Planetary Science Update
&
Lunar Science Plans

Presentation at the 39th LPSC

James L. Green
Director, Planetary Science Division

March 12, 2008

JLG Reflections

- 18 months ago the PSD had these problems:
  - Research & Analysis was cut by 15%
    - Below life support! - Professors telling students don't go into PS
  - Astrobiology cut 50%
    - Putting in question if it would survive - NASA abandoning field?
  - New Frontiers mission Juno was being considered for cancellation (in Phase-A and over $1B)
    - Leading to the possible killing of NF program entirely
  - All NEO activities were moving to ESMD
    - A very small program but a political football
  - VSE did not include science to/from/on the Moon
    - LSSO was SMD's only activity and it was a token at best
  - No Discovery selection (deja vu)
  - No Outer Planets Flagship
    - Community to be forced to survive within a dwindling R&A program
  - PSD was grossly understaffed with low morale
- Today these are no longer PSD top problems but we do have a few different challenges

Outline

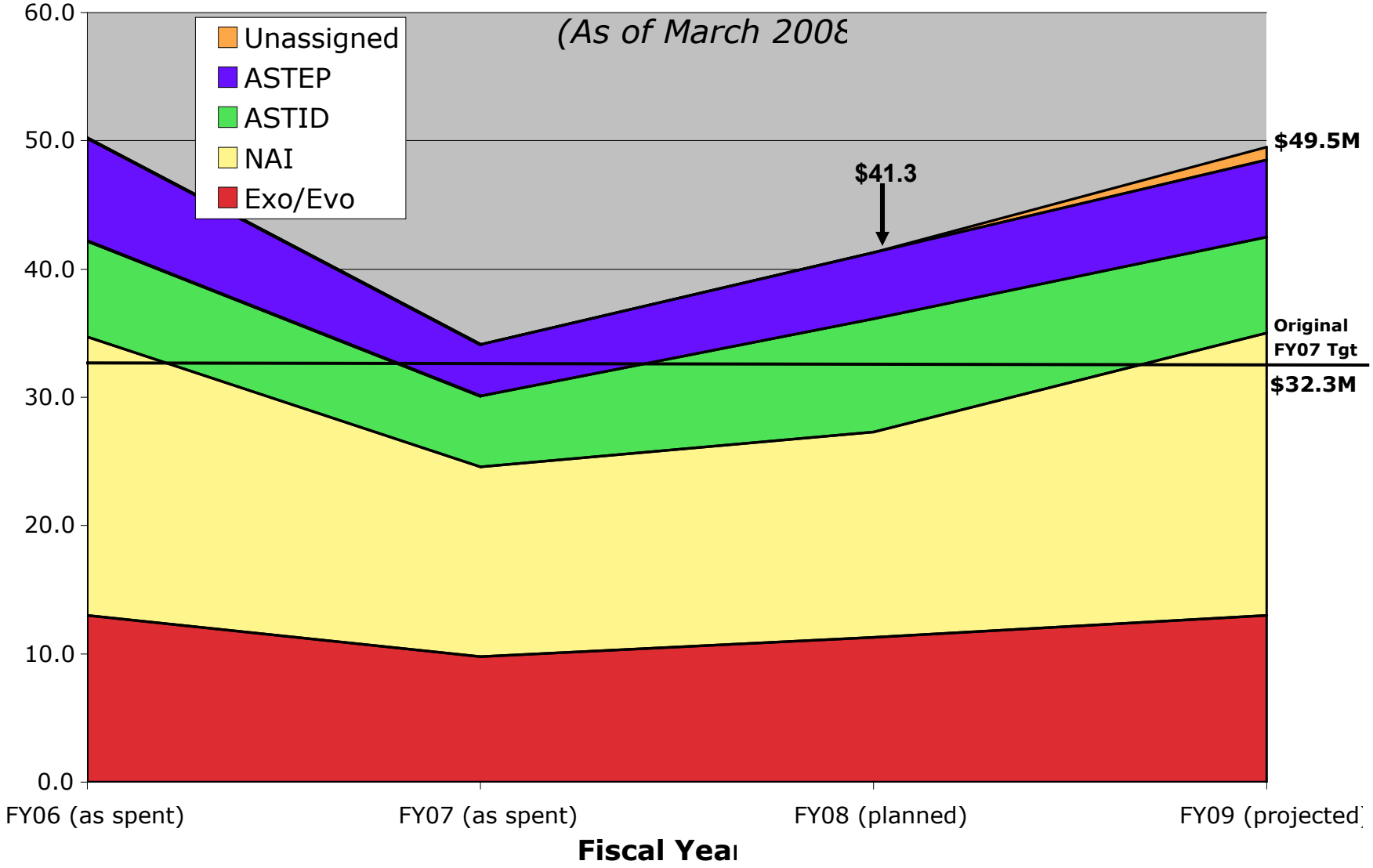
- Research & Analysis Update
- Planetary Announcements
- PSD Lunar Activities

R&A Program

Planetary R&A Overview

ROSES	Spent FY07	Planned FY08	Presidents FY09
Mars R&A	**$14,158**	**$23,333**	**$24,938**
Mars Fundamental Research			
Mars DAP			
Discovery Research	**$11,881**	**$16,898**	**$18,816**
Sample Return Lab Inst &DAP			
Discovery DAP & Stardust DAP			
MESSENGER Participating Scientists Prog			
Planetary R&A	**$79,256**	**$101,367**	**$101,223**
PG&G			
Cosmochemistry			
Planetary Astronomy			
Planetary Atmospheres			
Planetary Instruments			
Origins of Solar Systems			
Planetary Protection			
Outer Planets Research			
New Horizons & Jupiter DAP			
Cassini Data Analysis Program (OPF)			
Astrobiology	**$32,414**	**$40,283**	**$49,258**
ASTEP			
ASTID			
NASA Astrobiology Institute			
Astrobiology: Exo and Evo			
Lunar Research	**$3,800**	**$18,700**	**$25,000**
Lunar Sortie Science Opportunity			
LRO- Participating Scientist Program			
Lunar Science & Exploration Research			
NASA Lunar Science Institute & Nodes			
Total Planetary Research	**$141,508**	**$200,581**	**$219,235**

Astrobiology Budget Past & Future Plans



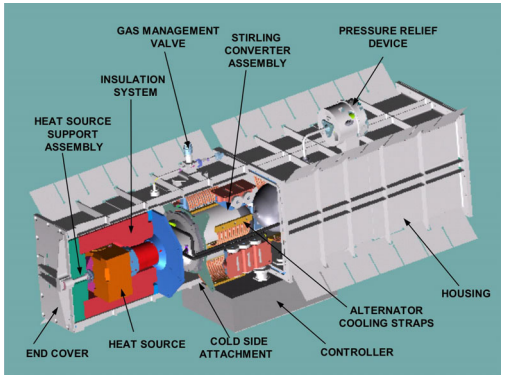
Planetary Announcements

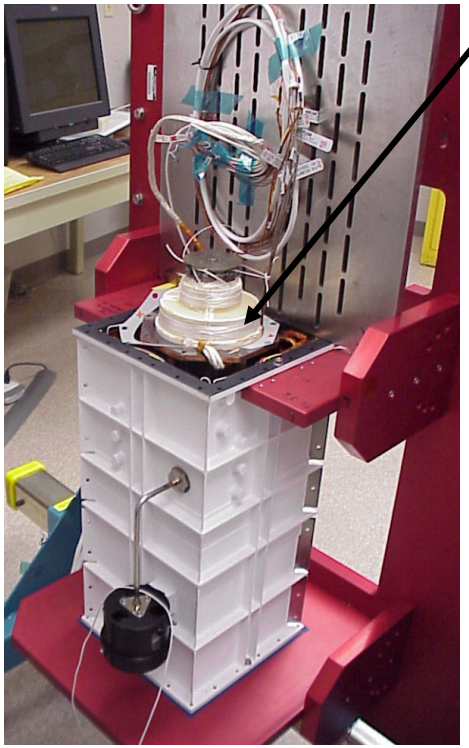
DSMCE Program Overview

- Program solicited mission concept proposals for small planetary missions that require the ASRG power source
  - Two Stirling Engines with ~140 Watts each (as GFE)
- Intended to foster science exploration in planetary science by missions enabled by ASRG
- Mission design assistance for these 6 month mission concept studies will be offered by NASA
- Selected 9 proposals
  - 40 proposals submitted with average budget of $271K
  - NRA directed proposers to budget $200,000-$300,000

Advanced Stirling Radioisotope Generator Engineering Unit

- Operation in space and on surface of atmosphere-bearing planets and moons
- Characteristics:
  - ≥14 year lifetime
  - Nominal power : 140 We
  - Mass ~ 20 kg
  - System efficiency: ~ 30 %
  - 2 GPHS ("Pu^{238} Bricks") modules
  - Uses 0.8 kg Pu^{238}
- Final wiring and connections for ASRG engineering unit underway
- Reliability to be demonstrated by the end of 2009





Outboard Housing and Paired ASC-Es

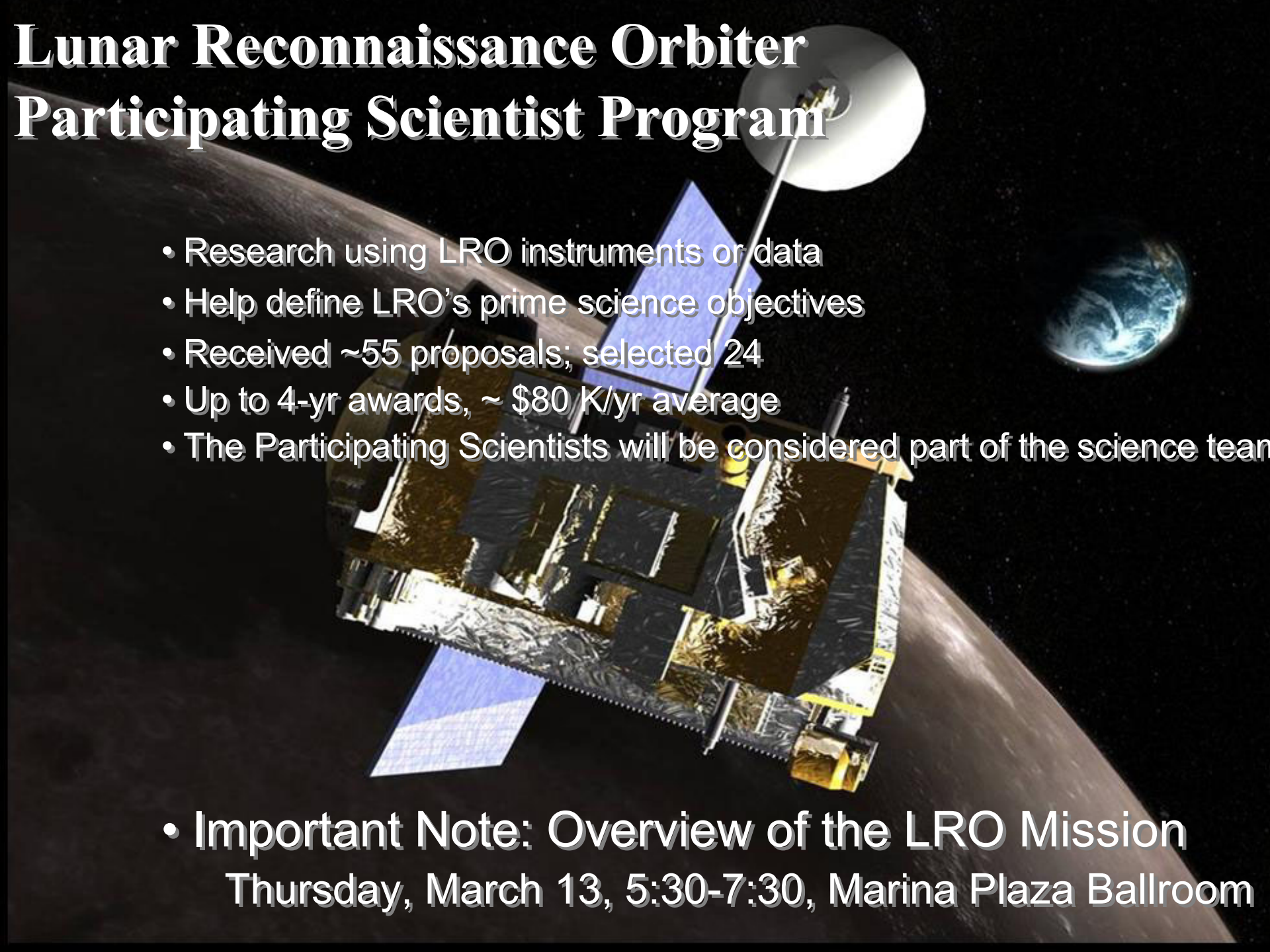
Lockheed Martin/Sunpower

Paired converters with interconnect sleeve assembly

DSMCE Selections

Baines, Kevin	JPL	Venus	Aerial Vehicle	Polar VALOR: The Feasibility of A Nuclear-Powered Long-Duration Balloon Mission to Explore the Poles of Venus
Elphic, Richard	Los Alamos National Laboratory	Moon	Lander	Locating and Characterizing Lunar Polar Volatiles: Feasibility of a Discovery-Class Mission
Jolliff, Bradley	Washington University	Moon	Rover	Journey to the land of Eternal Darkness and Ice (JEDI): A Lunar Polar Volatile Explorer
Rivkin, Andrew	Applied Physics Lab	Asteroid	Lander	Ilion: An ASRG-Enabled Trojan Asteroid Mission Concept
Hecht, Michael	JPL	Mars	Lander	A tour through Martian history: An ASRG-powered polar ice borehole.
Stofan, Ellen	Proxemy Research	Outer Planets	Lander	Titan Mare Explorer (TiME)
McEwen, Alfred	University of Arizona	Outer Planets	Orbiter	Mission Concept: Io Volcano Observer (IVO)
Sandford, Scott	NASA/AMES	Comet	Sample Return	Concept Study for a Comet Coma Rendezvous Sample Return Mission
Sunshine, Jessica	Univeristy of Maryland	Comet	Lander	Comet Hopper

Lunar Reconnaissance Orbiter Participating Scientist Program



- Research using LRO instruments or data
- Help define LRO's prime science objectives
- Received ~55 proposals; selected 24
- Up to 4-yr awards, ~ $80 K/yr average
- The Participating Scientists will be considered part of the science team

- Important Note: Overview of the LRO Mission
  Thursday, March 13, 5:30-7:30, Marina Plaza Ballroom

PI First name	PI Last name	Title	Institution	Team
Brent	Archinal	Lunar Precision Geodesy: Registration and Enabling the Use of Lunar Reconnaissance Orbiter Datasets for Scientific and Operational Purposes	U. S. Geological Survey	LROC
Joshua	Bandfield	Characterization of lunar thermophysical and spectral properties with the Diviner radiometer	Arizona State University	Diviner
Olivier	Barnouin-Jha	Measuring the surface roughness of the Moon and the topographic shape of impact craters.	Johns Hopkins University Applied Physics Lab	LOLA
James	Bell	Mineralogic and Morphologic Analyses of the Moon During LRO Operations	Cornell University	LROC
Ross	Beyer	Lunar stratigraphy and topography investigations with LRO	NASA Ames Research Center	LROC
Lynn	Carter	Radar polarimetric studies of the lunar poles and lunar pyroclastic deposits	Smithsonian Institution	Mini-RF
Thomas	Duxbury	Lunar Local and Global Cartography and Calibration	Jet Propulsion Laboratory	LOLA
Richard	Elphic	Synthesis of LRO and Other Data to Characterize the Physical Properties of Lunar Cold Traps	Los Alamos National Laboratory	Diviner
Rebecca	Ghent	Thermophysical properties of fine-grained ejecta haloes from LRO Diviner radiometer observations	University of Toronto	Diviner
Lisa	Gaddis	Geologic Analyses of Historic and LRO Data of Lunar Volcanic	U.S. Geological Survey	LROC
William	Garry	Analysis of the Morphology and Emplacement of Volcanic Features on the Moon with the Lunar Reconnaissance Orbiter	Center for Earth and Planetary Studies	LROC
Jeffrey	Gillis-Davis	Assessment of Lunar Resources: Using Targeted Observations of Mini-RF in Conjunction with Data from LROC, LEND, DLRE, LOLA, and LAMP.	University of Hawaii, Manoa	Mini-RF
Timothy	Glotch	Compositional Variability of the Lunar Surface from the Diviner Lunar Radiance Experiment and the Lunar Reconnaissance Orbiter Camera	SUNY	Diviner
Bernard	Hawke	An Investigation of Lunar Dark Mantle Deposits Using LROC Data	University of Hawaii	LROC
Amanda	Hendrix	Investigation into Lunar Surface Composition and Weathering Effects	JPL/CalTech	LAMP
Laszlo	Keszthelyi	Flow on the Moon: A Stepping Stone to Mars and Beyond	United States Geological Survey	LROC
Rongxing (Ron)	Li	Integration of Lunar Reconnaissance Orbiter Camera (LROC) and Lunar Orbiter Laser Altimeter (LOLA) Data for Near Real-time Precision Lunar Topographic Mapping and Landing Sites Assessment	The Ohio State University	LROC
Paul	Lucey	LRO Mission Participation: Mineral Mapping With Diviner and LOLA	University of Hawaii	LOLA
Timothy	McClanahan	Enhancement of Lunar Exploration Neutron Detector (LEND) Mission Operations and Science Return	NASA Goddard Space Flight Center	LEND
Jürgen	Oberst	Studies in Lunar Geodesy and Cartography	German Aerospace Center (DLR)	LROC
Timothy	Stubbs	Mapping Lunar Surface Electric Fields and Characterizing the Exospheric Dust Environment	NASA Goddard Space Flight Center	CRaTER
Thomas	Watters	Tectonism on the Moon: Global Characterization and Analysis of Lunar Faults	Smithsonian Institution	LROC
Michael	Wyatt	Mapping Silicate Variations on the Moon with the Diviner Lunar Radiometer Experiment (DLRE) and Cross-Comparisons with other Compositional Approaches	Brown University	Diviner
Cary	Zeitlin	Comparison of Lunar and Martian Radiation Environments	Lawrence Berkeley National Laboratory	CRaTER

Lunar R&A Programs

- Lunar Advanced Science & Exploration Research (LASER)
  - Co-funded with ESMD
  - Proposals received in September
  - Evaluation just completed
  - Expect selection in March

Just Released NRC NOSSE Report

- "*Opening New Frontiers in Space: Choices for the Next New Frontiers AO*" - NASA should:
  - R1: Emphasize science objectives
  - R2: Expand the list of candidate missions
  - R3: Limit to the list below unless compelling science
- Recommended target list in alphabetic order:
  - *Asteroid Rover/Sample Return**
  - Comet Surface Sample Return
  - *Ganymede Observer**
  - *Io Observer**
  - Jupiter Polar Orbiter with Probes
  - Kuiper Belt/Pluto
  - Lunar South Pole Aitken Basin Sample Return
  - *Mars Network Science**
  - *Trojan/Centaur Reconnaissance**
  - Venus In-Situ Explorer

* Additions

NASA/PSD Response

- NASA accepts the NRC's recommendations
- Consistent with the NRC report: NF3 will be open to any Solar System target except the Sun and Earth
- All missions proposed must fit NF3 mission cost, timescale, and launch vehicle constraints
- Proposed missions must also be consistent with the unavailability of radioisotope power sources
- Although missions to any target can be proposed, priority will be given to the NRC report list
- NF3 Schedule:
  - Draft ~July 2008
  - AO ~October 2008
- Expect NF3 AO to be greatly simplified

PI Qualifications Matrix

Table 1 – Principal Investigator Experience Level Required
for Different Mission Cost Classes

Mission Cost Class [1]	Minimum Required PI Experience [2,3]
Large Missions	Either (i) at least four years experience in a lead role [4] for a single orbital or deep space mission which will be launched prior to AO downselection or (ii) two experiences of at least two years each in lead roles [4] on orbital or deep space missions and/or orbital or deep space instruments, all of which will be launched prior to AO downselection.
Medium Missions	At least two years of experience in a lead role [4] for an orbital or deep space mission or instrument that will be launched prior to AO downselection.
Small Missions	At least two years of experience in a lead role [4] for a space project (orbital, deep space, or suborbital) such as a mission, instrument, or experiment.
Large Non-Mission Projects [5]	At least two years of experience as a participant in a space project (orbital, deep space, or suborbital) such as a mission, instrument, or experiment.
Small Non-Mission Projects [5]	None

New Frontiers ←

[1] Mission cost class will be identified in the AO.
[2] Experience must include the development of flight hardware. Pre-proposal and Phase A concept studies do not meet this requirement.
[3] Unless otherwise changed in the AO.
[4] Lead role includes the responsibilities of a Principal Investigator (PI), Project Manager (PM), Project Scientist (PS), and Deputy PI/PM/PS.
[5] Non-mission projects include instruments and Missions of Opportunity.

SALMON AO Schedule

• SALMON Solicitation Development	Sept 2007 – Feb 2008
• Release Draft for comment	March 2008 (Friday!)
• Revise SALMON based on comments	April 2008
• SALMON Release	
– Program Element Cycle I	May 2008
• Proposals Due	August 2008
• Selections Announced	NLT February 2009
• SALMON Amendments (notional)	
– Program Element Cycle II (special)	May 2008
– Program Element Cycle III (regular)	May 2009

Types of Missions of Opportunity

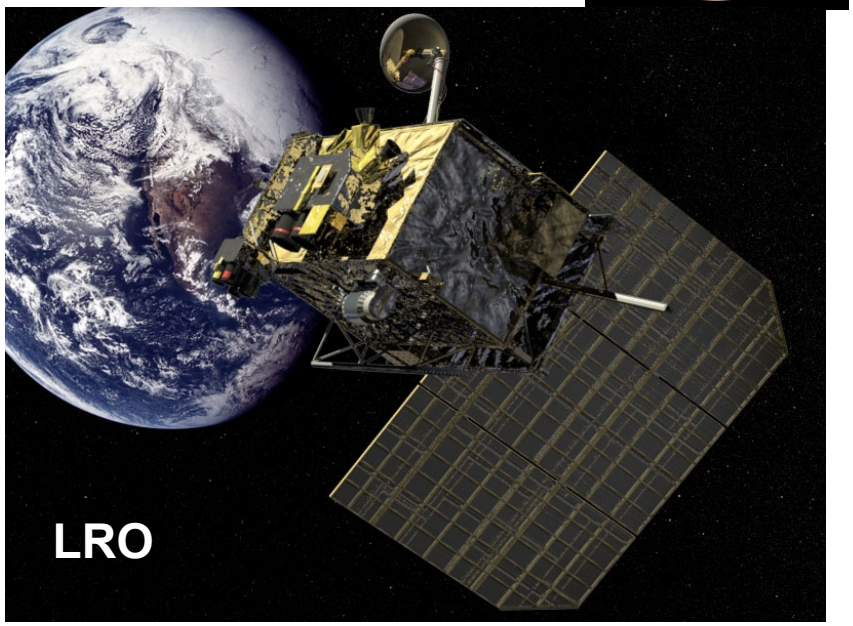
- Traditional MoOs
  - Investigations involving participation in non-NASA space missions (ie: science instrument, technology demonstrations, hardware components …)
- U.S. Participating Investigator
  - Co-Investigator (non-hardware) for a science or technology experiment to be built and flown by an agency other than NASA
- New Science Missions using Existing Spacecraft
  - Investigations that propose a new scientific use of existing NASA spacecraft (ie: NExT, EPOXI …)
- Small Complete Missions
  - Science investigations that can be realized within the specified cost cap (includes all phases from access to space through data publication)
- Focused Opportunities
  - Investigations that address a specific, NASA-identified flight opportunity

PSD Lunar Activities

Lunar Exploration Missions

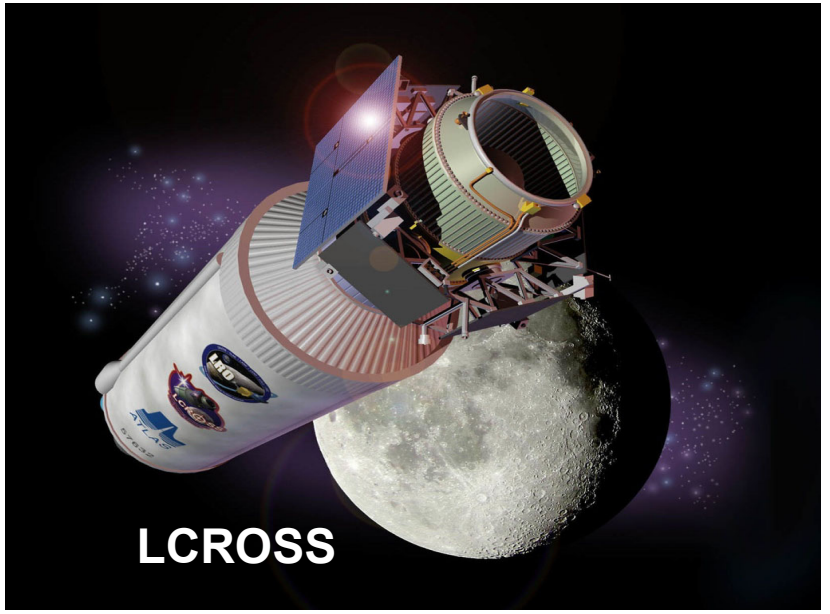
Lunar Reconnaissance Orbiter (LRO)

- Lunar mapping, topography, radiation characterization, and volatile identification
- 50km polar orbit
- One year operations
- Launched October 2008



Lunar CRater Observation and Sensing Satellite (LCROSS)

- Investigate the presence of water at the South Pole via a kinetic impactor and shepherding spacecraft

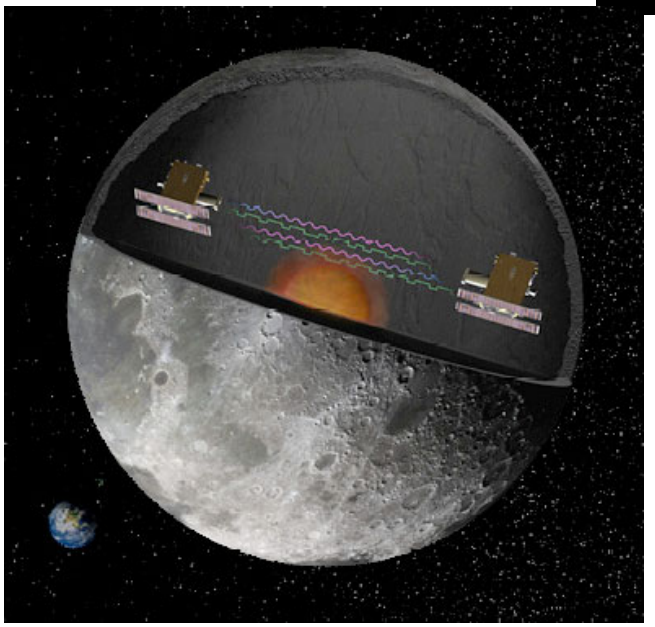


LRO Prime Science Mission

- PSD funds LRO extended mission
- Becomes the “Prime” Science mission
- Upgrades to PDS to handle LRO data volumes

GRAIL: Gravity and Interior Laboratory

Newly Selected Discovery Mission
In development



• **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.

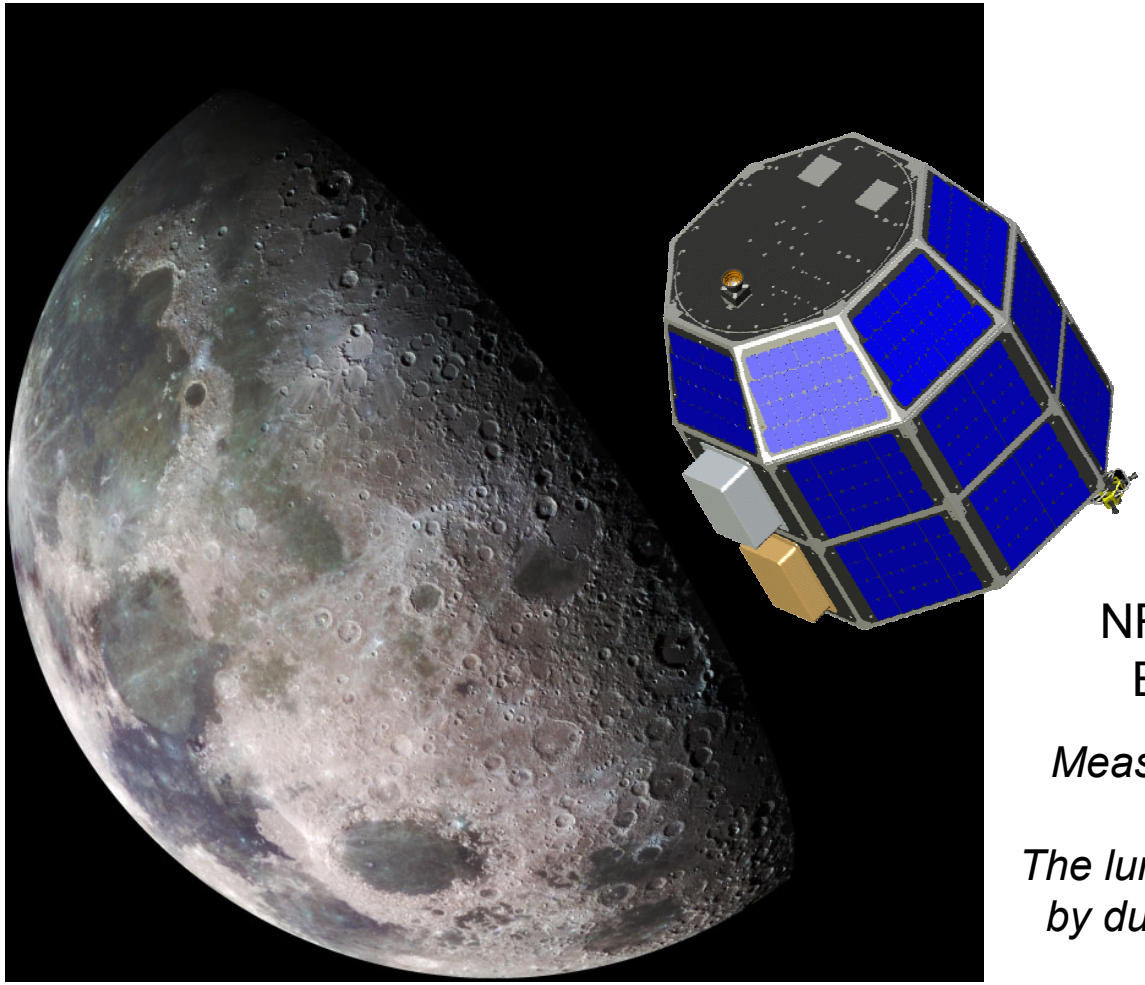
• **Mission:** Provide a global, high-accuracy (<10mGal),high-resolution (30km) lunar gravity map; build upon successful GRACE mission; adapt flight-proven LM XSS-11 bus to the duel spacecraft design.

• **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.

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

Laurie Leshin, SDT Chair

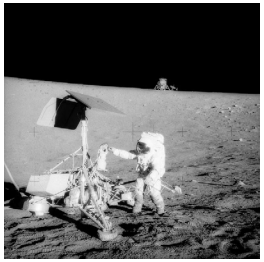
NRC: Scientific Context for Exploration of the Moon

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 2011 as a secondary payload to Grail

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 2013/2014 to the poles
- The ILN is designed to emplace 6-8 stations on the lunar surface - fixed or mobile



- Each ILN station:
  - Has a core set of instrument types (e.g., seismic, laser retro-reflector, heat flow) requiring broad geographical distribution
  - Could also include additional instruments as desired by the sponsoring space agency
  - Could also include additional passive, active, ISRU, or engineering experiments, as desired by each sponsoring space agency
- Joe Veverka and Barbara Cohen, Co-Chairs SDT

NASA ILN CONTRIBUTIONS

- NASA is committing now to two ILN nodes, launched to the lunar poles, in 2013/2014

- NASA is studying the option for a lunar comm relay orbiter enabling lunar far-side access for ILN nodes

- NASA is planning a second pair of ILN nodes in 2016/2017

- Expect international participation for the other network nodes

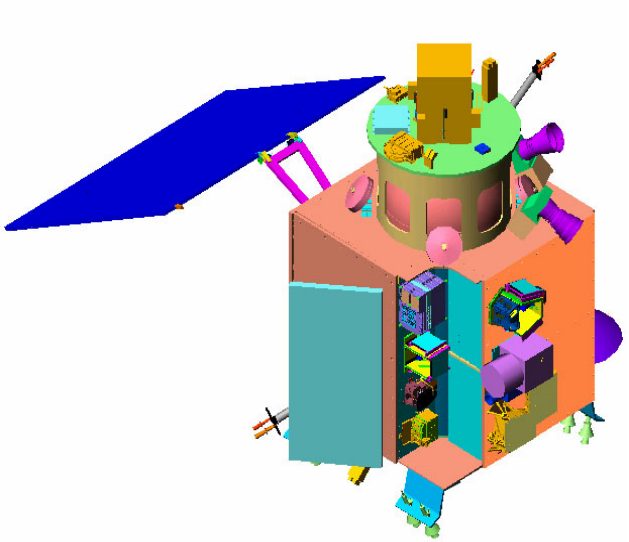
Moon Mineralogy Mapper (M^3)

Team

- PI: Dr. Carle Pieters, Brown University

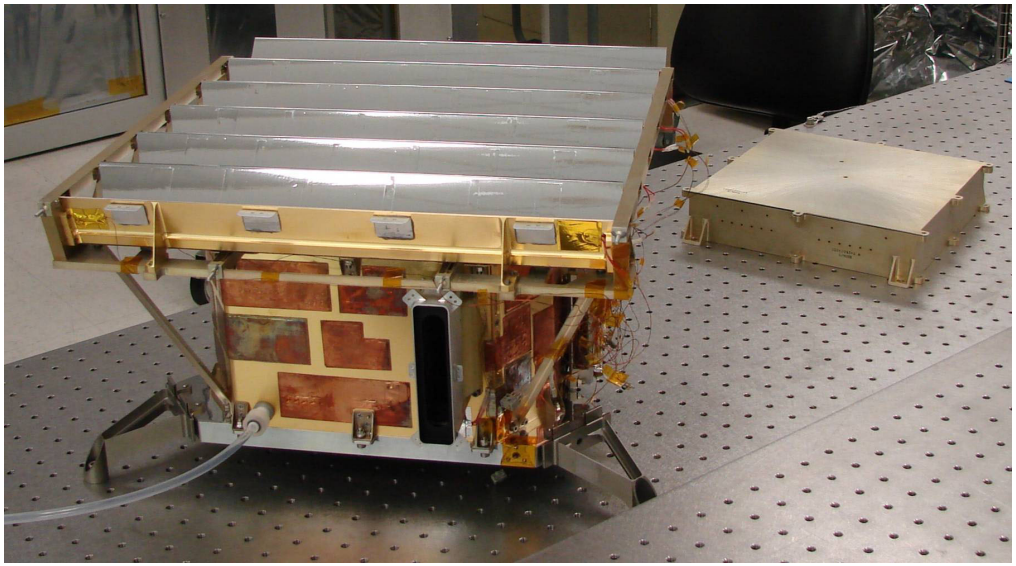
Mission

- M3 Instrument on Chandrayaan-1, India's first deep space mission.
- One of 11 instruments (5 of which are non-ISRO, 2 of which are from the US)
- Launch Date: Spring 2008 on ISRO's Polar Satellite LV
- Lunar Orbit: 100 km, polar
- Operational life: 2 years



Objectives

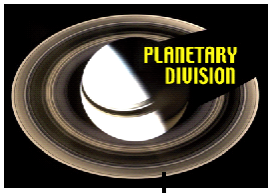
- Produce a Global Map of the Mineralogy content Lunar surface at 140m and 40 nm spectral resolution.
- Investigate specific targets at high spatial and spectral resolution
- Investigate the possibility of surface water ice at the lunar poles



Instrument

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

Lunar Missions Schedule



FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15

Lunar Research and Analysis

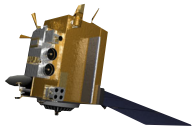
Mission of Opportunity
Science-Funding-Opportunity Driven

LADEE Launch Goal

Mini Lander Launch Goal

ILN Operation Start Goal

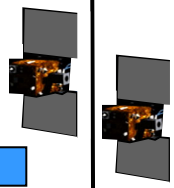
Possible Intl. Partner Early Operations



ESMD *SMD*

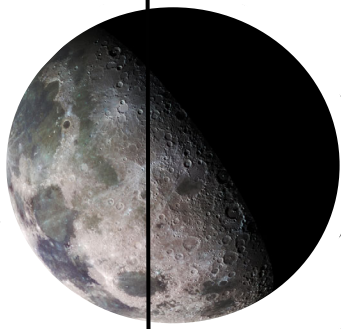
C/D | E | E+

LRO *(ESMD)*

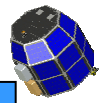


B | C & D | Cruise | E

GRAIL *(SMD-Discovery Prg.)*

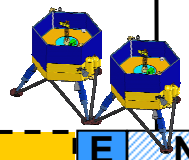


SDT *Science Definition*



A | B | C & D | Cruise | E

LADEE *(SMD-Full Moon Prg.)*



SDT *Science Definition*

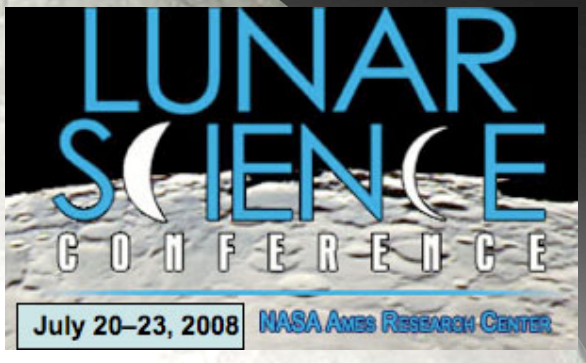
A | B | B/C/D duration finalized during A | E | Node I & II Ops

Mini Lander *(SMD- Full Moon Prg.)*

Launch date to be set during Phase A

NASA Lunar Science Institute

- Objective: help lead the agency's research activities for future lunar science missions related to NASA's exploration goals
- Member Teams (4-6) chosen from initial CAN (target release 5/16/08)
  - $1-2M per team per year (4 yr terms)
- Modeled after NASA Astrobiology Institute
  - Most of funding to teams
  - Small central office managed by NASA Ames Research Center
- Science focus:
  - **Of the Moon**: Investigations of the nature and history of the Moon
  - **On the Moon**: Science for human exploration
  - **From the Moon**: The Moon as an observational platform



http://lunarscience.arc.nasa.gov


NASA's
Planetary Science
Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space
"Flyby, Orbit, Land, Rove, and Return Samples"