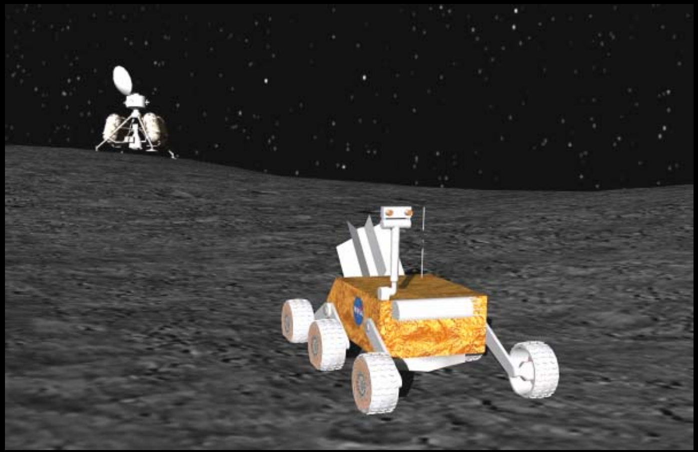
Robotic missions:

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



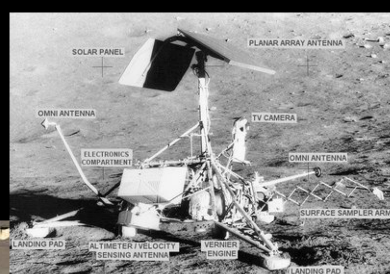
Make exploration more capable and sustainable

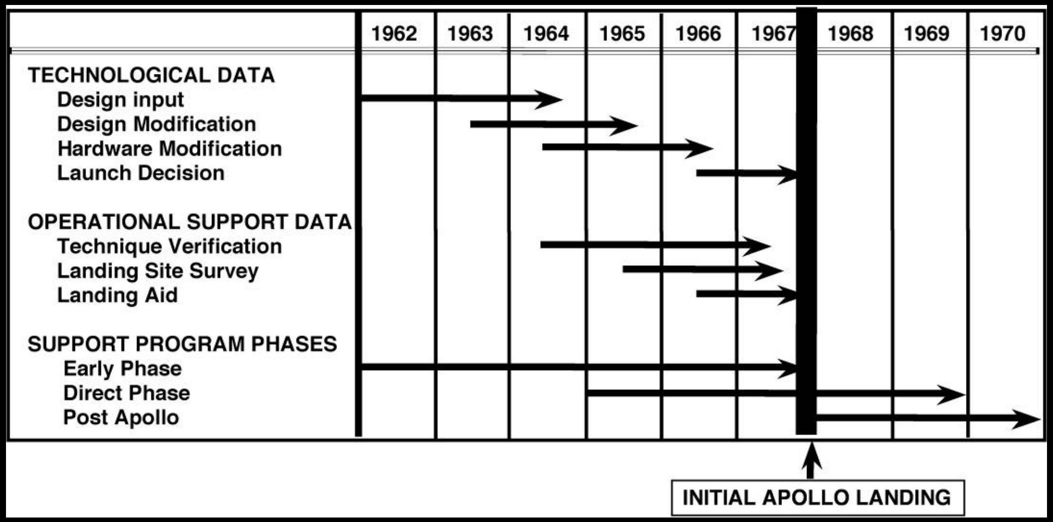
- Emplace surface systems
- Demonstrate new technologies that will enable settlement
- Operational experience in lunar environment
- Create new opportunities for scientific investigation

Lunar Precursor Robotic Program
Apollo Robotic Precursors

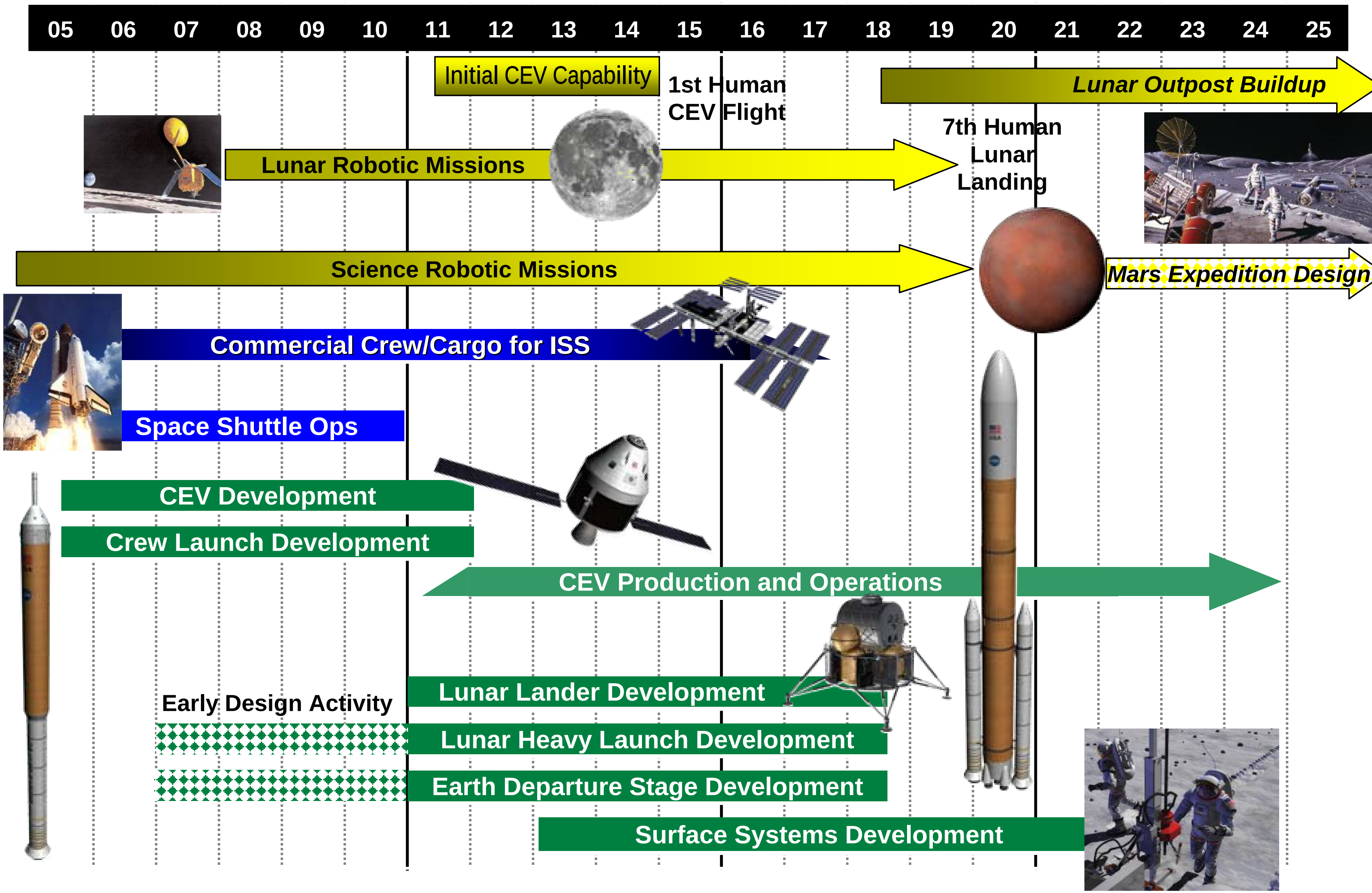
Apollo had three robotic exploration programs with 21 precursor missions from 1961-68

- **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

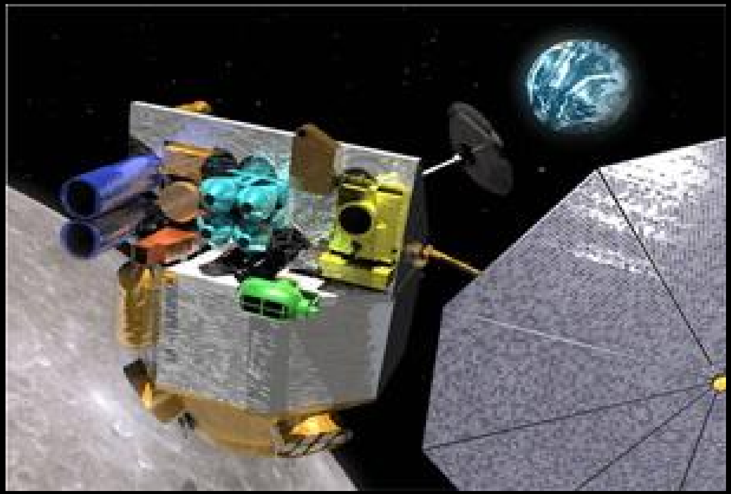




Lunar Precursor Robotic Program
LPRP in context of NASA's Exploration Architecture



Lunar Precursor Robotic Program
First Two LPRP Missions



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

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

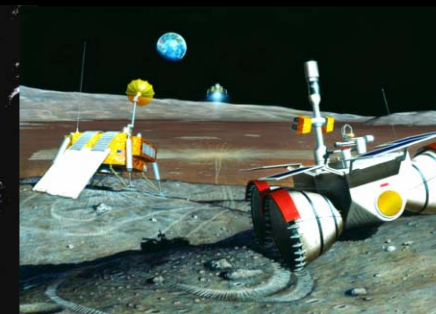
Launch: With LRO

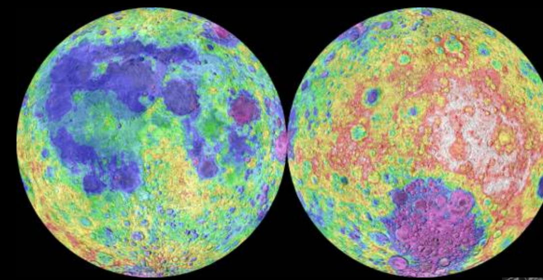
Lunar Precursor Robotic Program
Post LRO: 2011 and Beyond

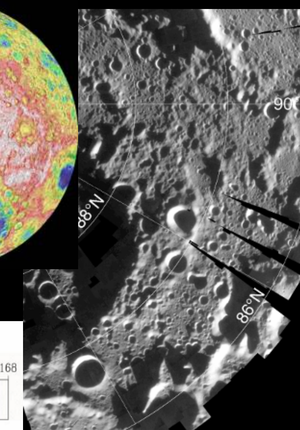
Objectives:

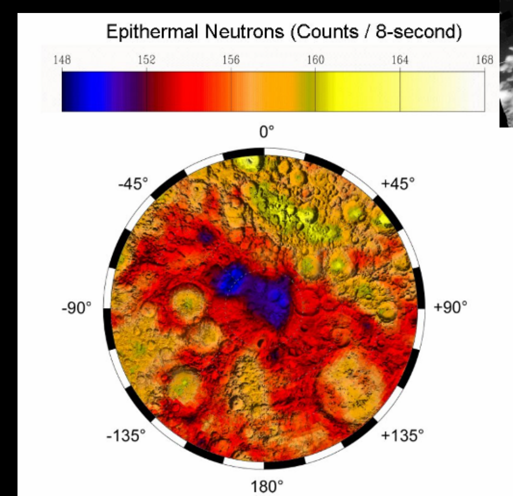
- Find and characterize resources that make exploration affordable and sustainable
  - Volatiles (e.g., H)
  - Sunlight
- Landing site morphology
- Physical properties
- Dust
- Oxidation potential
- Radiation environment / shielding

- 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







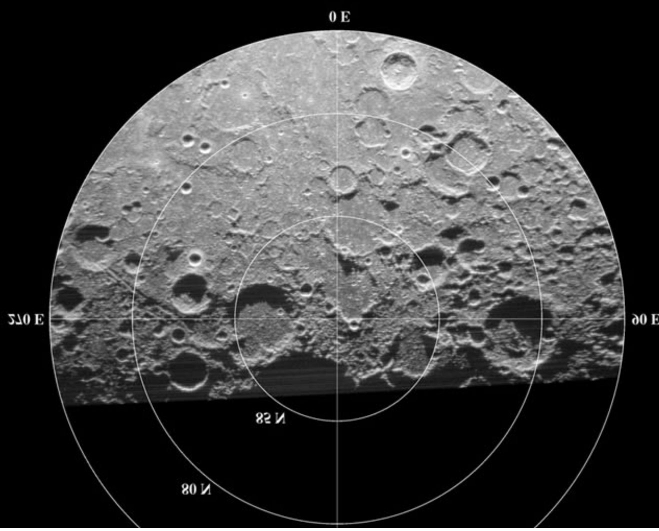


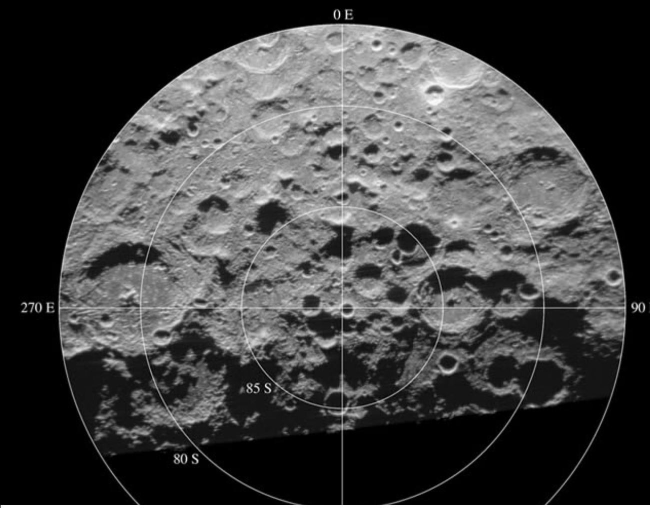
Architecture Background - Resources

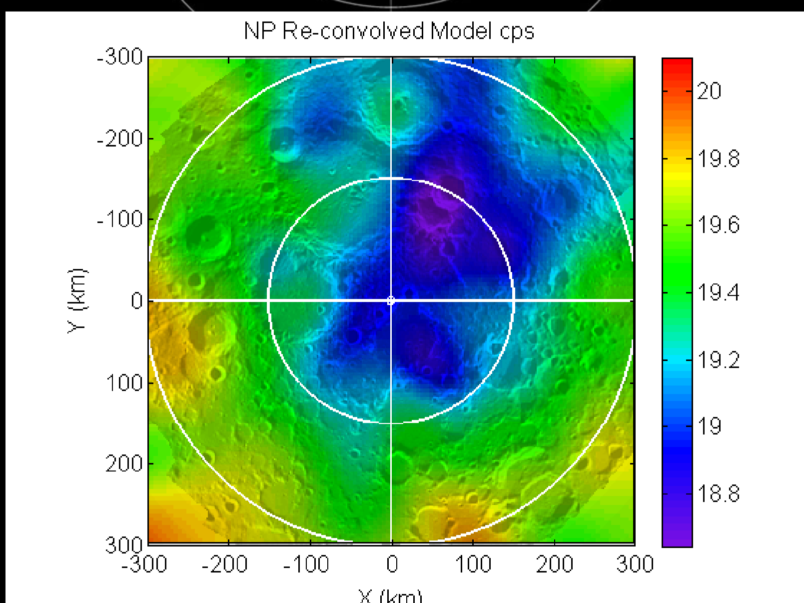
- LP Neutron Spectrometer data indicate polar H content of ~150 ppm
  - LP NS pixels are large
  - H could be of solar wind origin and uniformly distribution
  - H could be of solar wind or cometary origin and cold trapped in permanent shadows
- Pyroclastic deposits suggested to have high H content
  - Apollo 17 orange glass and Apollo 15 green glass highly enriched in volatile elements
- Oxygen can be found globally – H is the resource driver

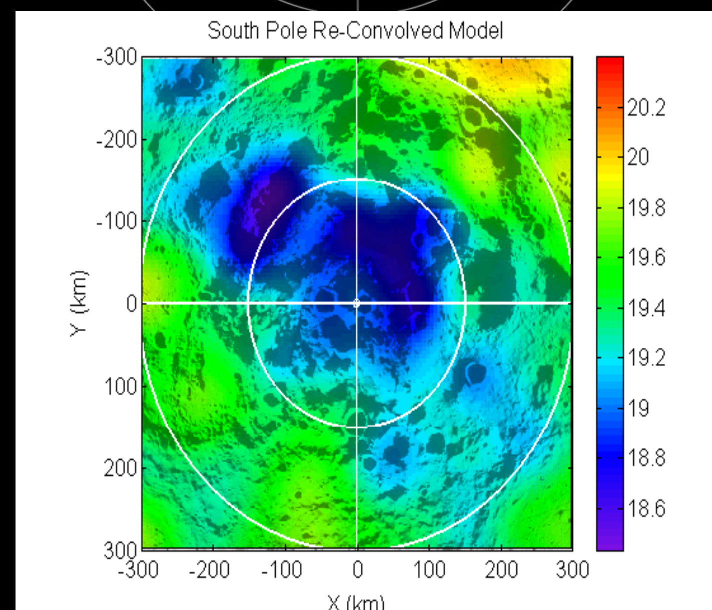
Lunar Precursor Robotic Program

Polar Volatiles: Shadows, Neutrons, Radar, Imagination

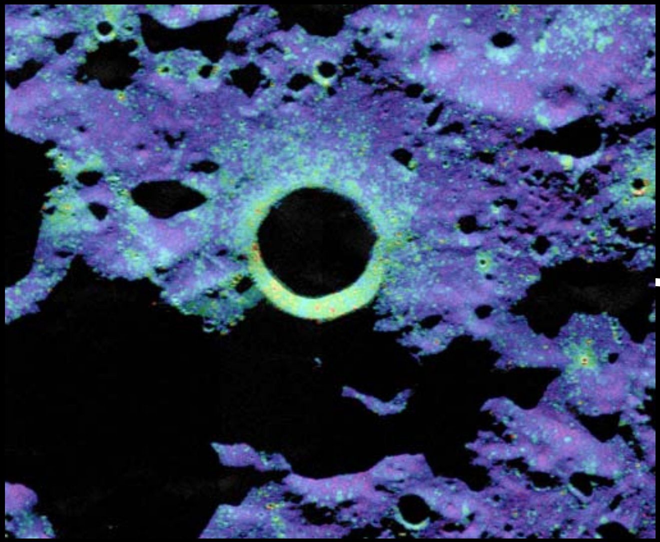


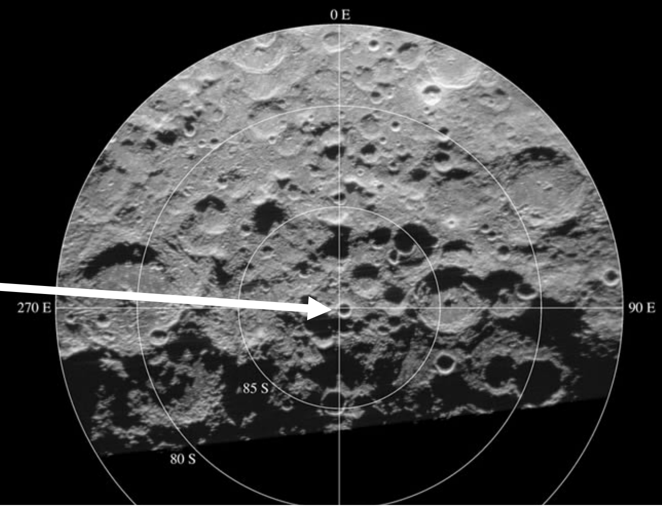


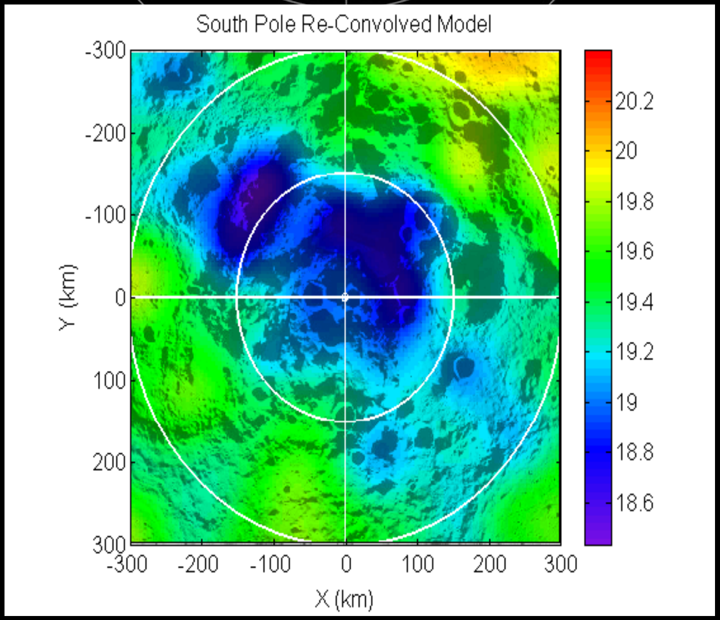


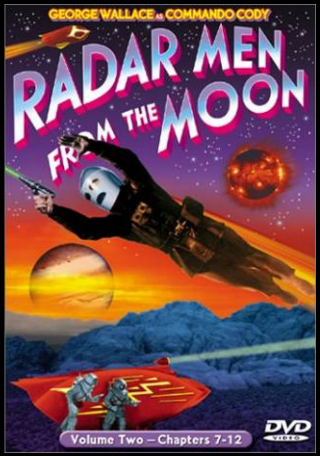


Lunar Precursor Robotic Program
Polar Volatiles: Shadows, Neutrons, Radar, Imagination









Incremental Understanding of H Distribution

Architectual 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*

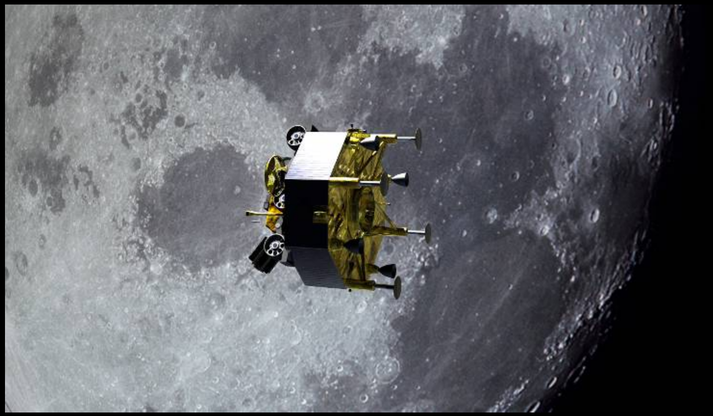
Polar Light Mission - Notional

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

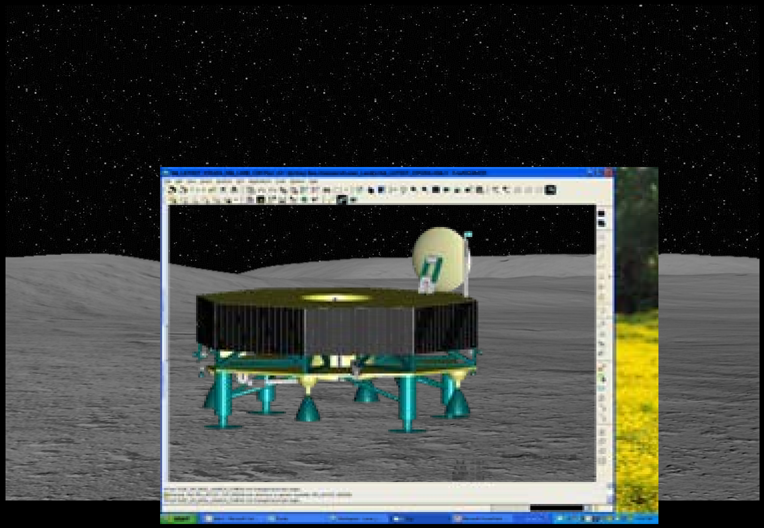
Characterize sun illumination over a seasonal cycle

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

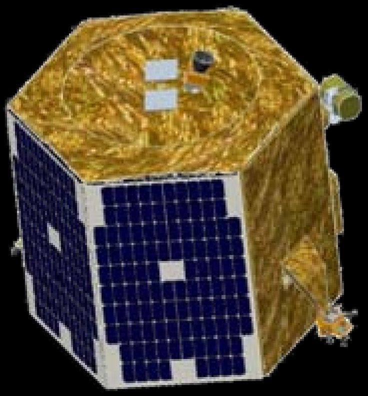
Possible micro-rover for near-field investigation (if funded separately)



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

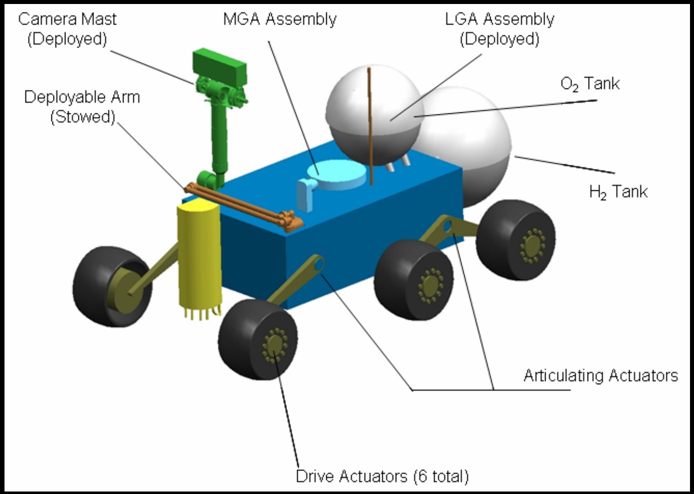
Concept of Operations

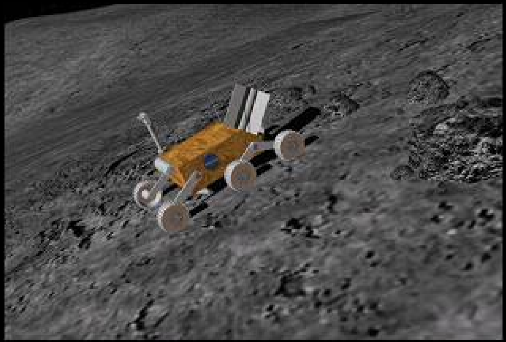
Rover delivered directly to the crater floor by the lander (which expires shortly after rover egress)

Rover traverses to selected sites obtaining ground penetrating radar and neutron spectrometer profiles along the way

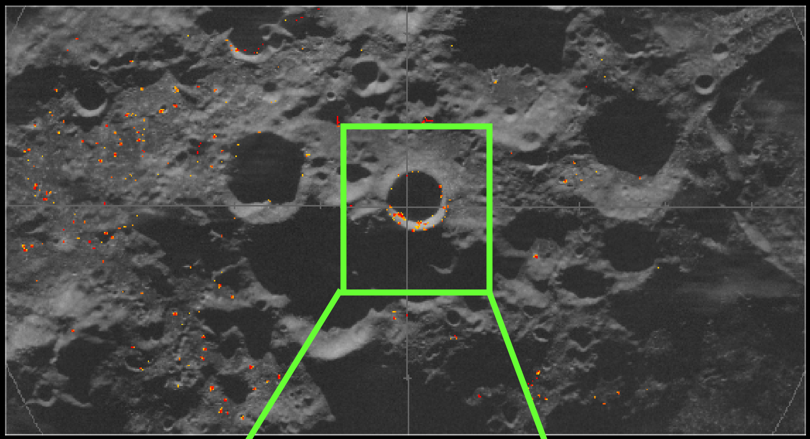
Sampling at predetermined site, rover drills and samples material approximately every 50 cm to a maximum depth of 2 m

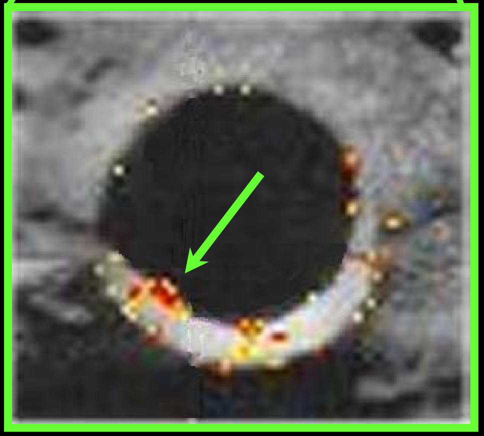
On-board analysis of volatile content and composition



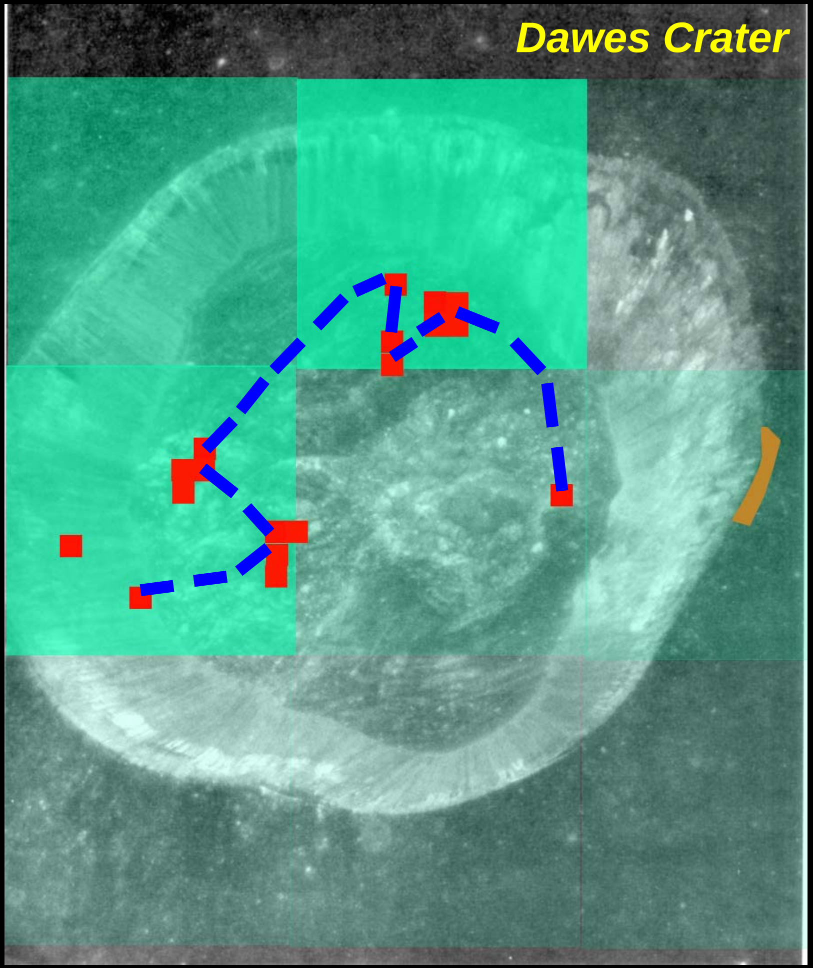


Lunar Precursor Robotic Program
Polar Dark Mission with Rover - Notional





*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

Lunar Architecture Decision

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