3RD SPACE EXPLORATION CONFERENCE & EXHIBIT

NASA's Lunar Science Program

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Date: February 27, 2008

Overview of Lunar Activities

Science Definition and Execution (HQ: SMD)

- Strategic Planning
- Research & Analysis Administration
- Program Direction
- Robotic Science Missions
  - Gravity Recovery And Interior Laboratory (GRAIL)
  - Lunar Atmosphere Dust Environment Explorer (LADEE)
  - International Lunar Network (ILN) Landers
  - International Robotic Science Instruments

Operations (HQ: SOMD)

- Operations Systems and Demonstrations, such as Communications

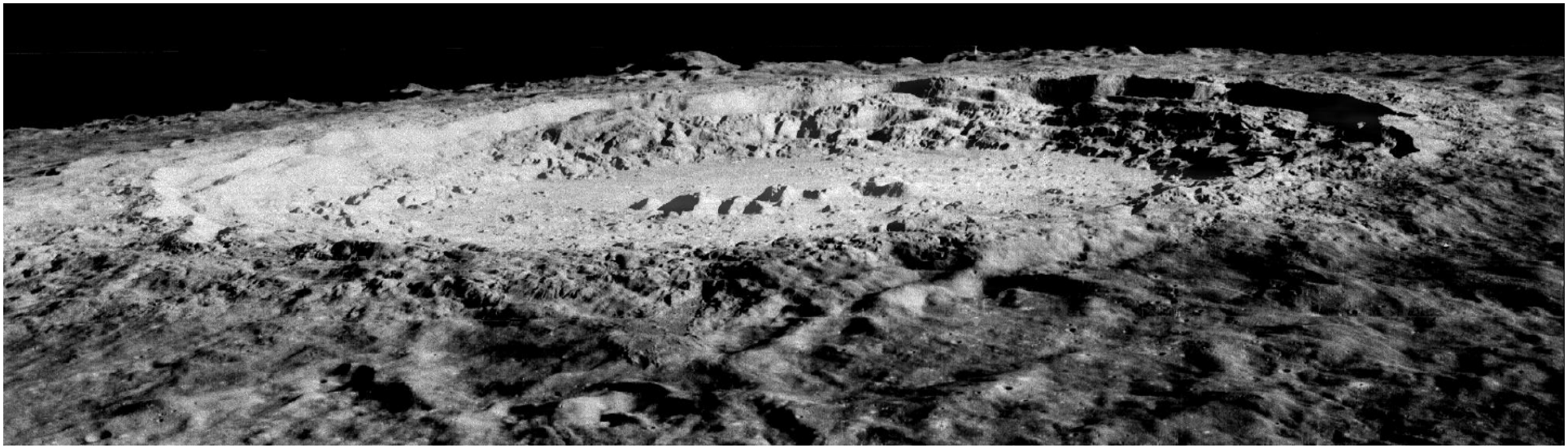
The Lunar Environment Characterization (HQ: ESMD)

- Support human Lunar landing design
- Support for Lunar surface mobility and habitability
- Cooperation with future mission of opportunity
  - Fly instruments for needed data
  - Technology demonstrations
- Robotic Missions
  - Lunar Reconnaissance Orbiter (LRO)
  - Lunar Crater Observation and Sensing Satellite (LCROSS)

Robotic Lunar Exploration

"Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare for and support future human exploration activities"
- Space Exploration Policy Directive (NPSD31), January 2004

- Objectives:
  - Environmental characterization for safe access
  - Global topography and targeted mapping for site selection and safety
  - Resource prospecting and assessment of In-Situ Resource Utilization (ISRU) possibilities
  - Technology "proving ground" to enable human exploration

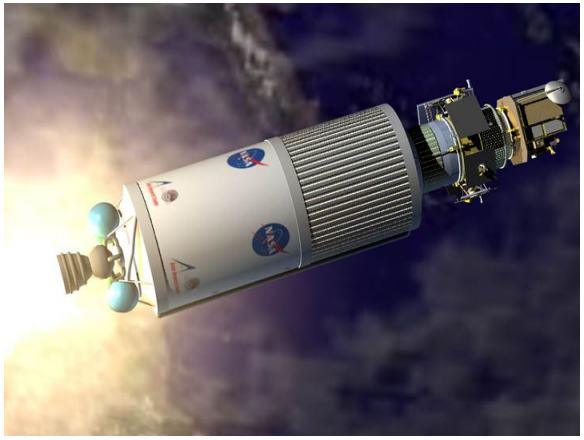


Science Mission Directorate Lunar Activities

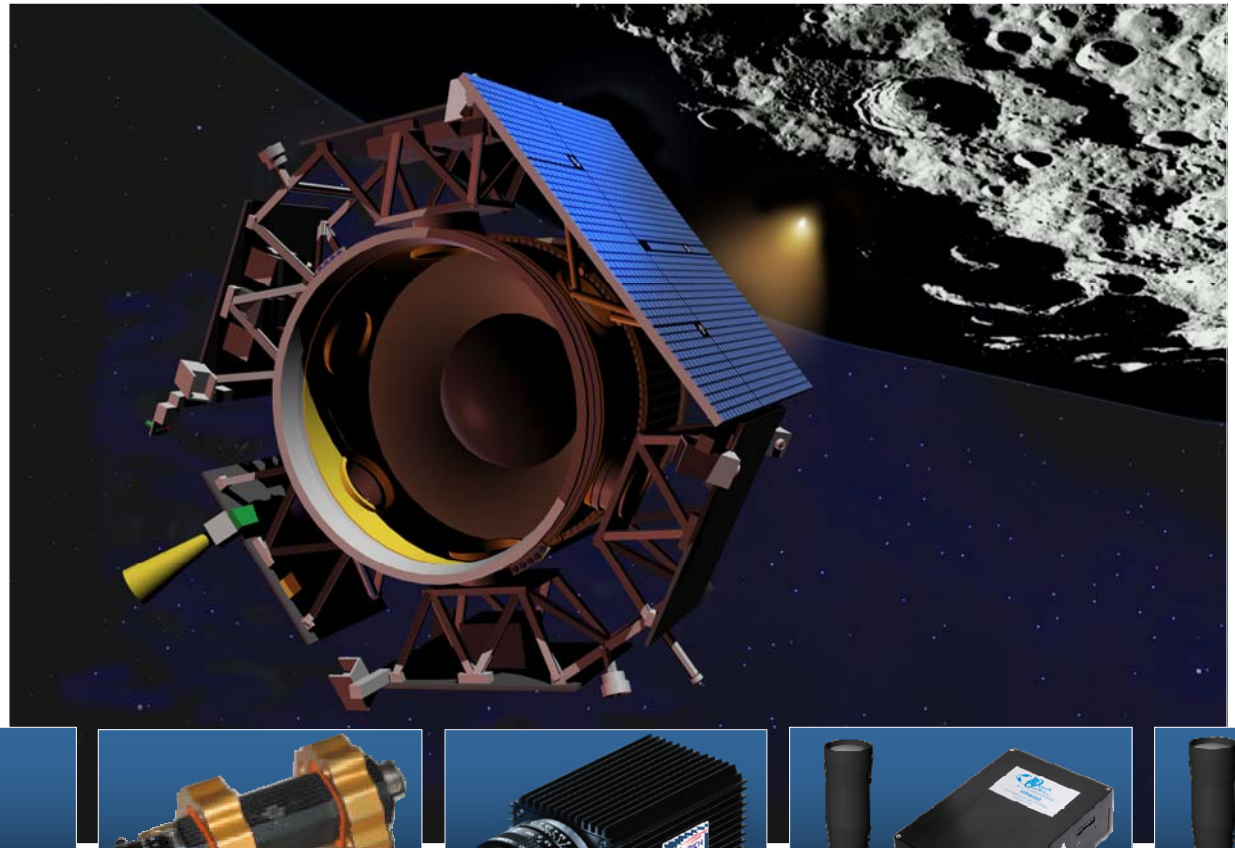
- Lunar Missions and Instruments on Missions of Opportunity
- Focused Research & Analysis (R&A)
- NASA Lunar Science Institute
- Lunar Science Conference

Lunar Reconnaissance Orbiter
(an Exploration Mission)

- LRO is NASA's first step in returning humans to the Moon.
- Focuses on identifying safe landing sites, locates lunar resources, and studies how the lunar radiation environment will affect humans.
- Will create the comprehensive atlas of the Moon's features and resources necessary to design and build the lunar outpost.
- The LRO mission will enable future exploration and also return lunar data that will significantly advance lunar and planetary science.
- LRO payload, comprised of six instruments and one technology demonstration.
- After 1 year of operation will be transferred to the Planetary Science Division



Lunar CRater Observation & Sensing Satellite



Mid-Infrared Camera
- Curtain, Crater Temperature
- Curtain Morphology
- Water Ice

Visible Camera
- Impact Context
- Curtain Morphology

Near Infrared Camera
- Water Ice / Curtain Morphology
- NIR Context

Visible Spectrometer
- Flash Spectroscopy
- Water Vapor
- Organics

Near Infrared Spectrometers
- Curtain Water Ice & Vapor
- Hydrated minerals

GRAIL: Gravity and Interior Laboratory

Newly Selected Discovery Mission
In development

Instrument: Ka-band ranging system determines the precise instantaneous relative range-rate of the two s/c; instrument is based on GRACE mission.

Flight: 3–4 month low energy trans-lunar cruise; LOI maneuvers separated by 25 hours; 50-km,near- circular polar orbits, with s/c separation of 175-225 km; 90-day Science Phase.

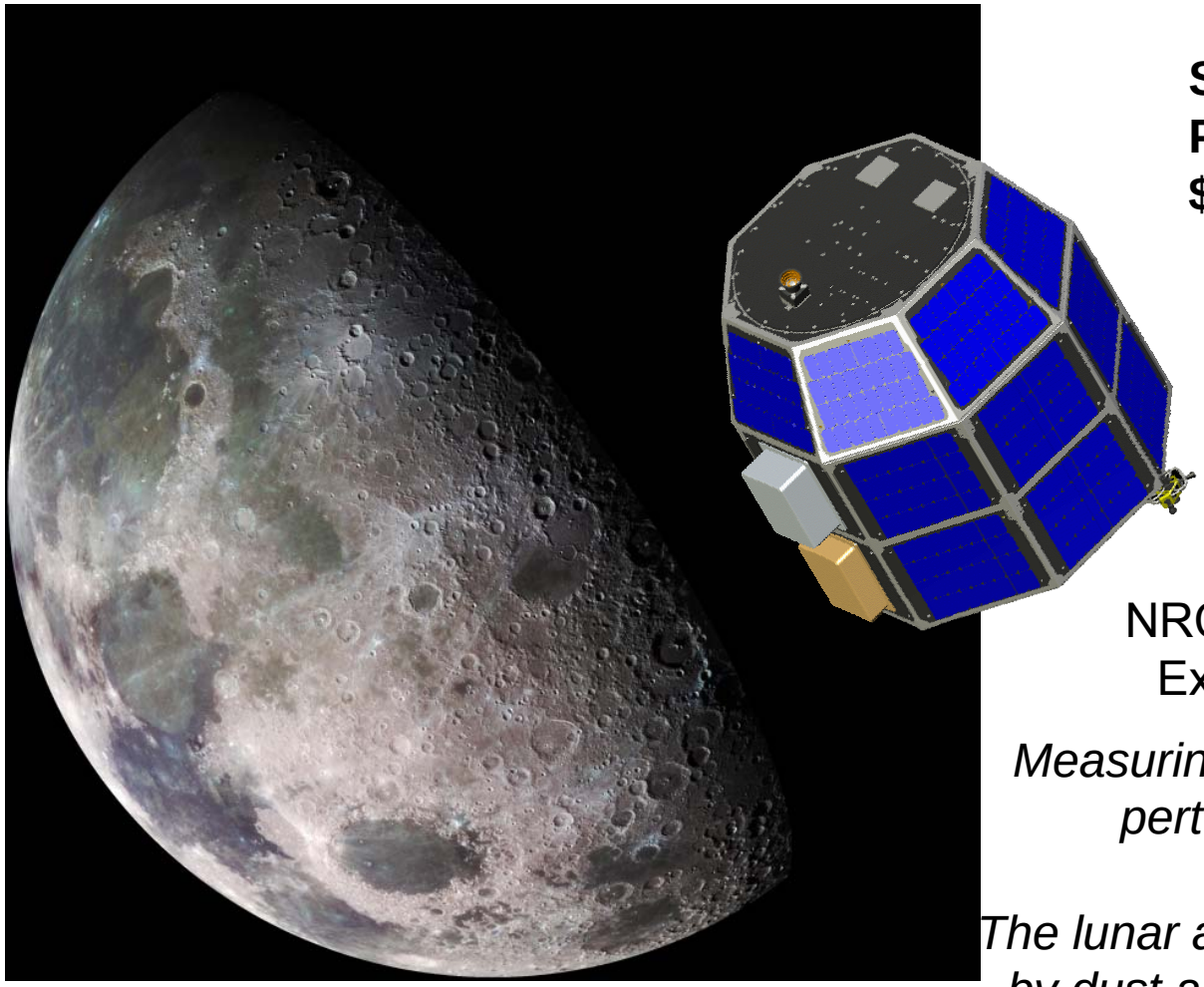
Team: PI Maria T. Zuber (MIT), DPI David E. Smith (GSFC), PM David H. Lehman (JPL), PS Michael Watkins (JPL), Co-I's from JPL, GSFC, UA, Washington University, CIW/DTM, IPGP.

Goals: Determine the structure of the lunar interior from crust to core; advance understanding of the thermal evolution of the Moon; extend knowledge gained from the Moon to the other terrestrial planets.

Mission: Provide a global, high-accuracy (<10mGal),high-resolution (30km) lunar gravity map; build upon successful GRACE mission; adapt flight-proven LM XSS-11 bus to the duel spacecraft design.

Lunar Atmosphere & Dust Environment Explorer

LADEE: Examining the Lunar atmosphere/exosphere



SmallSat Orbiter
Provider: ARC / GSFC
$80M LCC

Core Instruments:
Dust Counter
Neutral Mass Spectrometer

NRC: Scientific Context for Exploration of the Moon

Measuring the atmosphere before it is perturbed by human activity

The lunar atmosphere may be dominated by dust although its properties are not well known.

Launch in 2010 with Grail as secondary payload

International Lunar Network (ILN) Missions

- SMD/ESMD initiating an effort to coordinate future lunar landed missions into an International Lunar Network (ILN)
  - NASA provides two ILN nodes, launched to the lunar poles (TBD), in 2013/2014
  - Will consider a second pair of ILN nodes in 2016/2017
- The ILN is designed to emplace 6-8 stations on the lunar surface.
- Each ILN station would fly a core set of instrument types (e.g., seismic, laser retro-reflector, heat flow) requiring broad geographical distribution on the Moon
- Each ILN station could also include additional instruments as desired by the sponsoring space agency
  - Expect NASA instruments through Missions of Opportunity
- Informational briefing to potential ILN partner Agencies at LPSC (Mar. 11th)
- Multi-Agency meeting at LPI (Mar. 12th)
  - Form ILN charter Working Group
- ILN Charter signed (~July 20th)
  - Form ILN landing site and core instrument definition working groups
- ILN core instrument agreement (~Dec. 2008)

Moon Mineralogy Mapper (M^3)

Mission

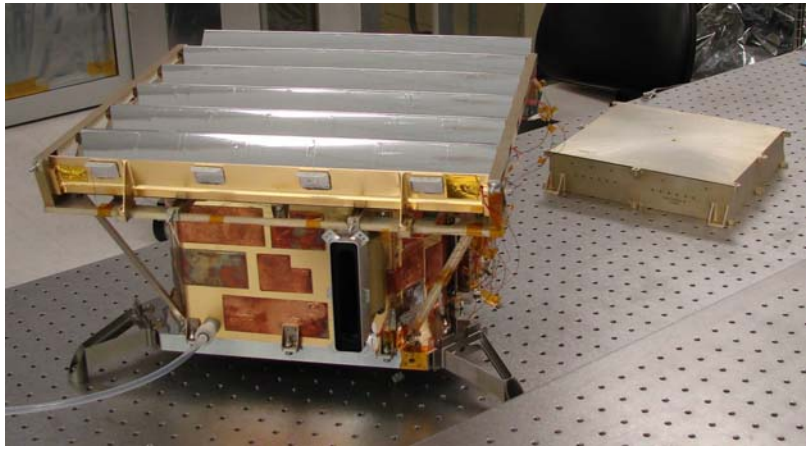
- M3 Instrument on Chandrayaan-1
- One of 11 instruments (5 of which are non-ISRO, 2 of which are from the US)
- Launch Date: Summer 2008 on ISRO's Polar Satellite LV
- Lunar Orbit: 100 km, polar; Operational life: 2 yrs

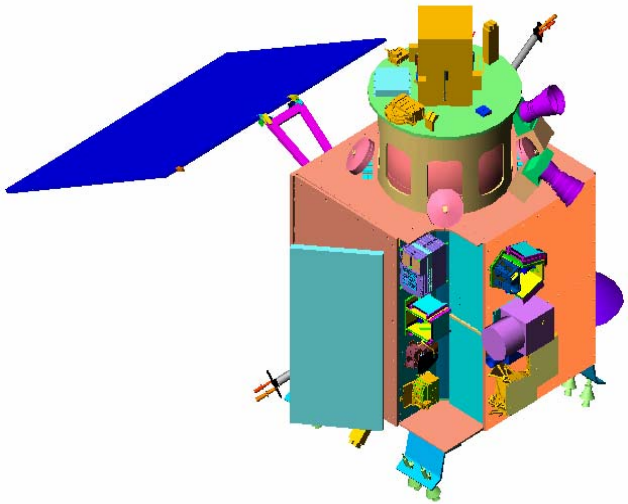
Objectives

- Produce a Global Map of the Mineralogy content Lunar surface at 140m and 40 nm spectral resolution.
- Investigate specific targets at high spatial and spectral resolution
- Investigate the possibility of surface water ice at the lunar poles

Instrument

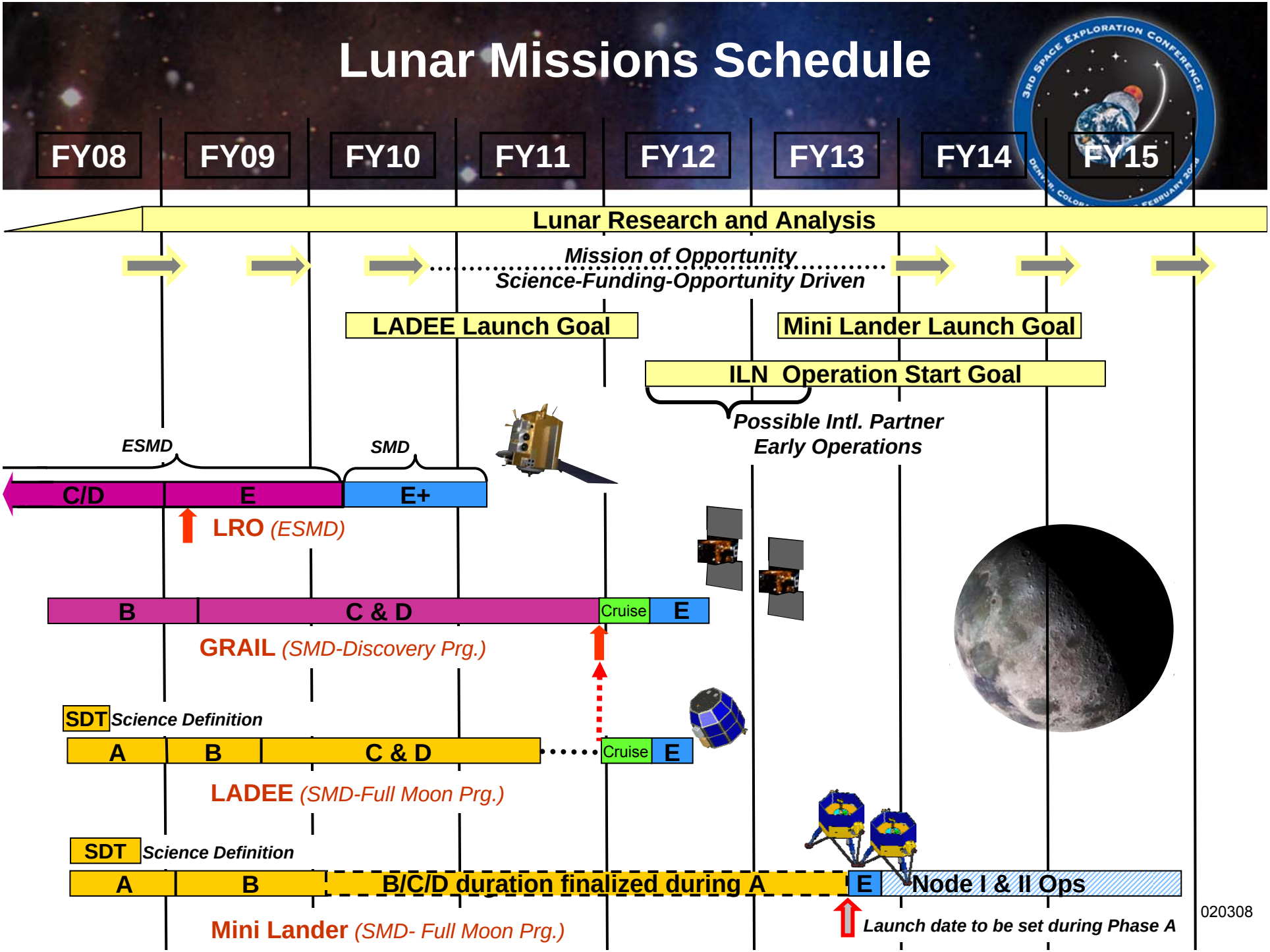
- A grating spectrometer, operating over the spectral region of 0.43 to 3 microns (Vis/Near IR)
- 2 Imaging Modes: Global (125 m res) and Targeted (63 m res)
- Instrument Delivered: Summer 2007





PI: Dr. Carle Pieters, Brown University

Lunar Missions Schedule



Lunar Research and Analysis

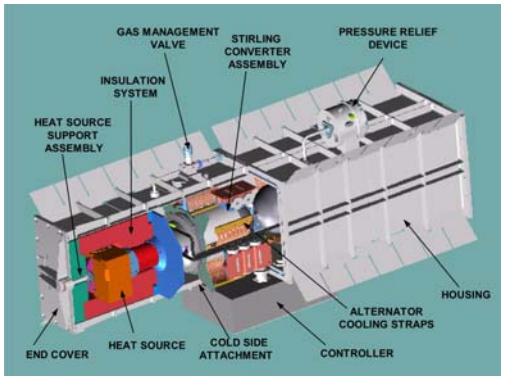
- Lunar Advanced Science & Exploration Research program (LASER)
  - Joint SMD/ESMD sponsored
  - Basic & Applied lunar research
  - Received ~160 received; selection in March
  - Up to 4-yr awards, ~ $100K/yr average
- Moon and Mars Analog Mission Activities Program (MMAMA)
  - Established to enhance science integration into VSE architecture and technology development process
  - Small pilot program, 1-yr awards ~15-50K/yr average
  - Proposals due March 14, 2008

Technology and Instrumentation

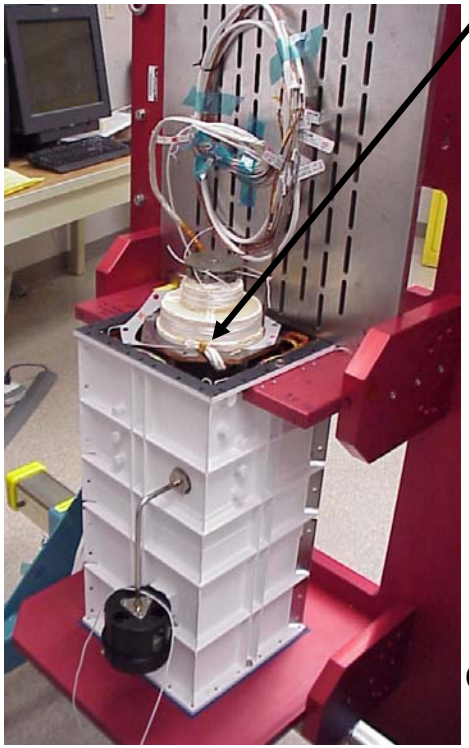
- Lunar Sortie Science Opportunities (LSSO)
  - One-year concept studies (may be considered again in FY09)
  - Selected 14 studies at ~$100K average/proposal
  - Spans geology, geophysics, physics, astronomy, & astrophysics
- Planetary Instrument Definition & Development Program (PIDDP)
  - Several lunar-focused instruments selected in 2007
  - Augmented in 2008 for add'l lunar instrument development
  - Up to 4-yr awards, ~$250K/yr average
- Stand-Alone Mission of Opportunity Notice (SALMON)
  - Call for proposals will include lunar research and missions
  - Draft to be released for comment in March
- Discovery and Mars Scout Mission Concept Studies
  - New concepts using a GFE - Radioisotope Power System
  - Received 41 proposals - 14 Lunar mission concepts
  - Evaluation in February with selection in March

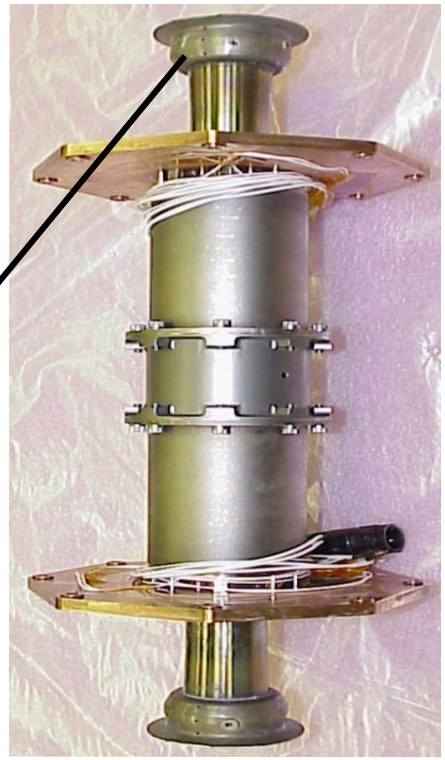
Advanced Stirling Radioisotope Generator Engineering Unit

- Operation in space and on surface of atmosphere-bearing planets and moons
- Characteristics:
  - ≥14 year lifetime
  - Specific Power – > 7 We/kg
  - Nominal power : 140 We
  - Mass ~ 20 kg
  - System efficiency: ~ 30 %
  - 2 GPHS ("Pu^{238} Bricks") modules
- Final wiring and connections for ASRG engineering unit underway
- Reliability to be demonstrated by the end of 2009



Lockheed Martin/Sunpower





Paired converters with interconnect sleeve assembly

Outboard Housing and Paired ASC-Es

NASA Lunar Science Institute

- Purpose
  - Address basic lunar science, lunar sorties and outpost applications (e.g., lunar astronomy), exploration & science needs (e.g., lunar dust).
  - Quick response capability for VSE lunar science support
  - Grow and foster a Lunar science research community
  - Support NASA lunar flight missions
  - Train the next generation of lunar scientists, and communicate lunar science with educators and the public
- Modeled after the successful NASA Astrobiology Institute (NAI)
- Structure: Central node at AMES and distributed remote nodes
  - Provide for large focused research teams 8-15 FTEs each
  - Distributed nodes: Universities, Centers, non-Profits, and international partners
  - Expect to fund 5-7 nodes at $750k-$2M/yr(SMD 4-5, ESMD 1-2)
- International Partnerships
  - Non-U.S. lunar science organizations can propose to become either Associate or Affiliate Members of the NLSI on a no-exchange-of-funds basis.
  - Requires long-term commitment with tangible and specific plans

Schedule

10/07	Alan Stern announces NLSI at DPS meeting
	NLSI assigned to ARC for implementation
11/07	Chris McKay assigned organization of first LSC
01/08	David Morrison appointed Interim Director
02/08	Search begins for permanent Director
03/08	NLSI office opens in NASA Research Park
	Website up and operating
04/08	CAN released for initial team selection
07/08	First Lunar Science Conference
	Proposals for membership due
08/08	Lunar Science Roadmap workshop
09/08	Initial member teams selected
10/08	Begin funding for selected teams