The Lunar Volatiles Orbiter: A Solar System Volatiles Mission

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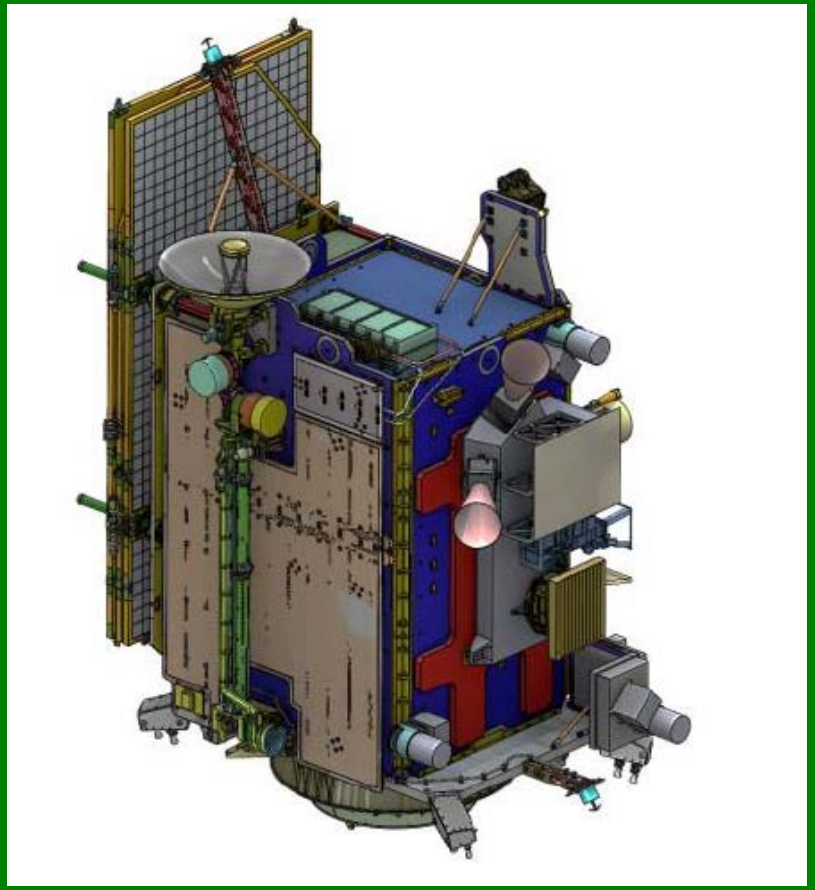
Mission Overview

- Discovery-class mission in development
- Understand the interaction of solar system volatiles with airless bodies using the Moon as a natural laboratory
- One year, polar orbiting satellite
- Based largely on the on-going Lunar Reconnaissance Orbiter
- Suite of surface and atmosphere sensing instruments will test a range of hypotheses for how volatiles move and evolve through the lunar system



Science Objectives

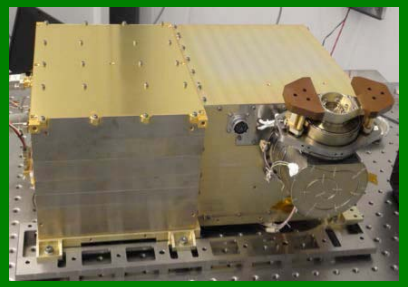
- The Hydrogen Cycle
- Water in the Lunar Environment
- The Surface-Subsurface Connection
- The Ancient Volatile system

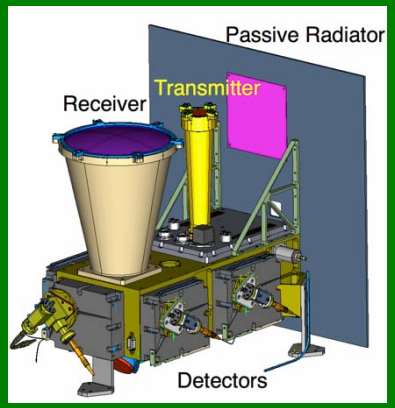
The Hydrogen Cycle

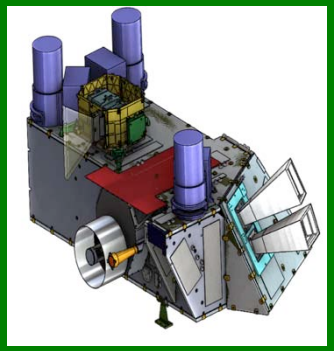
- H is the principal constituent of the solar wind, a critical source of volatiles to the lunar system
- H reacts with surface materials to produce hydroxyl and possibly water
- The hydrogen budget is incompletely understood

The Hydrogen Cycle

- Neutral ion mass spectrometer
  - Measure the abundance and direction of H with latitude, time of day
- Laser spectrometer
  - Measures time variability of hydroxyl over lunar diurnal cycle
- Infrared imaging spectrometer
  - Extends spatial coverage
  - Leverages laser measurements





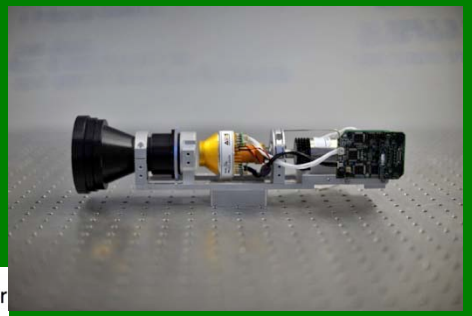


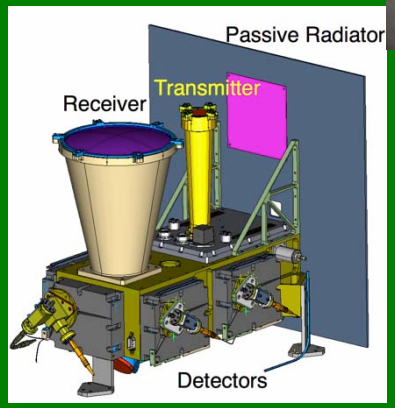
Water in the Lunar Environment

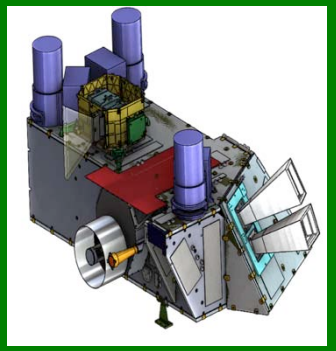
- Water
  - Special chemical properties
  - Mobile
  - Potential space resource
- Surface ice on polar surfaces (Moon, Ceres, Mercury)
- Mobility unknown
- Sources not constrained

Water in the Lunar Environment

- Laser spectrometer
  - Detection of surface ice in permanent shadow at poles
- Near-IR spectrometer
  - Extends coverage of laser spectrometer
  - Improved species identification
- 6 micron spectrometer
  - Definitive detection and characterization of molecular water

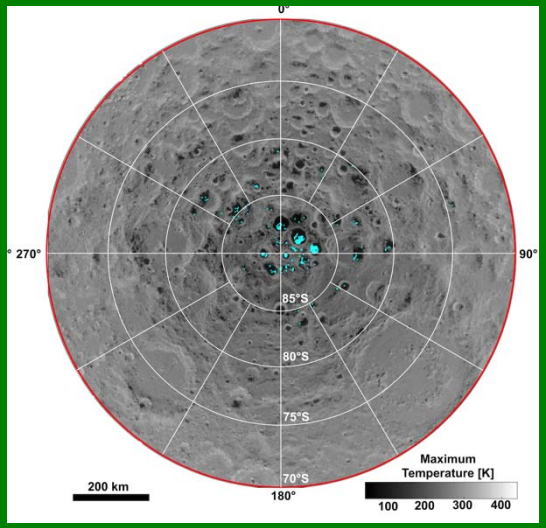


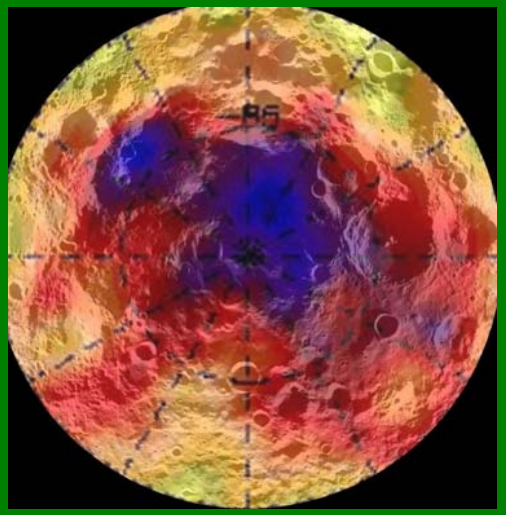




The Surface-Subsurface Connection

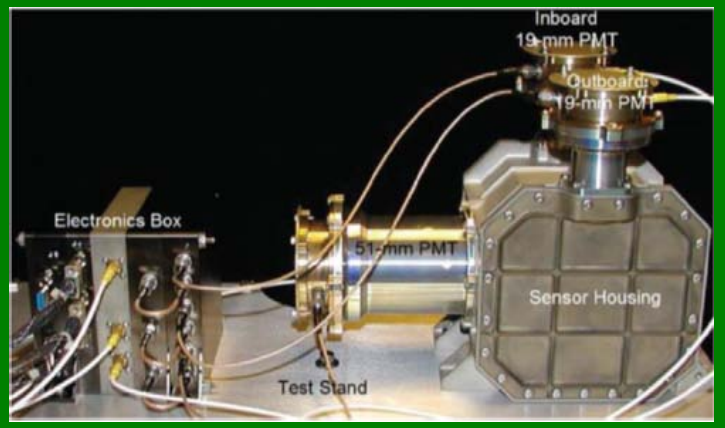
- Surface and subsurface ice is present in lunar polar regions
- Connection between the two reservoirs are unknown
  - Constant communication
  - No communication





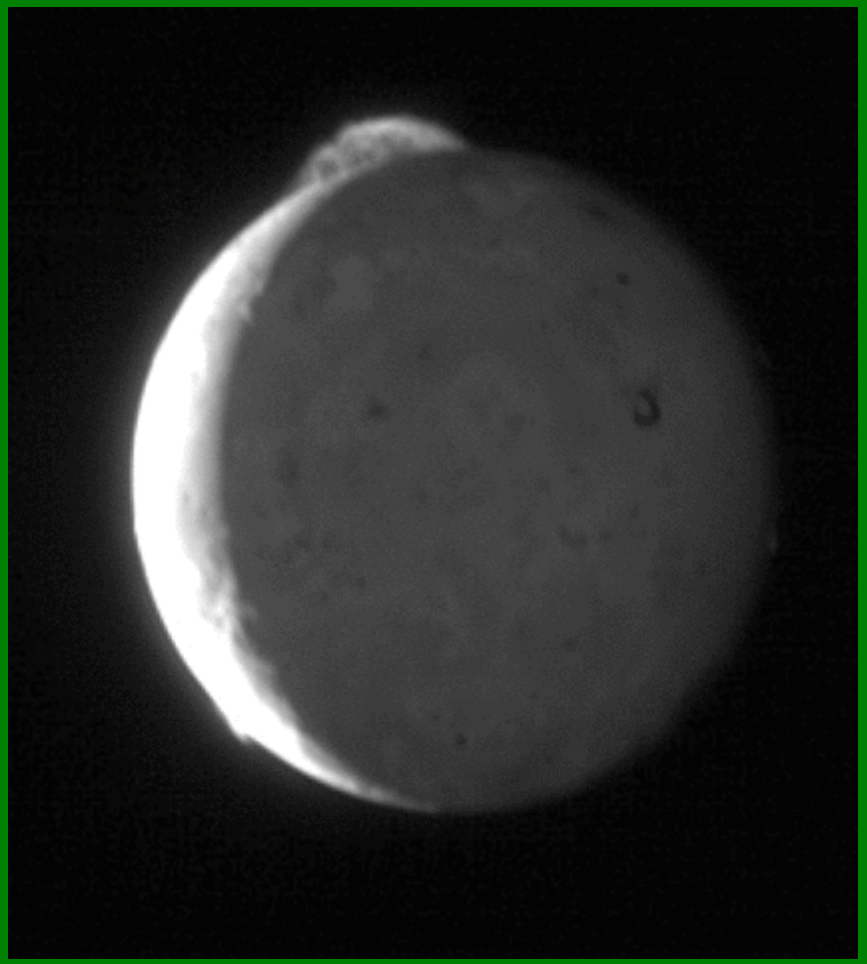
The Surface-Subsurface Connection

- High resolution neutron/gamma spectroscopy
  - Determine thickness of surface ice deposits
  - Determine spatial relationship between reservoirs as clue to connection



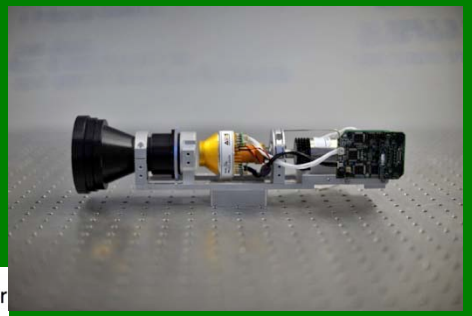
The Ancient Volatile system

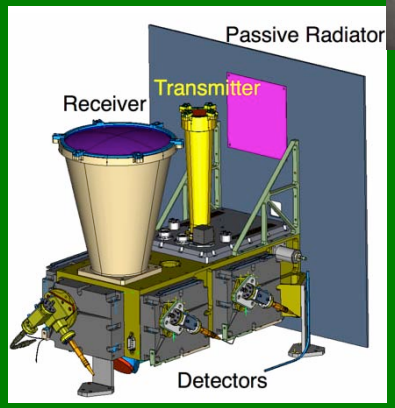
- Large impacts and lunar volcanism and tectonics supplied volatiles system with high masses
- Response to these impulses unknown
- Volatile species released not well constrained

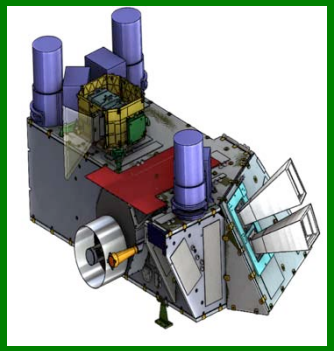


The Ancient Volatile system

- IR spectrometers determine H-bearing species and abundances at key sites
  - Water v hydroxyl
- Models verified from other science objectives inform volatile transport

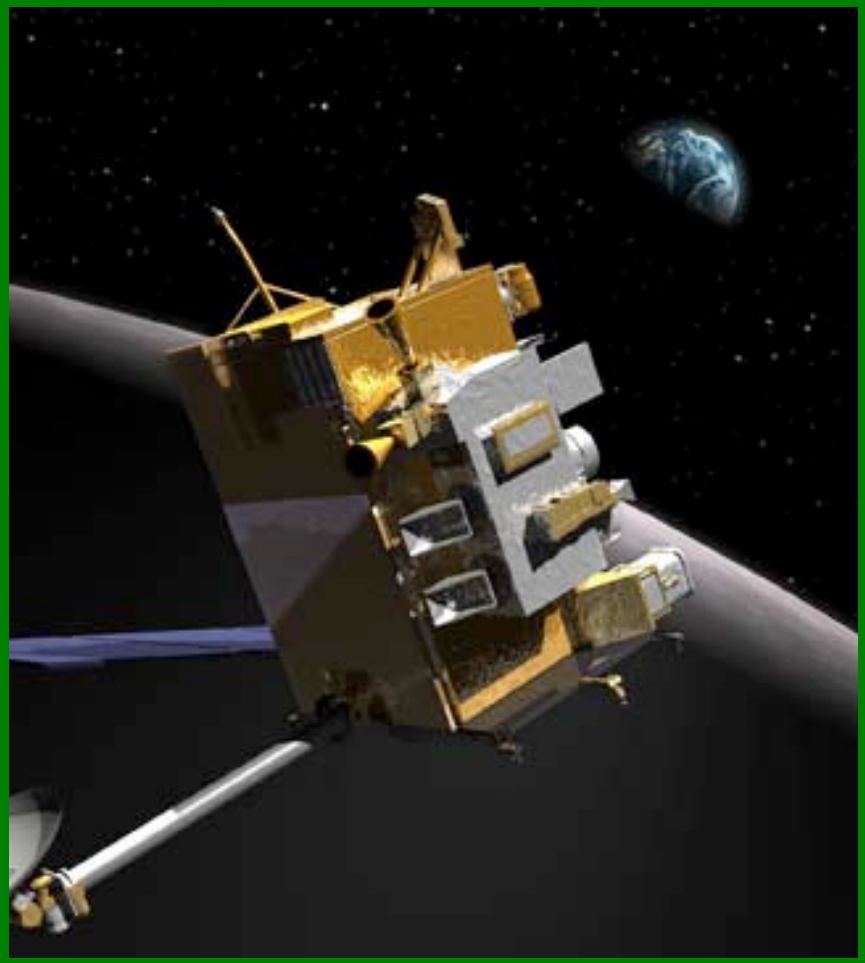






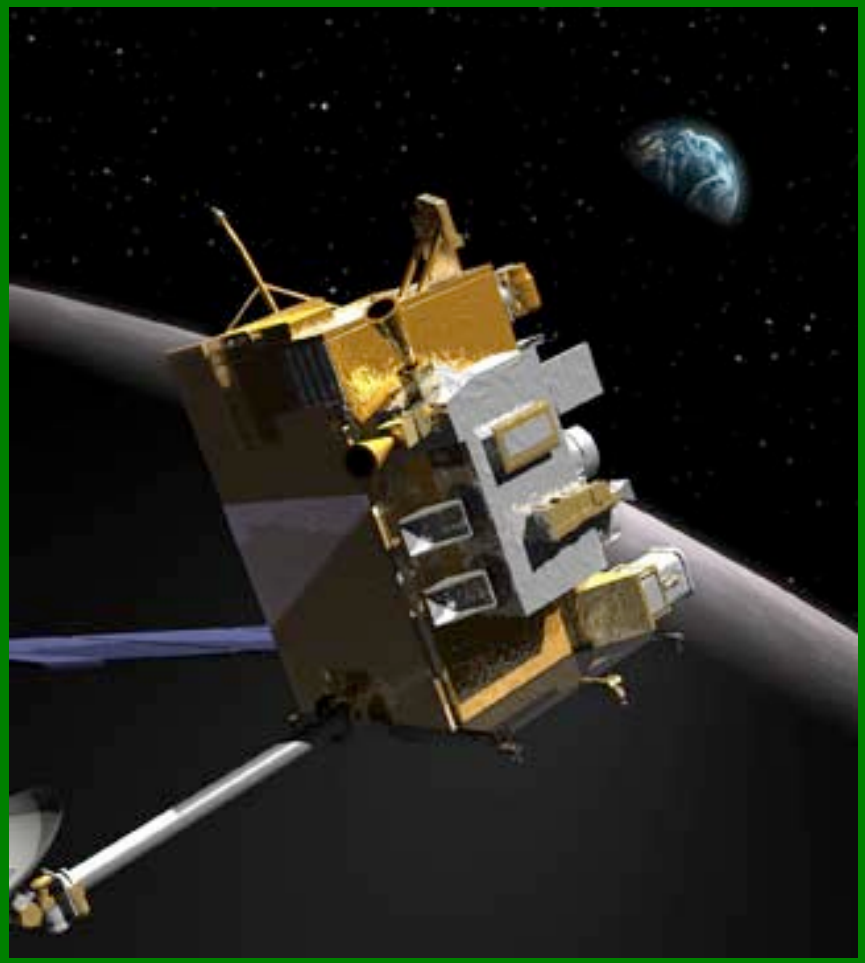
Mission Overview

- Leverage LRO design and operations to contain cost
- Constrain science objectives to LRO performance
  - LRO capabilities drove science requirements



Mission Overview

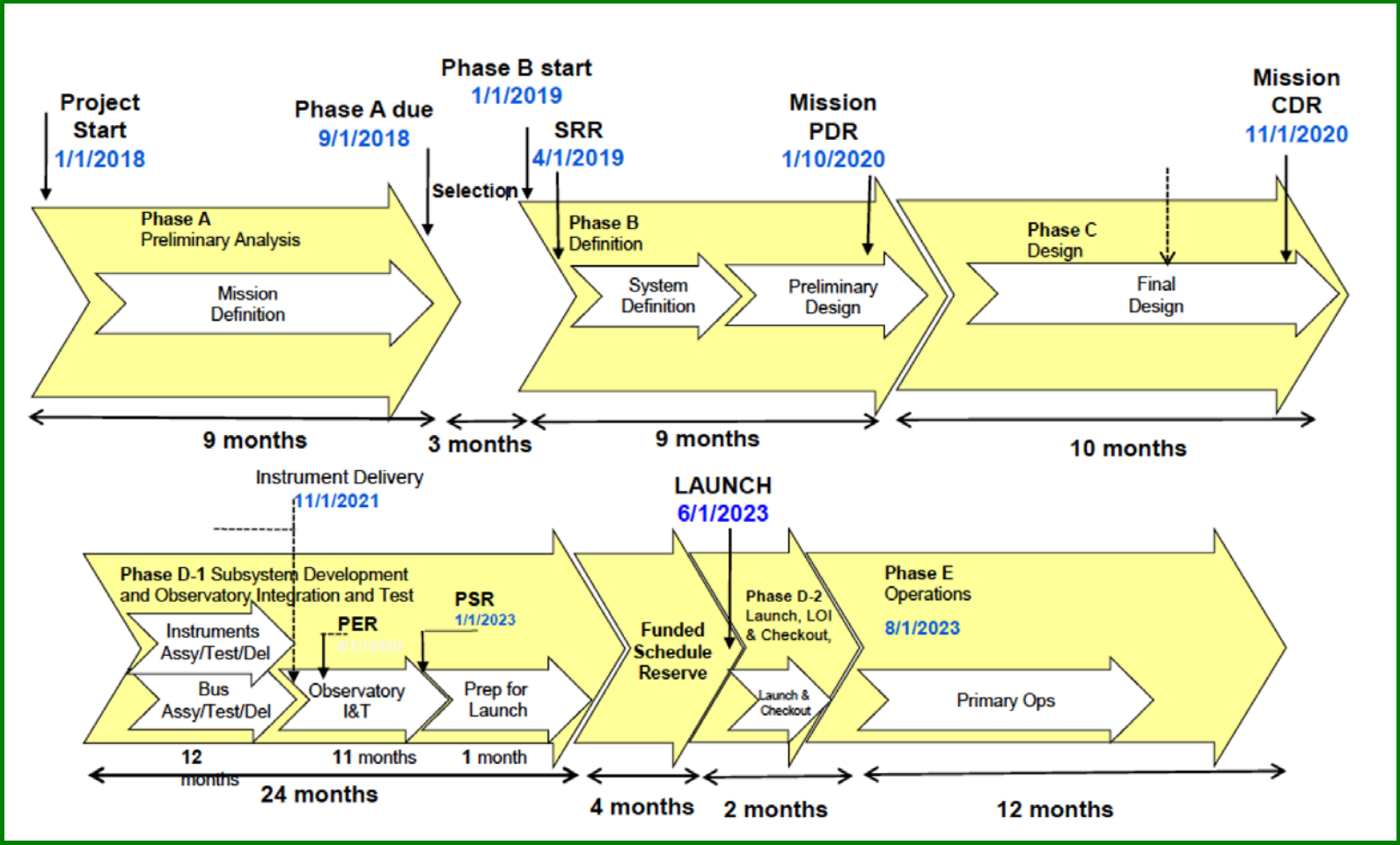
- Class C mission
- 14 month mission design life (2 months of commissioning followed by a 12 month science mission) with the goal of a two year extended mission in a low maintenance orbit
- 50 km +/-20 km, circular lunar orbit with 90˚ inclination



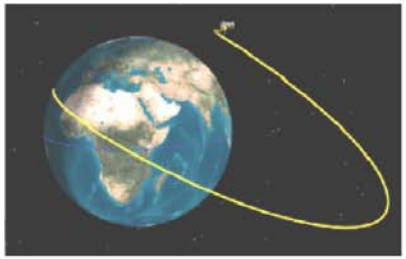
Mission Overview

- Launch on EELV class rocket (Atlas V, Delta IV or Falcon 9)
- Maximum launch mass same as LRO (2000 kg) to keep propellant requirements the same as LRO.
- Launch vehicle will have excess launch capacity that will allow for ride sharing with other payloads. (i.e. Like LCROSS)
- No data latency requirements
- Maximum daily science data volume is 560 Gbits(This is based on three 45 minute ground contacts per day plus the required margin)
- Launch date: 6/2023 assumed. Actual launch date will depend on the Discovery AO.

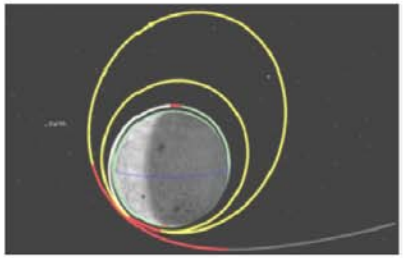
Mission Schedule



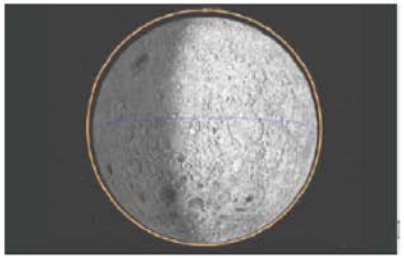
Trajectory and Orbit



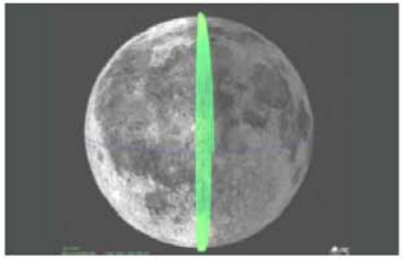
~ 4 Day minimum energy Lunar transfer



Lunar Orbit Insertion Sequence 4 maneuvers, 4-6 days



Commissioning phase, 30 x 216 km Altitude Quasi-Frozen Orbit, up to 60 Days



Science phase, 50 km circular, 90 degree inclination orbit, > 12 months followed by an extended mission

Mission Phases

- Launch –EELV puts LVO in direct lunar trajectory
- Early Cruise –acquire the sun, deploy solar array and high gain antenna system; check out propulsion system, initial MCC tracking ~ 1 day
- Mid-Course Correction –adjust trajectory, execute burn within 24 hours of launch
- Late cruise –plan for Lunar Orbit Insertion (LOI), spacecraft check out ~ 3 days
- LOI –Perform Lunar capture maneuvers, achieve low energy commissioning orbit
- Commissioning –full check out of spacecraft, instrument turn on, check out and calibrations, mission orbit adjustment ~ 60 days
- Nominal mission –data collection, delta V/delta H maneuvers, instrument special activities including target 'tracking mode' operations
- Extended mission –Fuel margin included to support a range of options

Conclusion

- Mission leverages new discoveries in planetary science, maps on to Discovery program goals
- Heavily leverages existing LRO spacecraft to contain cost
  - Increases instrument budget
- Science traceability constrained to LRO capabilities
  - "Wag the dog"