



SCIENCE & MISSION SYSTEMS



Lunar Overview

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Agenda



- I. Lunar Precursor Robotics Program (LPRP)
- II. Altair
- III. Lunar Science Program (LSP)
- IV. Questions



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Lunar Precursor Robotics Program (LPRP)



- LPRP Program Description

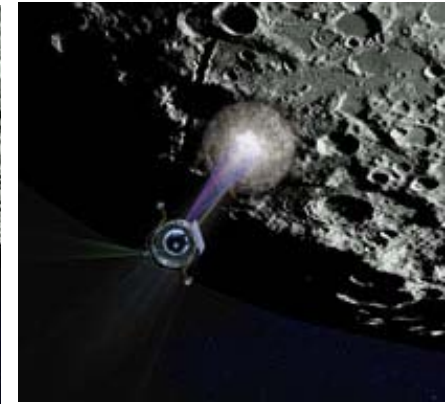
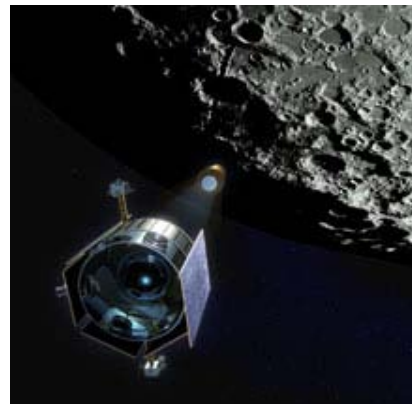
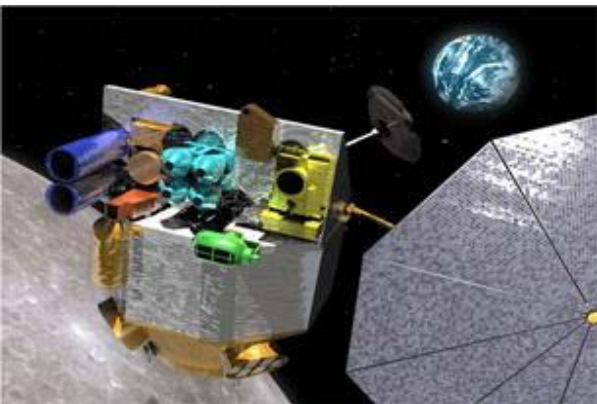
- The goal of the LPRP is to undertake robotic lunar exploration missions that will return data to advance our knowledge of the lunar environment and allow United States (US) exploration architecture objectives to be accomplished earlier and with less cost through application of robotic systems. LPRP will also reduce risk to crew and maximize crew efficiency by accomplishing tasks through precursor robotic missions, and by providing assistance to human explorers on the Moon.

- Objectives

- Starting no later than 2008, initiate robotic missions to the Moon to prepare and support future human exploration activities.

- Customer

- ESMD Advanced Capabilities Division
- Constellation Program



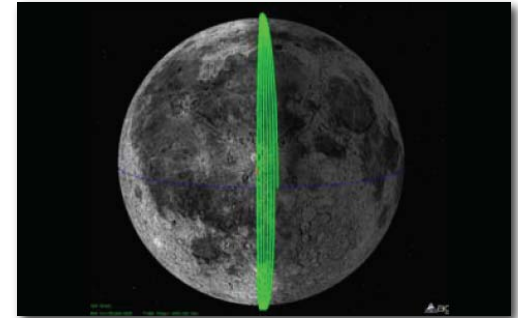


Lunar Reconnaissance Orbiter:

Launch April 2009



- Lead Center: GSFC
- Mission Description: One year mission in a 50 km lunar polar orbit
- Mission Objectives:
 - Characterize lunar radiation environment, biological impacts, and potential mitigation
 - High resolution global, three-d geodetic grid of the Moon
 - Resources at the Moon's poles
 - High spatial resolution addressing elemental composition, mineralogy, and Regolith characteristics
- Organizations: NASA GSFC (LOLA), Boston University (CRaTER), Arizona State University (LROC), Russia Institute for Space Research (LEND), Southwest Research Institute (LAMP), UCLA (DIVINER)



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



Nominal End of ESMD Mission: February 2010



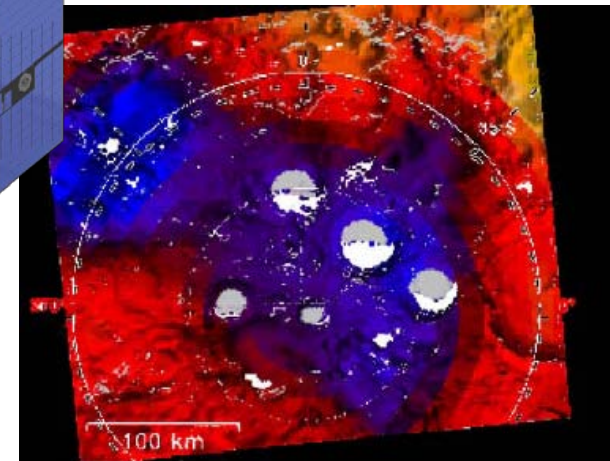
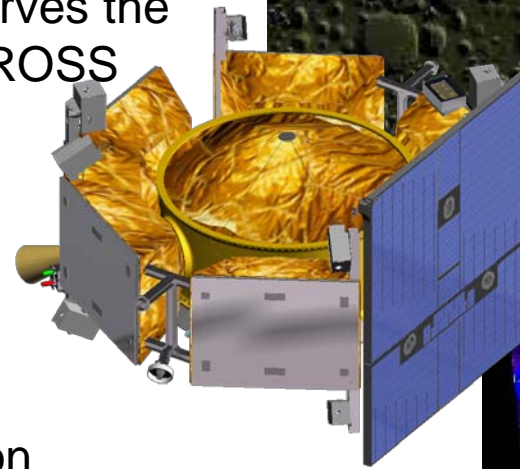


Lunar Crater Observation and Sensing Satellite:

Launch April 2009



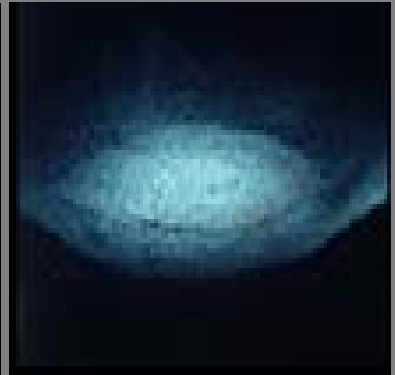
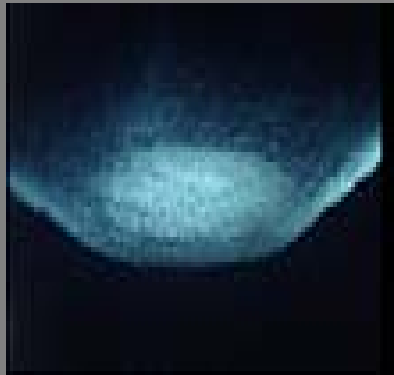
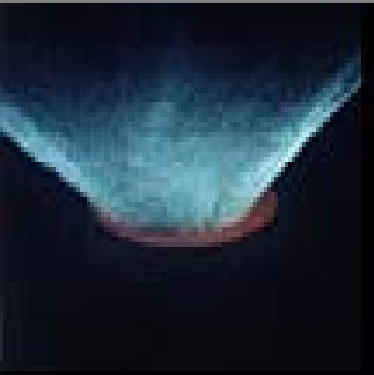
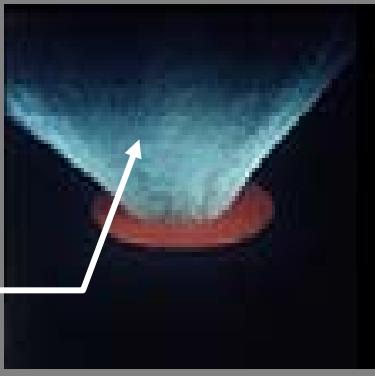
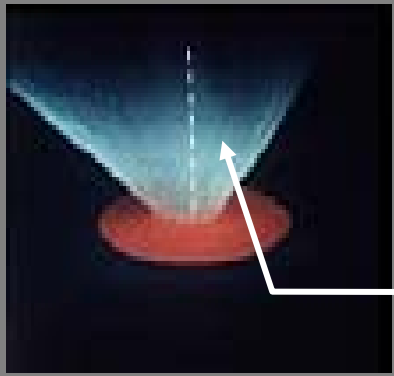
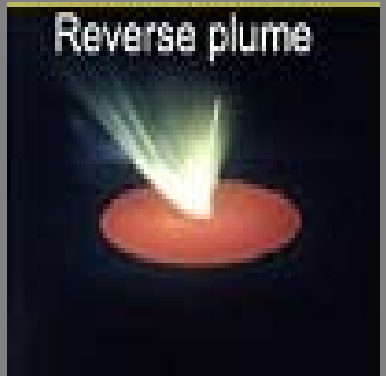
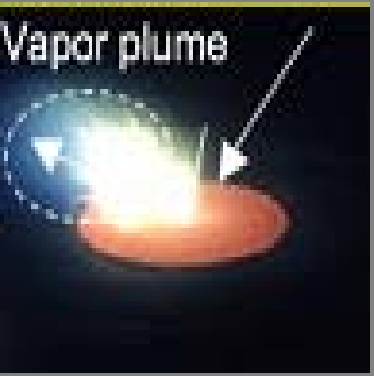
- Lead Center: Ames
- Mission Description:
- Co-manifested with LRO, LCROSS spacecraft is an impactor into a polar crater looking for water ice.
- The shepherding spacecraft releases Centaur upper stage and observes the upper stage impact before LCROSS impact.
- Mission Objectives:
 - Image the ejecta cloud
 - Measure the form and concentration of water
 - Measure ejecta composition
 - Measure other volatiles in the ejecta
- Organizations: NGST (Spacecraft)



Lunar Prospector Hydrogen Map
(Maurice et al., 2003)



Impact Concept



Ejecta Curtain

Peter Schultz



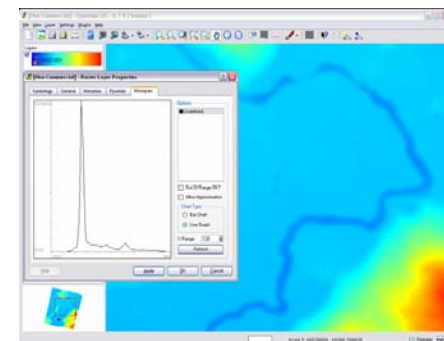
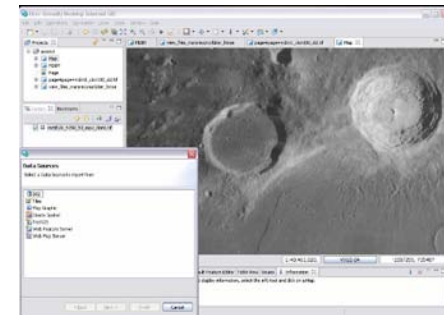
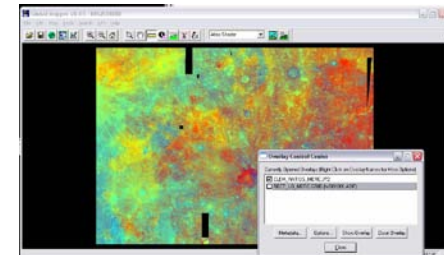
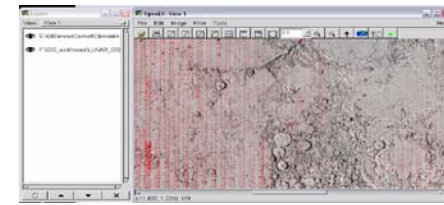
- Impact the moon at 2.5 km/sec with a Centaur upper stage and create an ejecta cloud that may reach up to 35 km above the surface.
- Observe the impact and ejecta with instruments that can detect water.



Lunar Mapping Project



- Lead Center: MSFC
- Project Description: Produce various lunar maps, tools, models, and displays from LRO and other lunar International Missions to support the Constellation engineers responsible for developing the Lunar elements as part of the VSE
- Objectives (tentative):
 - Lunar lighting, temperature, maps
 - Geo-registered global and local image maps
 - Digital Elevation Models
 - Rock abundance and surface roughness
 - Resource Maps
 - Geographical Information System
- Organizations: ESMD/Constellation Modeling, SMD, Constellation Environments Group, GSFC, Ames, USGS, JPL, CRREL, Constellation engineering, Constellation Program Science, EPO, MSFC, APL





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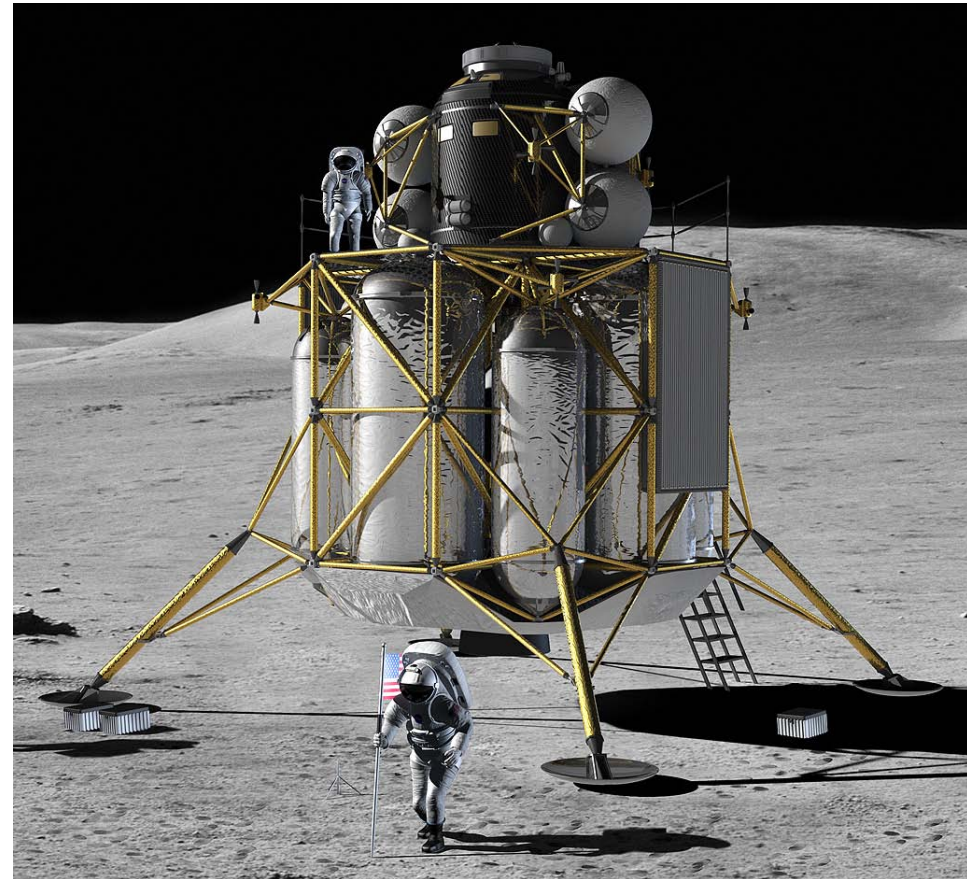
Altair Project

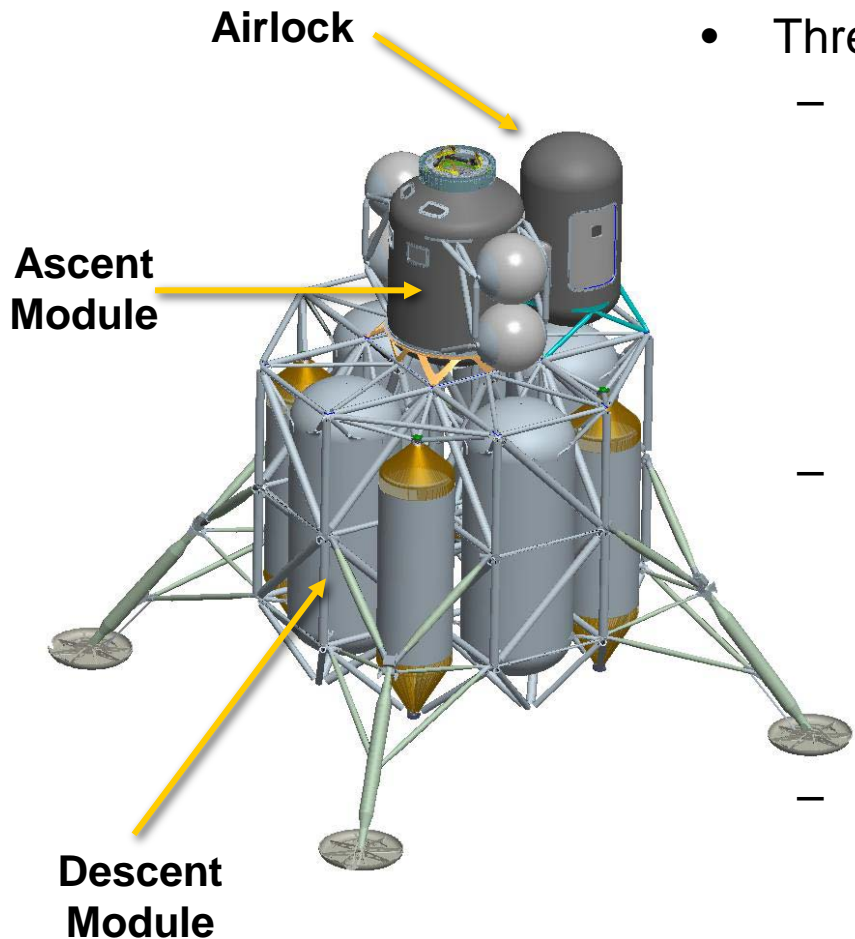


Altair Lunar Lander



- 4 crew to and from the surface
 - Seven days on the surface
 - Lunar outpost crew rotation
- Global access capability
- Anytime return to Earth
- Capability to land 14 to 17 metric tons of dedicated cargo
- Airlock for surface activities
- Descent stage:
 - Liquid oxygen / liquid hydrogen propulsion
- Ascent stage:
 - Hypergolic Propellants or Liquid oxygen/methane





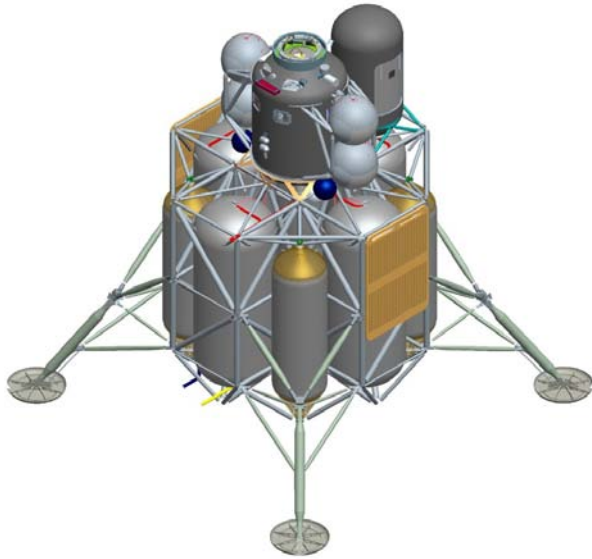
- Three Primary Elements
 - Descent module
 - Provides propulsion for LOI and powered descent
 - Provides power during lunar transit, descent, and surface operations
 - Serves as platform for lunar landing and liftoff of ascent module
 - Ascent module
 - Provides propulsion for ascent from lunar surface after surface mission
 - Provides habitable volume for four during descent, surface, and ascent operations
 - Contains cockpit and majority of avionics
 - Airlock
 - Accommodates two astronauts per ingress/egress cycle
 - Connected to ascent module via short tunnel
 - Remains with descent module on lunar surface after ascent module liftoff



- 3 Design Reference Missions (DRMs) with Mission Timelines and Functional Allocations
 - Sortie Mission to South Pole
 - 4 Crew / 7 Days on Surface / No support from surface assets
 - No restrictions on 'when' (accommodating eclipse periods)
 - Outpost Mission to South Pole
 - 4 Crew with Cargo Element (LAT Campaign option 2)
 - Outpost provides habitation on surface (down and out)
 - 210 Days with surface support (power)
 - Cargo Mission to South Pole
 - Short duration, large payload
- One Lander design, with variants (kits) if required for the different DRMs

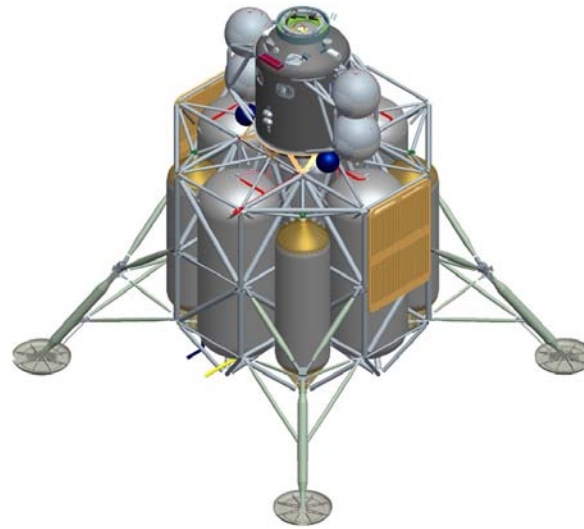


Configuration Variants



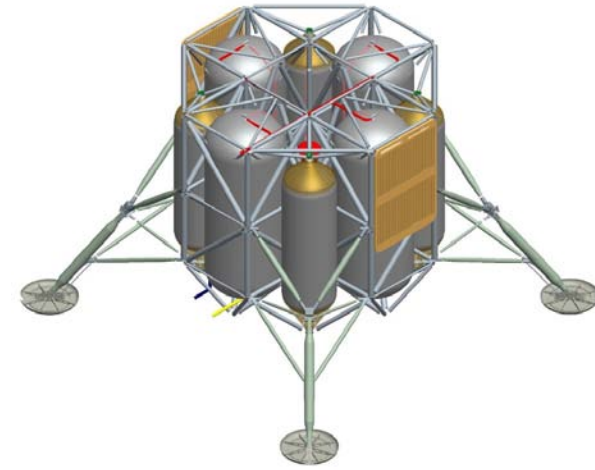
Sortie Variant
45,000 kg

Descent Module
Ascent Module
Airlock



Outpost Variant
45,000 kg

Descent Module
Ascent Module



Cargo Variant
53,600 kg

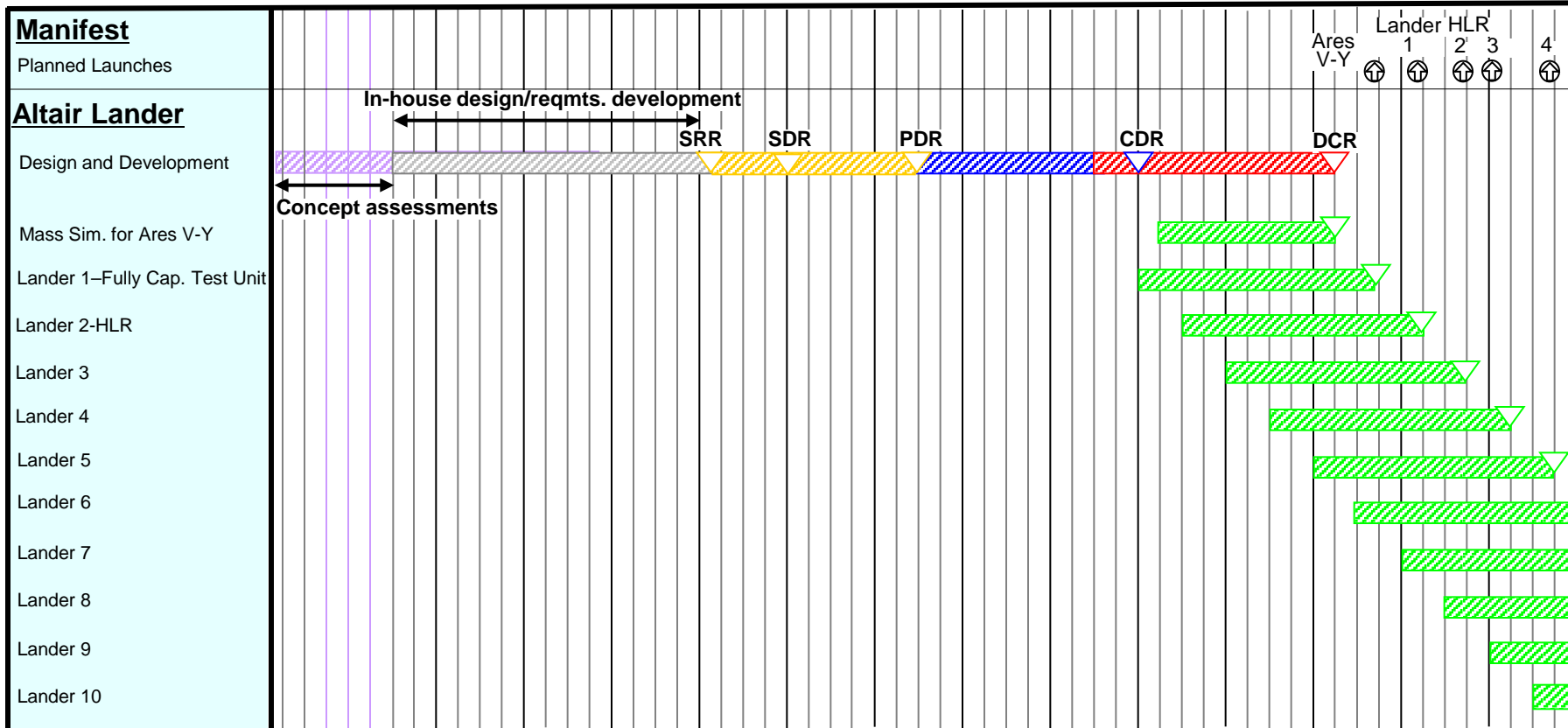
Descent Module
Cargo on Upper Deck



Draft Lunar Lander Schedule (Accelerated SRR Schedule)



FY06 | FY07 | FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 | FY16 | FY17 | FY18 | FY19 | FY20



Note: Schedule still preliminary. Milestone timing dependent on funding availability, which is in work.

Note 1: Assumed all Lander deliveries 6 months prior to launch

Note 2: Schedule based on parametric cost estimate





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Lunar Science Program (LSP)



- Lunar Missions will be highly focused and thus directed.
- Mission 1: Small Orbiter launched in 2010 or 2011
- Missions 2 & 3 : Two Small “Mini” Landers launched in 2012, 2013, or 2014 (depending on resource availability) to form the anchor nodes for a International Lunar Network
 - International Lunar Network
 - Series of US and International Partner provided Lunar Landers which act as common science nodes in a lunar geophysical network
 - Each Lander in ILN will provide a minimum core suite of 2 instruments
 - NASA will provide 2 anchor nodes (Mission 2 & 3 Landers)
 - NASA anchor nodes will drive network measurements and data formats
 - At least one International Partner (IP) needed in ILN
 - Currently have had conceptual discussions with JAXA, DLR, BNSC
 - Communication relay capability required for ILN node operation on backside of Moon



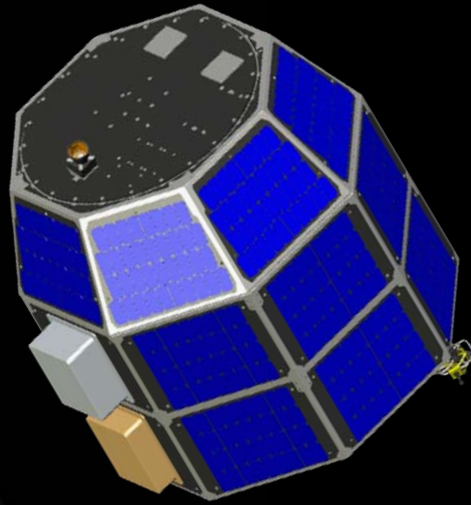
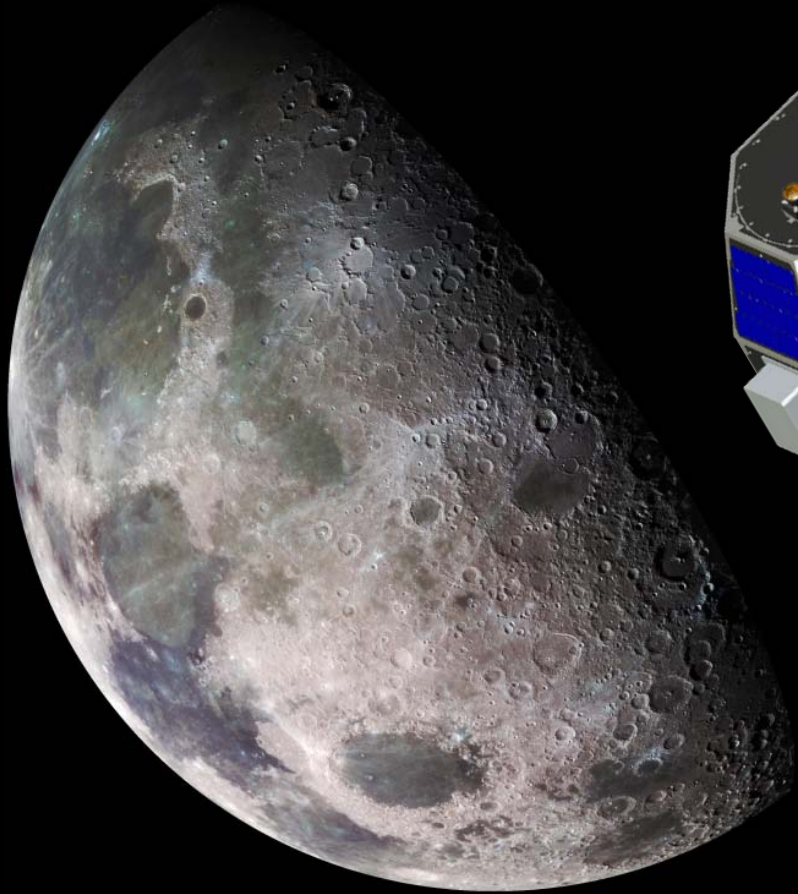
Mission 1 - Lunar Atmosphere & Dust Environment Explorer (LADEE)



- Objective
 - Measure Lunar Dust ----Supports ESMD
 - Examine the Lunar atmosphere
 - NRC recommendation to study the atmosphere early while still in low mass & pristine state
- Key parameters
 - Launch in 2010 (goal) or 2011 (threshold)
 - Mission length: 100 days in orbit
- Spacecraft
 - Type: Small Orbiter - Category III, Class D
 - Provider: ARC provided small sat (partnered with GSFC)
- Instruments
 - Core Instruments: Dust Counter, Mass Spectrometer,
 - Science Definition Team (SDT) to provide Science priorities for optional 3rd instrument
 - RFI to be used to identify in-house NASA instruments available
- Launch Vehicle
 - Minotaur V
- Dependencies
 - None



LADEE: Examining the Lunar atmosphere



SmallSat Orbiter
Provider: ARC /GSFC

Core Instruments
Dust Counter
Neutral Mass Spectrometer

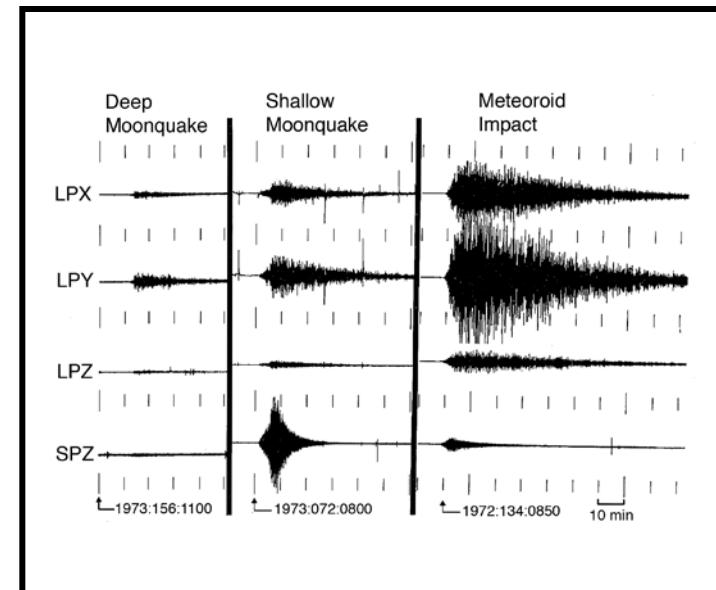
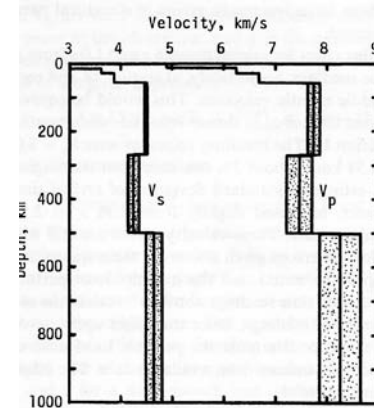
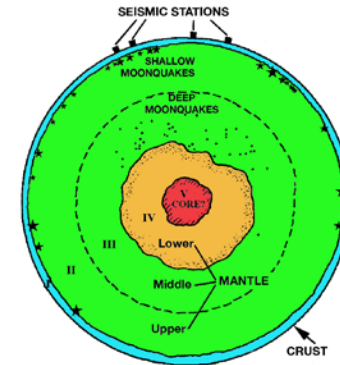


International Lunar Network (ILN): Status

MSFC APL



- A Lunar Geophysical Network has been recommended by the Scientific Context for the Exploration of the Moon (2007), the Tempe meeting (2007), and New Frontiers in the Solar System (2008)
- **The goal of a Lunar Geophysical Network is to understand the interior structure and composition of the moon -** fundamental information on the evolution of a differentiated planetary body.
 - Determine the size, composition, layering, and state (solid/liquid) of the core, mantle, and crust of the moon.
 - Characterize the thermal state of the interior





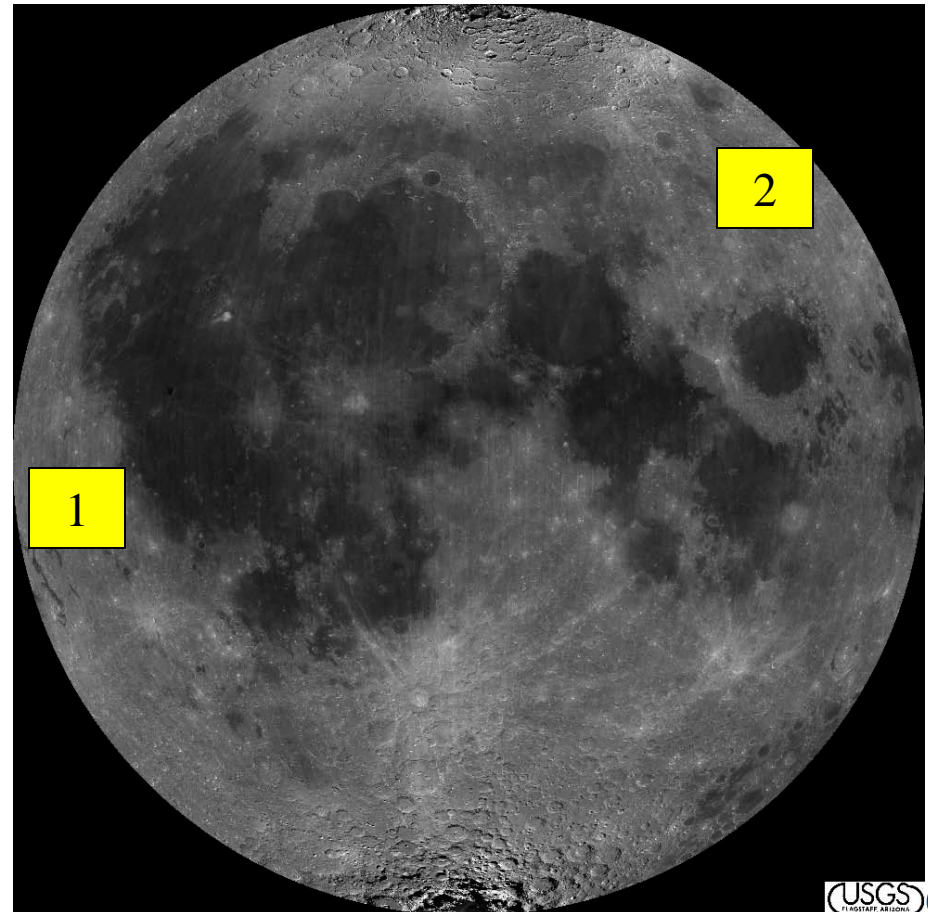
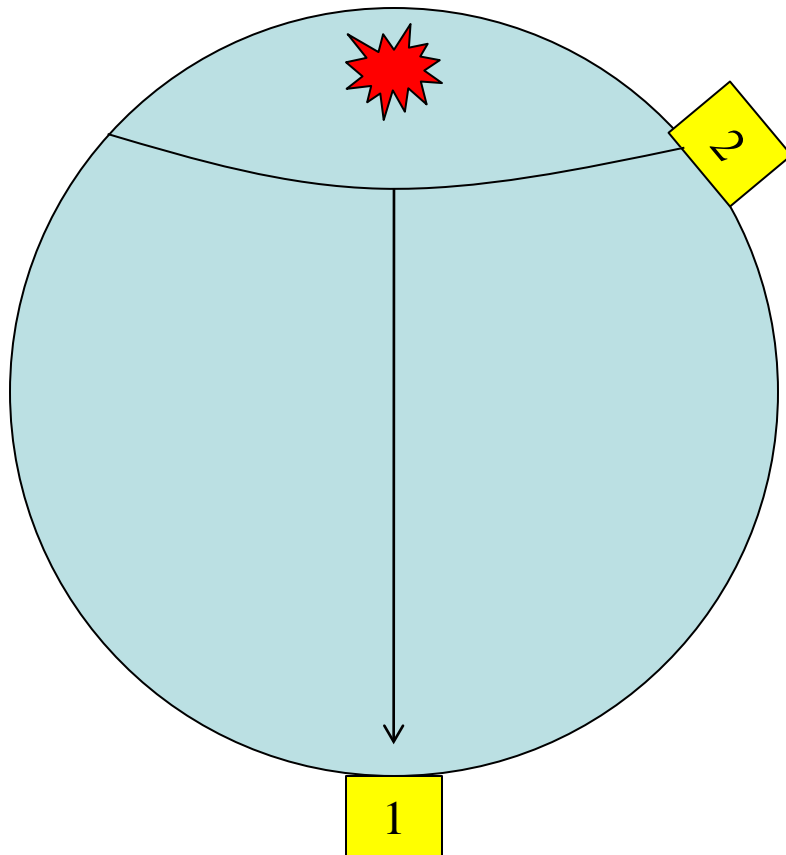
ILN SDT - Site Selection



- Convolving suitable moonquake nests with desires from heat flow and seismic access to the far side leads to the following *approximate* sites for the first two nodes:

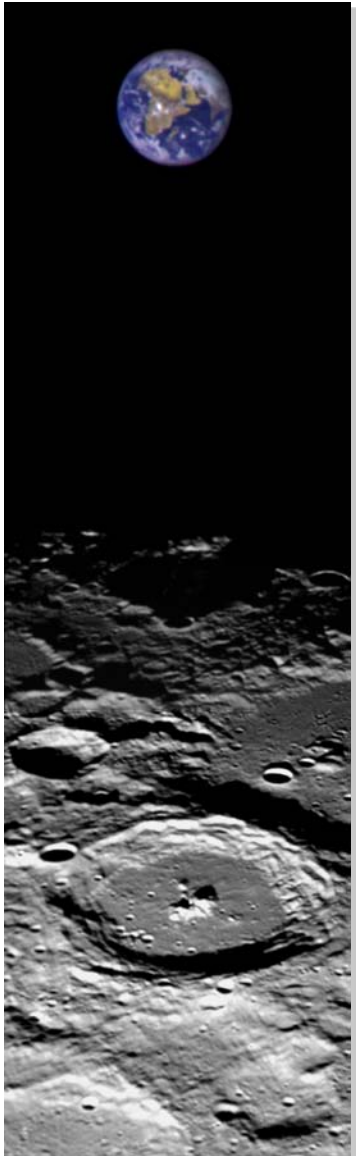
Station 1: -5°S , 75°W

Station 2: 30°N , 75°E





ILN Lander Concept Study Objectives, Assumptions, Mission Level Requirements



Develop & cost baseline and floor science missions:

- Floor mission:
 - 2 landers co-manifested to near side using direct-to-earth communication.
 - Operate together for 2 years, Seismometry only, operates continuously.
 - Precision landing not required.
- Baseline mission:
 - 4 landers; precision landing not required.
 - 2 landers co-manifested to near side using direct-to-earth communication.
 - 2 landers co-manifested to farside will use lunar relay satellite.
 - Operate together for 6 years, 2 launches 2 years apart. (8 year design life)
 - Each lander includes seismometer, heat flow instrument and EM sounder plus passive laser retroreflector array.
- Each lander includes nuclear power source (1/2 ASRG) for lunar night operation or solar + battery for continuous ops
 - One GPHS (0.53 kg Plutonium) available for each ILN Lander with development funded separately
- Launch on Minotaur V, Falcon 9 or Taurus II, certified for nuclear launch by separate funding.
- Class D Mission: Level 2 or 3 class parts, single string, accept higher risk.
- Environment:
 - 13.3 day light/ 14.7 day dark cycle
 - Radiation levels 2 krad/year on surface + 12 krad from ASRG



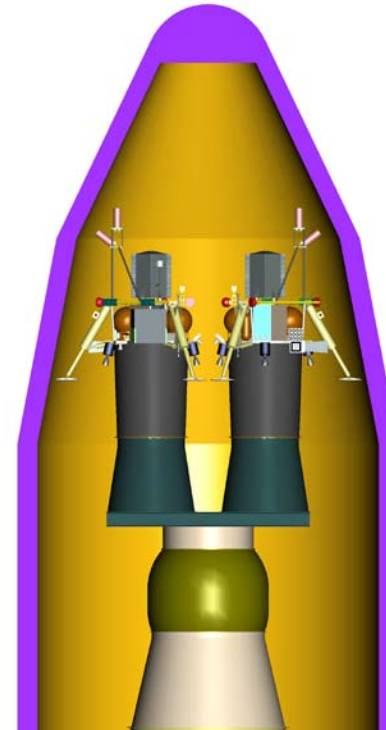
Launch Configuration - Taurus II and Minotaur V vehicles



- Lander maximum diameter sized to fit side-by-side in a Taurus II fairing or a single lander in a Minotaur V fairing.



Minotaur V



Taurus II



Lander Payload Accommodation

