



Planetary Science Division Update

*Presentation at the
Planetary Science Subcommittee*

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March 3, 2007



Outline

- Administration
- President's FY09 Budget & Impacts
- Research & Analysis Overview
- Lunar Program
- Outer Planets Flagship status
- Upcoming Announcement of Opportunities
- PSS Findings and Recommendations

- (Mars Exploration Program covered by Doug)



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% (~\$32M)
 - 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



Administration

- Dr. Mike Kelly Joined us; Duties include:
 - Program Scientist for NExT and EPOXI
 - Program Officer for PG&G
 - Hq contact on SBAG
- Dr. Sarah Noble - new NASA Post-Doc
- Jim Adams (PSD Deputy) on temporary assignment to front office (Dep AA for Flight Programs) come back to PSD today!



MAJOR FY09 BUDGET CHANGES



- ~\$600M transfer from Space Science (Astro, Helio, Planetary) to Earth Science over 5 years for their new Decadal missions
- Six new FY09 missions starts: more than in the past four budgets combined; at least one per SMD science area:
 - Earth Science: IceSat II & DESTINY (2012, 2015 launches)
 - Astrophysics: JDEM (launch in 2014)
 - Heliophysics: Solar Probe Plus (launch in 2015)
 - Planetary: Outer Planets Flagship (launch in 2016/2017) and lunar science orbiter (launch in 2010/2011)
- Substantial increases in astrophysics, heliophysics, and planetary science R&A/MO&DA
- Increased budgets for suborbital rockets and balloons

Funding for new starts and R&A increases came from:
internal transfers, efficiencies, out-year mission ops savings,
and re-phrasings for MMS and Scout.



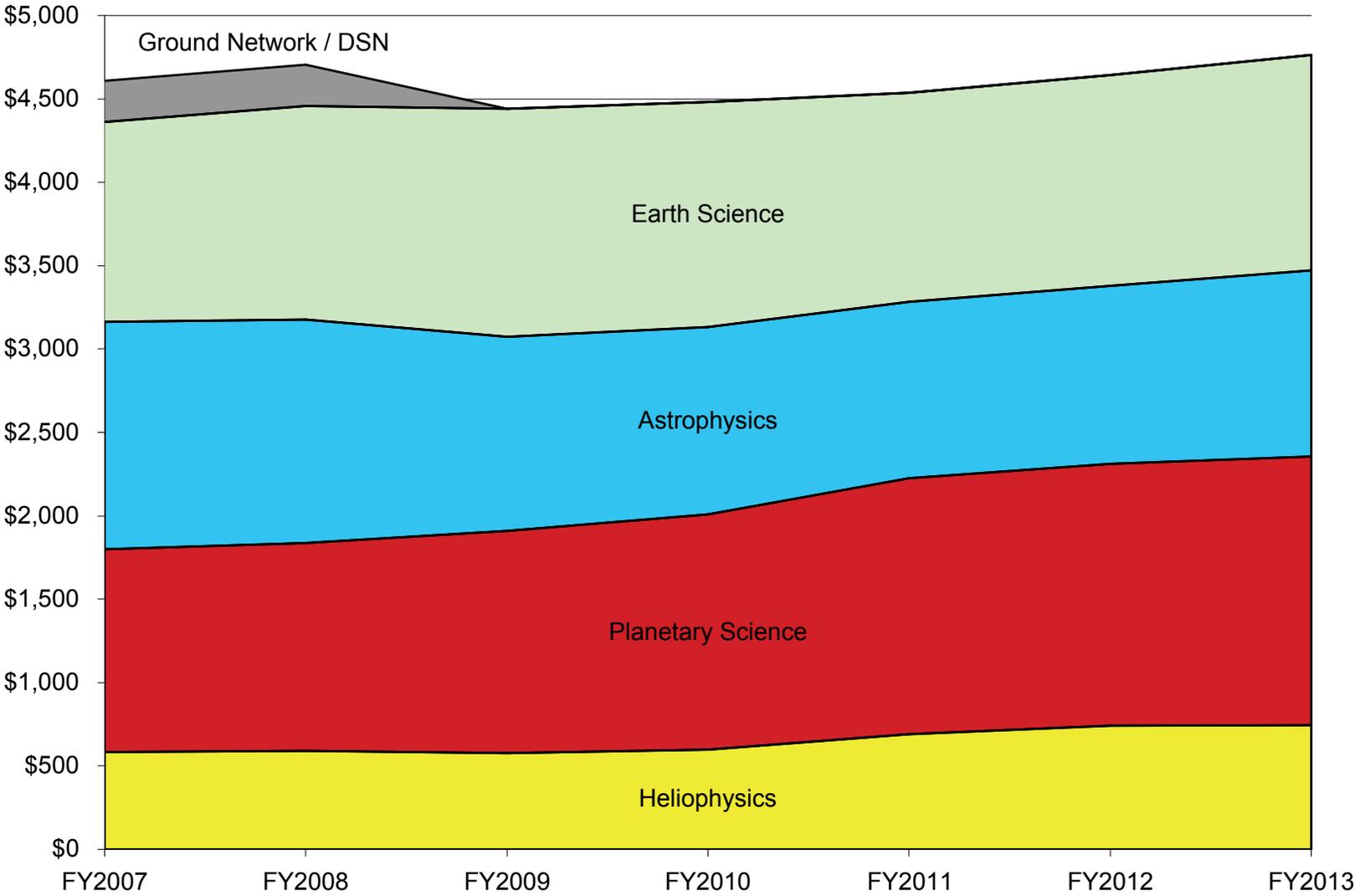
NASA PRESIDENT'S BUDGETS: FY09-FY13



	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013
Total NASA	\$16,231.0	\$17,300.5	\$17,610.7	\$18,022.9	\$18,457.0	\$18,901.6	\$19,355.4
Science	\$4,609.9	\$4,706.2	\$4,441.5	\$4,482.0	\$4,534.9	\$4,643.4	\$4,761.6
Earth Science	\$1,198.5	\$1,280.3	\$1,367.5	\$1,350.7	\$1,250.9	\$1,264.4	\$1,290.3
Planetary Science	\$1,215.6	\$1,247.5	\$1,334.2	\$1,410.1	\$1,537.5	\$1,570.0	\$1,608.7
Astrophysics	\$1,365.0	\$1,337.5	\$1,164.5	\$1,122.4	\$1,057.1	\$1,067.7	\$1,116.0
Heliophysics	\$583.7	\$590.9	\$575.3	\$598.9	\$689.4	\$741.2	\$746.6
DSN / Ground Network	\$247.2	\$250.0					
Aeronautics Research	\$593.8	\$511.7	\$446.5	\$447.5	\$452.4	\$456.7	\$467.7
Education	\$114.1	\$137.9	\$112.1	\$122.7	\$120.4	\$120.4	\$120.4
Exploration Systems	\$2,837.6	\$3,143.0	\$3,500.5	\$3,737.7	\$7,048.2	\$7,116.8	\$7,666.8
Constellation Systems	\$2,114.7	\$2,471.9	\$3,048.2	\$3,252.8	\$6,479.5	\$6,521.3	\$7,080.5
Advanced Capabilities	\$722.9	\$671.1	\$452.3	\$484.9	\$568.7	\$595.5	\$586.3
Space Operations	\$5,093.5	\$5,526.2	\$5,774.7	\$5,872.7	\$2,900.1	\$3,089.9	\$2,788.5
Space Shuttle	\$3,295.3	\$3,266.7	\$2,981.7	\$2,983.6	\$95.7		
International Space Station	\$1,469.0	\$1,813.2	\$2,060.2	\$2,277.0	\$2,176.4	\$2,448.2	\$2,143.1
Space and Flight Support (SFS)	\$329.2	\$446.3	\$732.8	\$612.1	\$628.0	\$641.7	\$645.4
Cross-Agency Support	\$2,949.9	\$3,242.9	\$3,299.9	\$3,323.9	\$3,363.7	\$3,436.1	\$3,511.2
Agency Management and Operations	\$971.2	\$830.2	\$945.6	\$945.5	\$939.8	\$950.5	\$961.3
Institutional Investments	\$223.8	\$319.7	\$308.7	\$331.7	\$335.9	\$330.4	\$338.3
Congressionally Directed Items		\$80.0					
Center Management and Operations	\$1,754.9	\$2,013.0	\$2,045.6	\$2,046.7	\$2,088.0	\$2,155.2	\$2,211.6
Inspector General	\$32.2	\$32.6	\$35.5	\$36.4	\$37.3	\$38.3	\$39.2



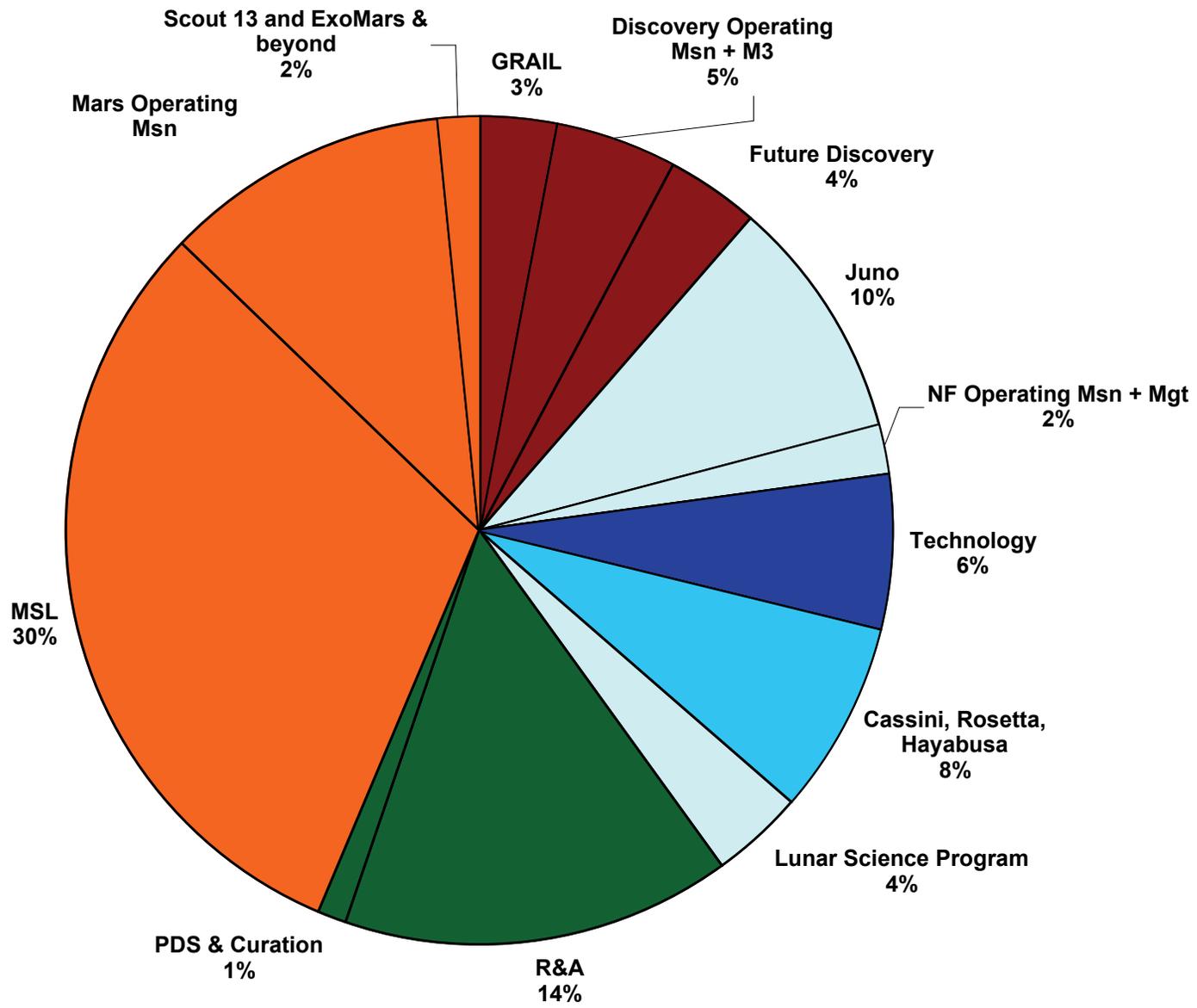
BUDGET BY SCIENCE THEME





Planetary Division

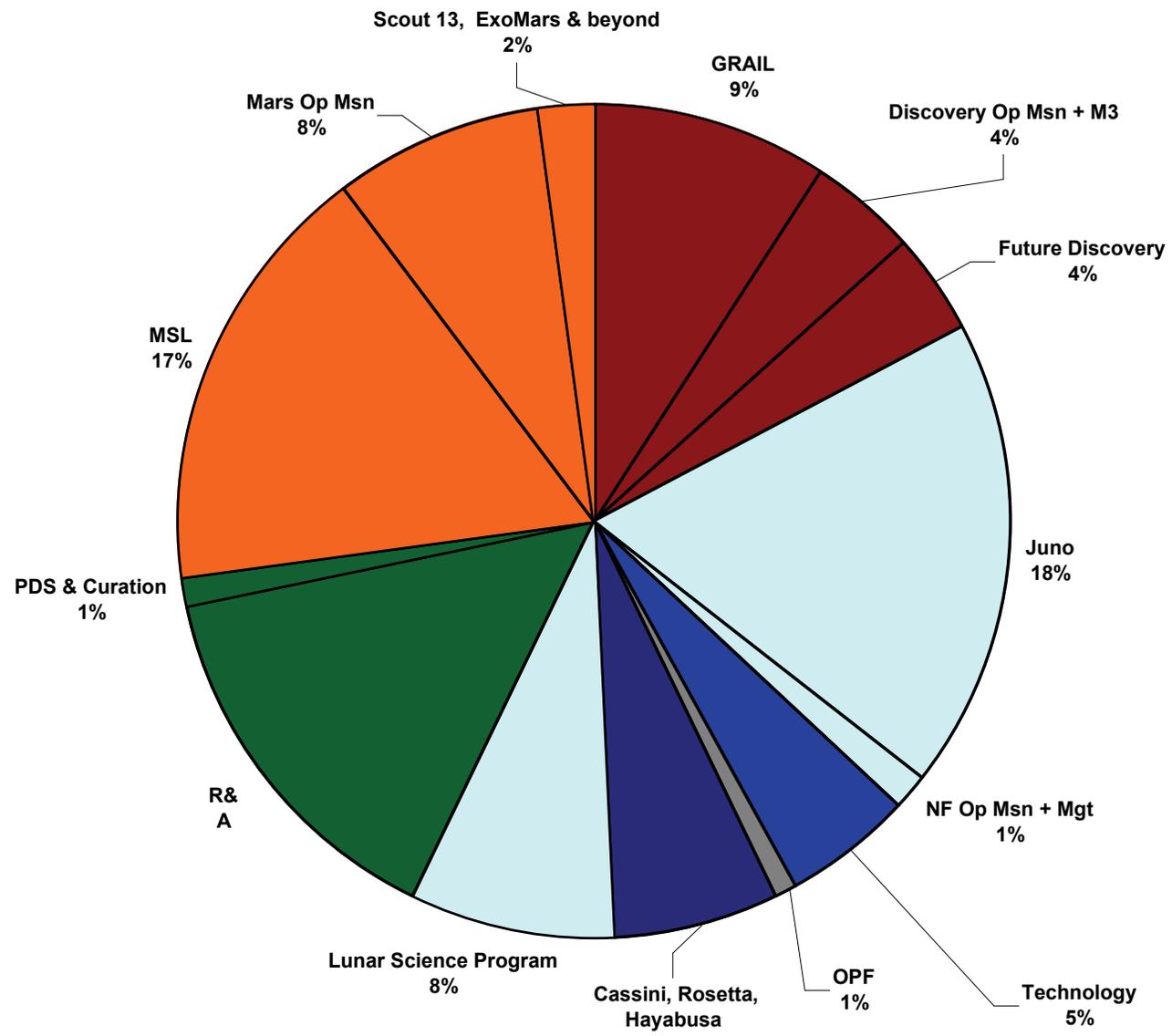
FY 2008 "Enacted" Budget, \$1158M





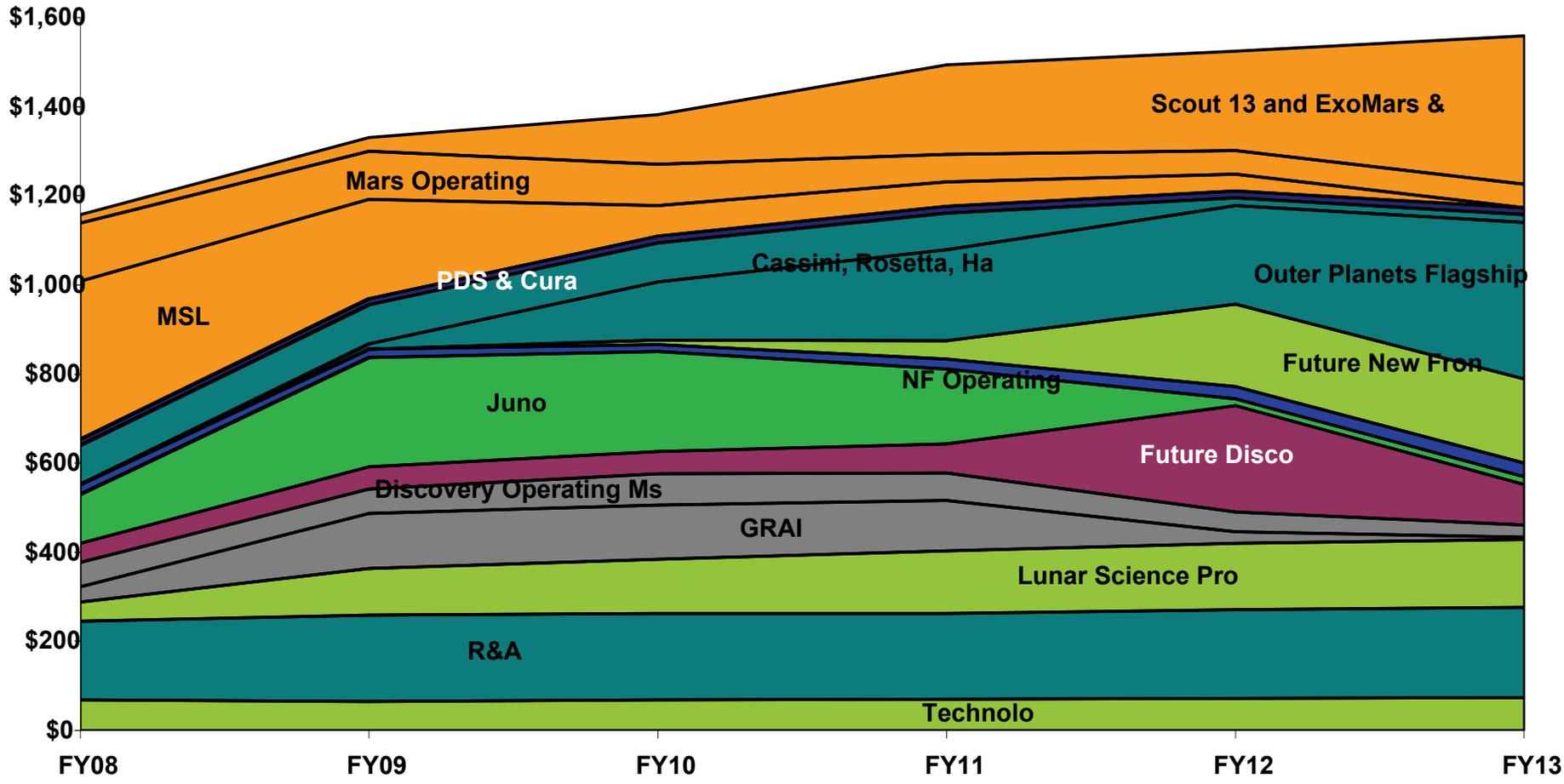
Planetary Division

FY09 President's Budget, \$1330M





Planetary Division FY 2009 Budget (\$M)*



* Note: Congress still has to pass this budget



What Changed, What's the Same



What Changed:

- Initiates an Outer Planets Flagship (OPF) to establish a balance between inner and outer solar system exploration.
- Lunar Science Research augmented to include a series of small lunar spacecraft.
- Augments and enhances R&A to return more results from Planetary missions.
- Discovery Program: Includes the recently selected MoOs (EPOXI and Stardust-NExT), adds Aspera-3 2nd extension (ESA/Mars Express), and selected GRAIL.
- Preserves critical ISP work FY08 thru FY10, but deletes outyear activities in favor of more critical R&A and RPS enhancements.
- Completes the Advanced Stirling RPS development and prepares for flight demonstration.
- Mars Scout 2011 delayed to 2013 due to conflict of interest discovered during proposal evaluation.
- Redirects the Mars Program to focus on Mars Sample Return (MSR)
- Expands US participation on the ESA/ExoMars mission by funding the potential selection of BOTH candidate U.S. instruments and EDL support.

What's the Same:

- Discovery Program: MESSENGER, Dawn, Mars Express/Aspera-3, Chandrayan/MMM
- New Frontiers Program: Juno and New Horizons
- Mars Program: Odyssey, MER, MRO, Phoenix, MSL
- Research Program: Lunar Science, PDS, ESA/Rosetta, JAXA/Hayabusa



R&A Program

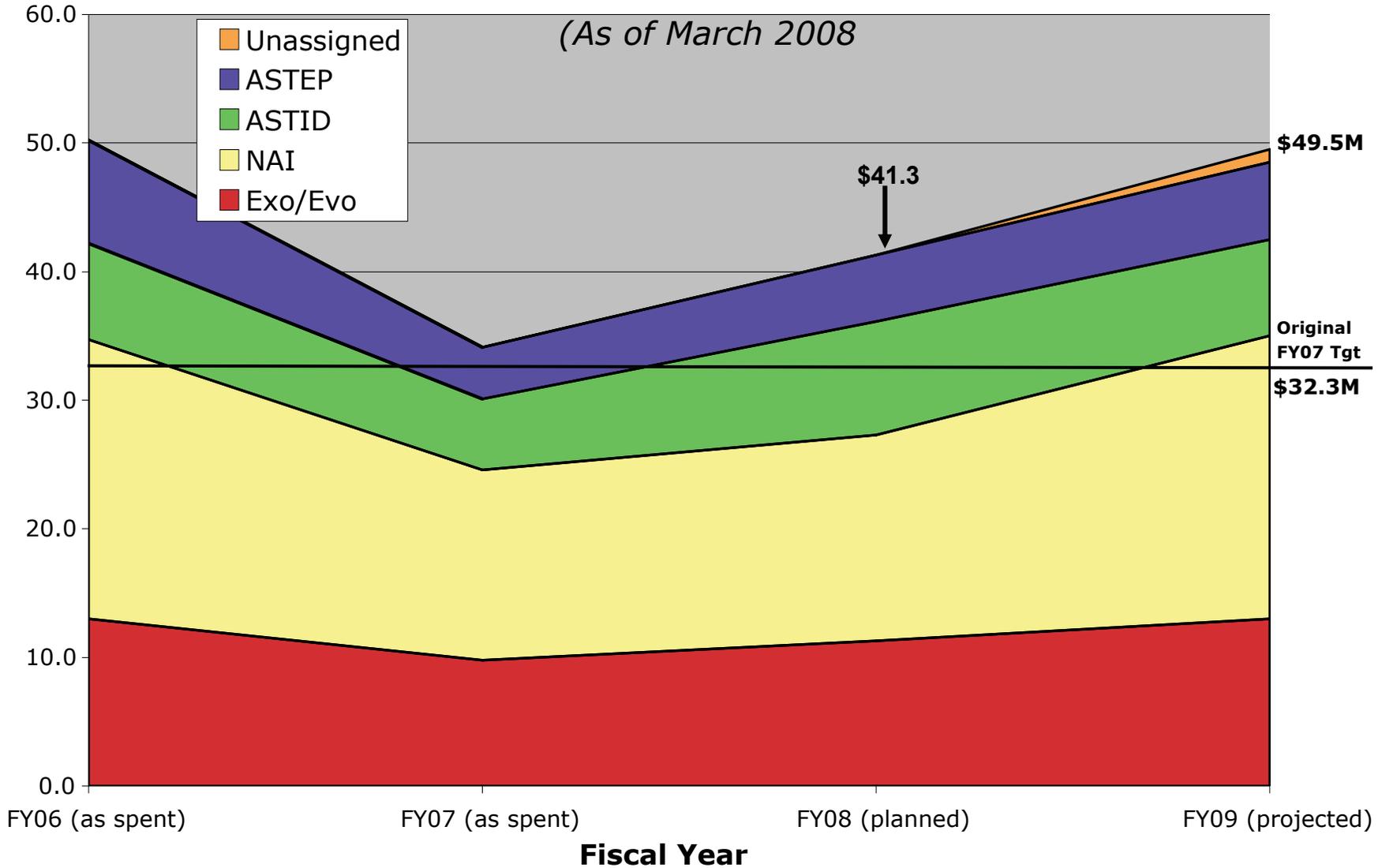


Planetary R&A Overview



	Spent	Planned	Presidents
ROSES	FY07	FY08	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





Lunar Missions

LRO, LCROSS, Grail, LADEE, ILN
M³(Chandrayaan-1)



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.
 - *Launch date:* October 2008
 - Also carries LCROSS Lunar impactor as a secondary.
- After 1 year of operation will be transferred to the Planetary Science Division





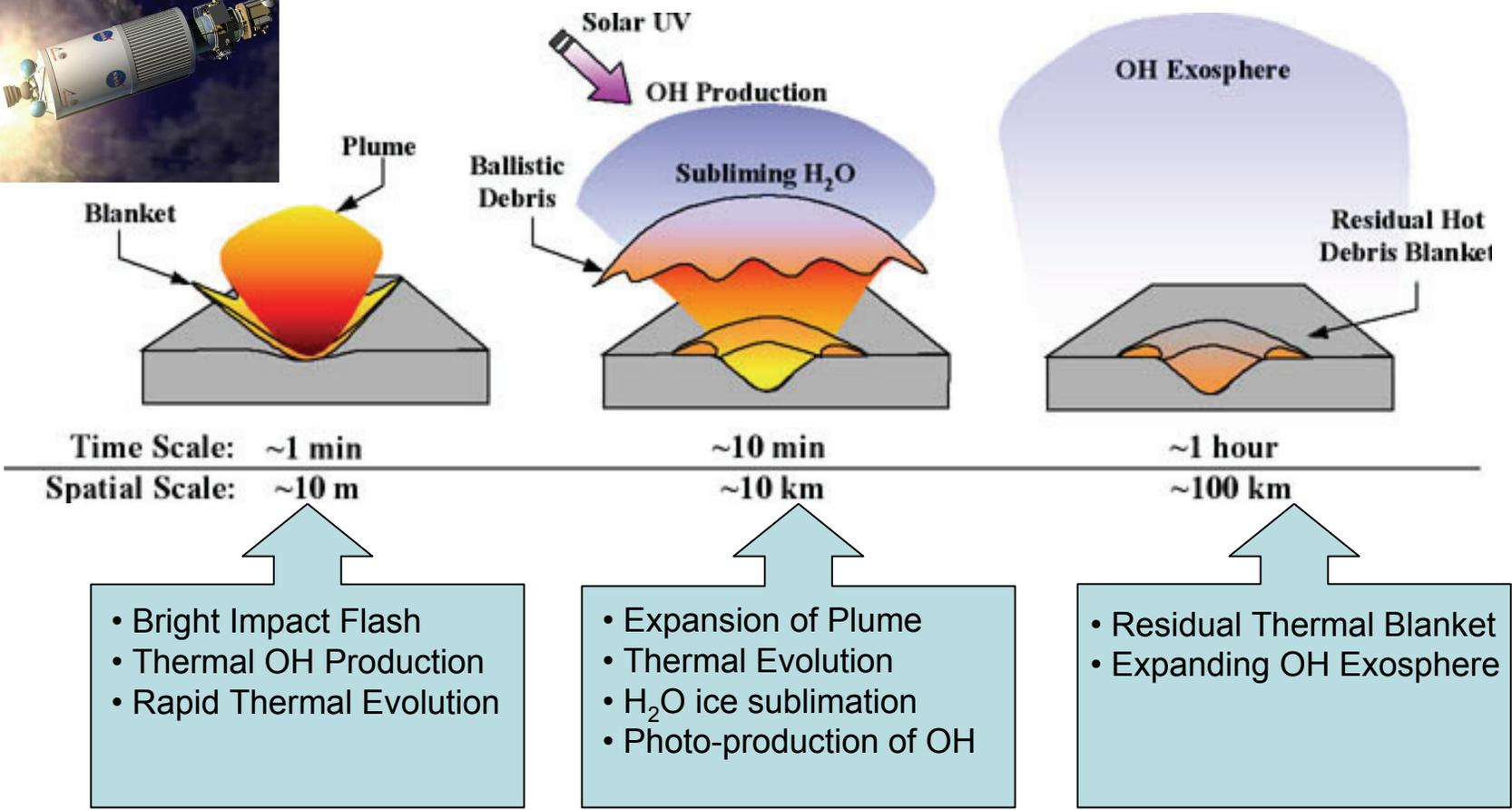
LRO Science Phase



- LRO Prime Science Mission
 - PSD funds the LRO extended mission (FY10 on)
 - Becomes the “Prime” Science mission phase
 - Team developing Level-1 science objectives
 - Upgrades to PDS to handle LRO data volumes
- LRO 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, ~ \$ 80K/yr average
 - Expect this group to be part of the science team



Lunar Crater Observation and Sensing Satellite (LCROSS)



Ground-based, Earth-orbiting, and lunar-orbiting observatories will be able to observe and measure the impacts. Expect impacts ~4 months after launch (early 2009)



GRAIL: Gravity and Interior Laboratory

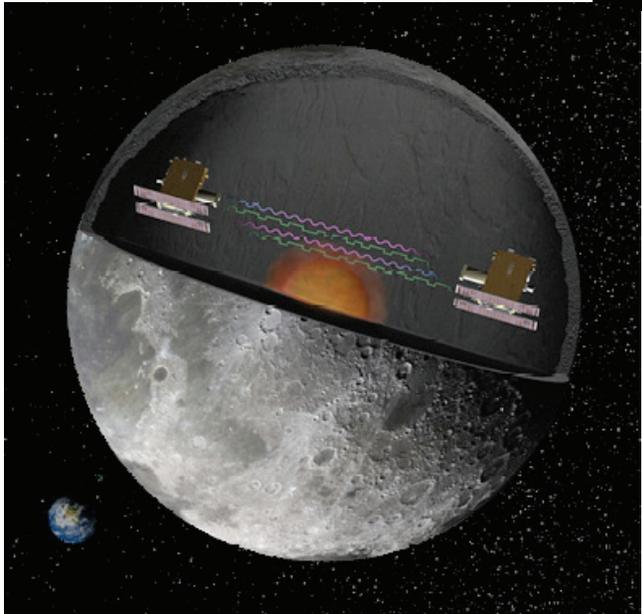


Newly Selected Discovery Mission In development

- **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 dual spacecraft design.

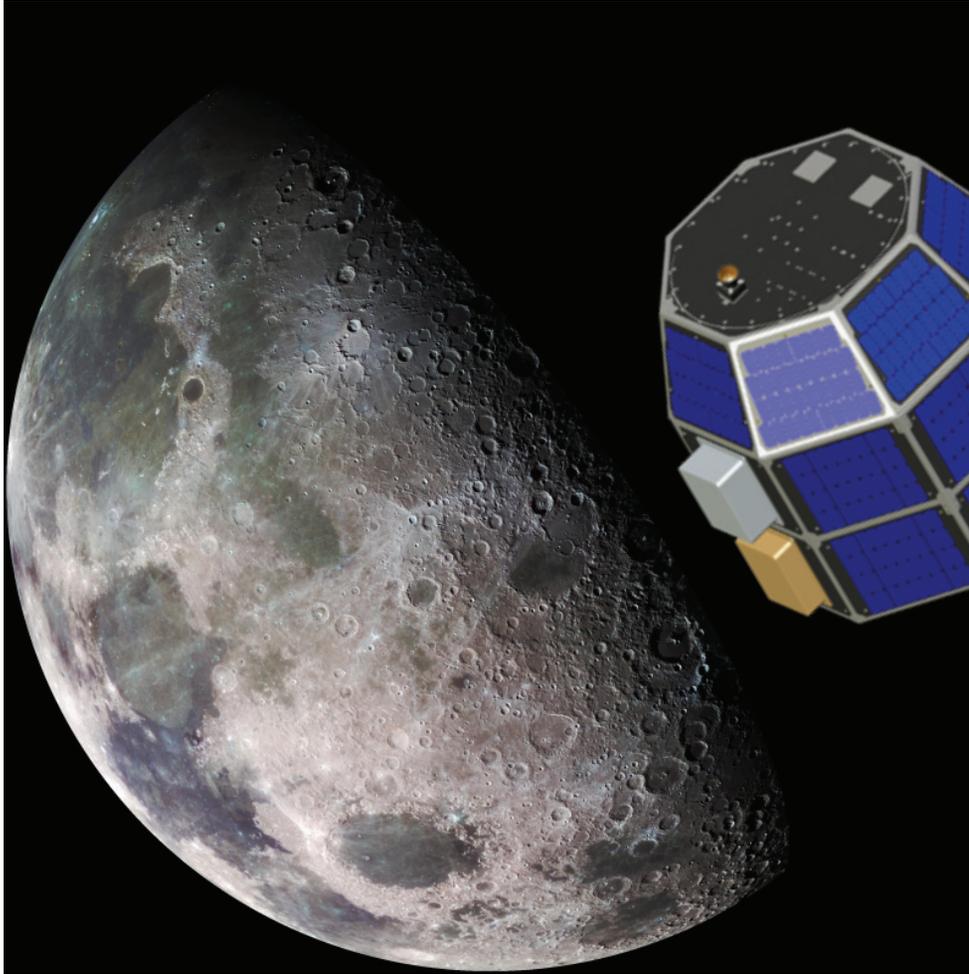


- **Instrument:** Ka-band ranging system determines the precise instantaneous relative range-rate of the two s/c; instrument is based on GRACE mission.

- **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

**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.*

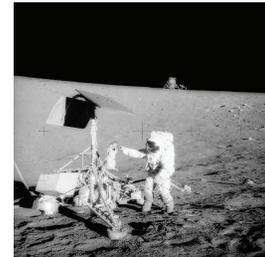
Launch in 2010 as secondary payload with Grail



ILN Missions



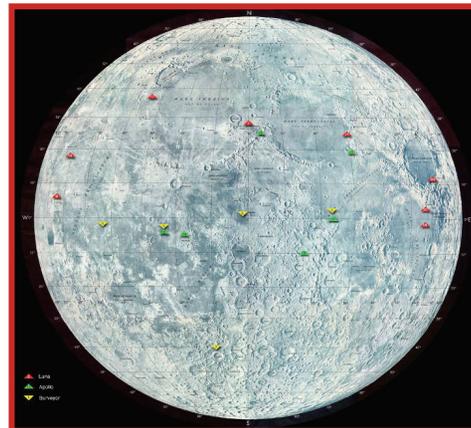
- SMD/ESMD initiating an effort to coordinate future lunar landed missions into an International Lunar Network (ILN)
 - NASA provides two ILN nodes, launched to the lunar poles (TBD), in 2013/2014
 - NASA (SOMD/ESMD) commits to a Lunar communications relay orbiter enabling lunar farside access for ILN nodes
 - 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





Next Steps

- Informational briefing to potential ILN partner Agencies at LPSC (Mar. 11th)
- Multi-Agency meeting at LPI (Mar. 12th)
 - Form ILN charter Working Group
- Anticipate an ILN Charter signed (~July 20th)
 - Form ILN landing site and core instrument definition working groups
- Anticipate an ILN core instrument agreement (Dec. 2008)





Moon Mineralogy Mapper (M³)



Team

- PI: Dr. Carle Pieters, Brown University

Mission

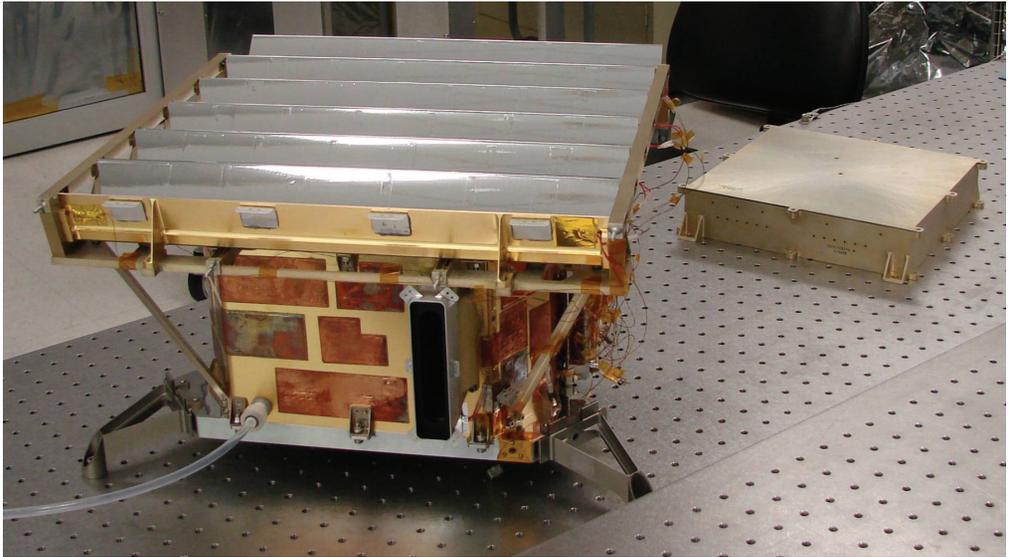
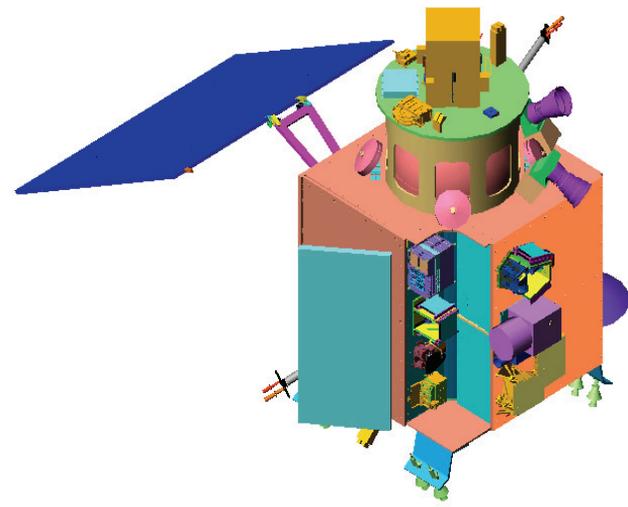
- M3 Instrument on Chandrayaan-1, India's first deep space mission.
- One of 11 instruments (5 of which are non-ISRO, 2 of which are from the US)
- Launch Date: Spring 2008 on ISRO's Polar Satellite LV
- Lunar Orbit: 100 km, polar
- Operational life: 2 years

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

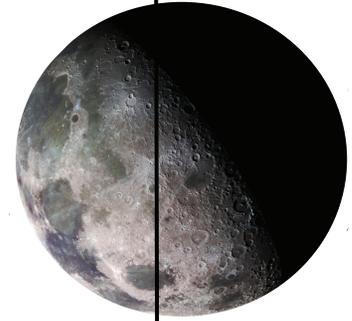
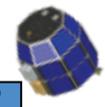
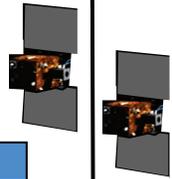
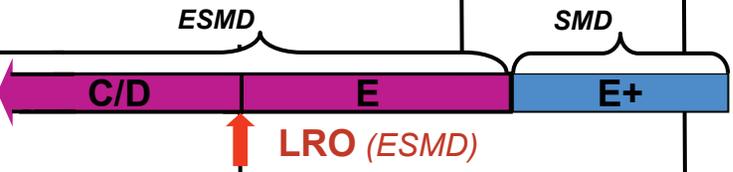
Mission of Opportunity
Science-Funding-Opportunity Driven

LADEE Launch Goal

Mini Lander Launch Goal

ILN Operation Start Goal

Possible Intl. Partner
Early Operations





Lunar R&A



- 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 Notification (SALMON)
 - Call for instruments will include Lunar missions
 - Draft to be released in February
- 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



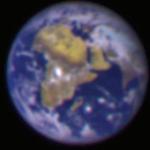
NASA Lunar Science Institute



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 to be competed: Universities, other 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 for scientific interaction that will produce results of mutual benefit



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
 - 03/08 CAN released for initial team selection
 - 04/08 Opening ceremonies
 - 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



The NSLI Lunar Science Conference, co-sponsored by the NASA Lunar Science Institute and the Lunar and Planetary Institute, will be held July 22–24, 2008, at the NASA Ames Conference Center, adjacent to NASA Ames Research Center, Moffett Field, California.

The conference will review the state of knowledge of, and opportunities for, science:
Of the Moon: Study the nature and history of the Moon (including research on lunar samples) and thereby provide insights into the evolution of our solar system;

On the Moon: Investigate the effects of the lunar environment on terrestrial life and the equipment that supports lunar inhabitants, and the effect on robotic and human presence on lunar environment;

From the Moon: Use the Moon as a platform for performing scientific investigations, including observations of the Earth and other celestial phenomena that are uniquely enabled by being on the lunar surface.



LUNAR SCIENCE CONFERENCE

July 22–24, 2008 NASA AMES RESEARCH CENTER

Sessions will be structured to report on recent results and anticipate future opportunities for lunar science. Abstracts on elements of education and public outreach will be included to better understand how lunar exploration can be used to stimulate public interest in space exploration and improve science literacy.

An announcement with a call for abstracts, registration form, and logistical information will soon be posted at <http://www.lpi.usra.edu>

For more information on the NLSI Lunar Science Conference contact:

Science

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Abstract submission

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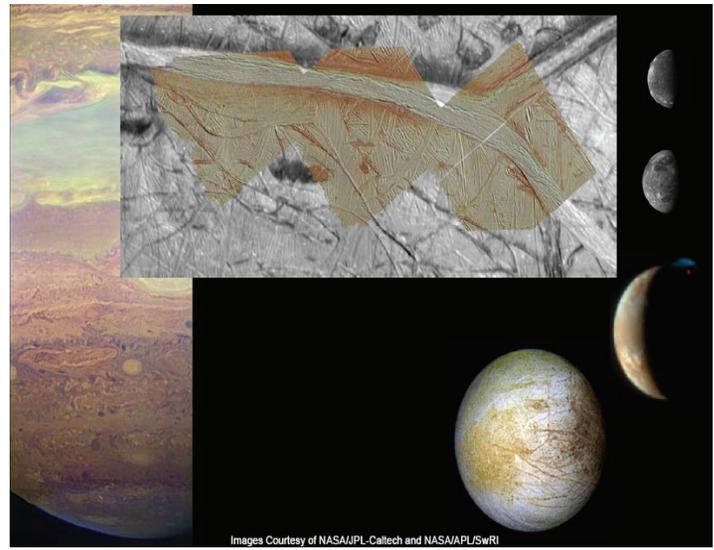
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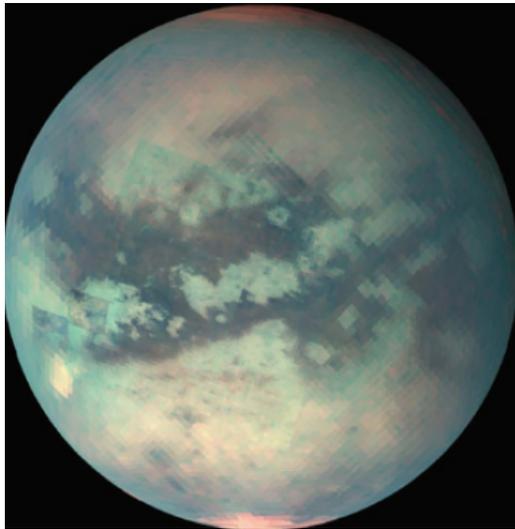
Flagship Mission Studies



Europa



Jupiter System



Titan

- Flagship studies underway
- Working with ESA and JAXA
- Expect a target downselect in early FY09



Upcoming Opportunities

- Stand-Alone Mission of Opportunity Notification (SALMON)
- New Frontiers AO
 - Draft in summer release 1st Quarter FY09
 - PI requirements have been revised
- Discovery AO in FY09



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
- Revise SALMON based on comments March – April 2008
- SALMON Release May 2008
 - 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



PSS Findings and Recommendations



PSS Findings & Recommendations



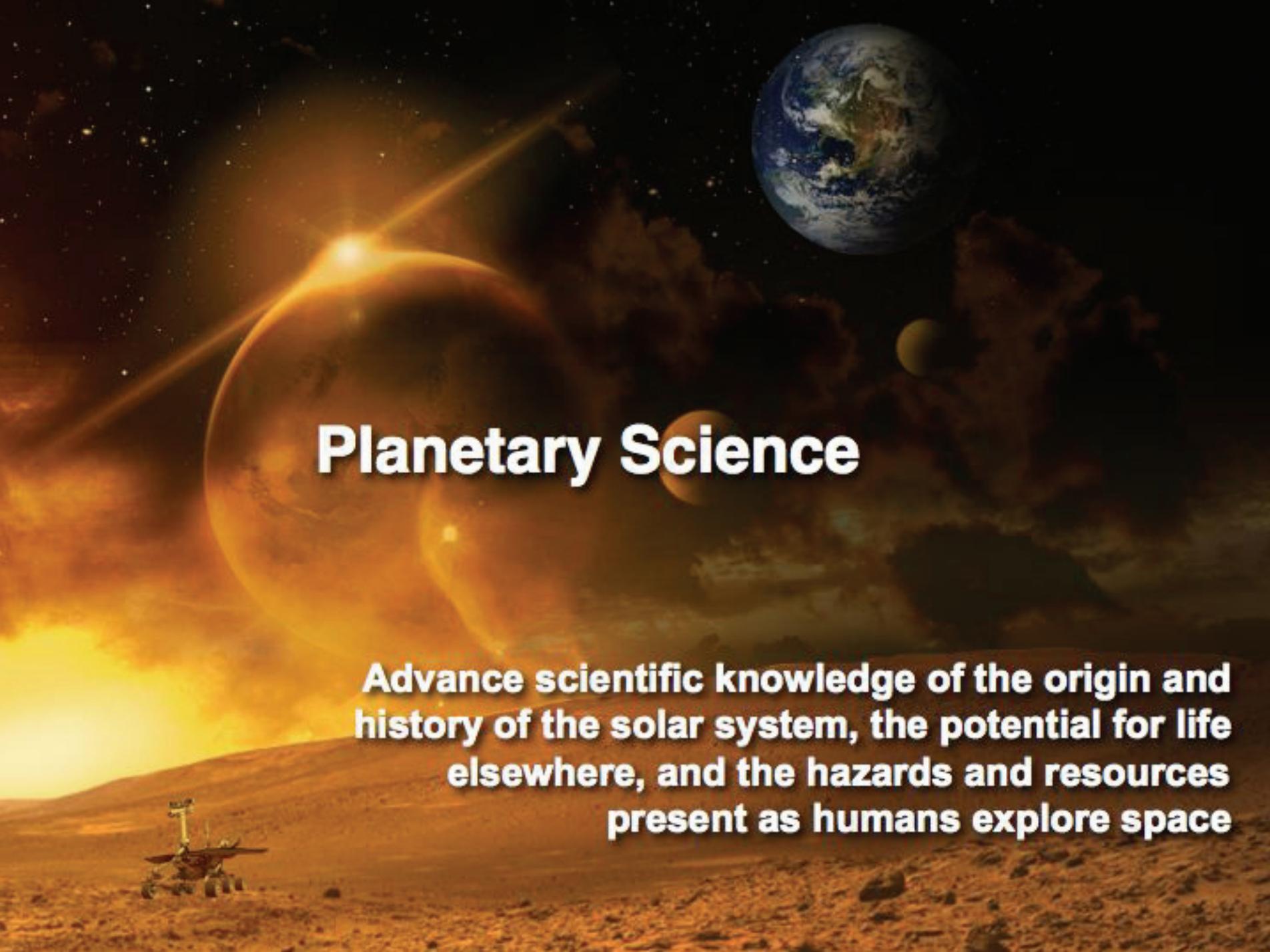
- Sept 2006: Restoration of cuts to R&A and Astrobiology
 - FY08 and onward budgets will nearly complete this action
 - PSD has a strong commitment to follow through on this
- Feb 2007: Maintain Arecibo's radar capability for NASA's use
 - Both the NASA and the NSF Appropriations Act of 2008 address this
- Oct 2007: Creation of the Small Bodies Assessment Group
 - PSD agrees and has assigned M. Kelly SBAG contact
- Oct 2007: NASA review the Lunar Precursor Robotic Program after LRO with the aim of devising innovative routes to undertake robotic exploration missions needed to initiate the next era of lunar and solar system exploration
 - New Lunar program with international participation underway



Appropriations Act 2008



- NASA p. 109-110: Further, the Appropriations Committees are concerned that NASA may reduce support for the Arecibo Observatory which is used by NASA to observe and detect NEOs. The Committees believe that this observatory continues to provide important scientific findings on issues of near-space objects, space weather, and global climate change, as well as numerous other research areas. The Committees believe that these endeavors will have scientific merit far beyond the end of the decade. NASA is directed to provide additional funding to the Arecibo Observatory.
- NSF p.131: The Appropriations Committees express concern over the conclusions of the NSF' s Division of Astronomical Sciences Senior Review with regard to the Arecibo Observatory. The Committees believe that this Observatory continues to provide important scientific findings on issues of near-space objects, space weather, and global climate change, as well as numerous other research areas. The Committees believe that these endeavors will have scientific merit far beyond the end of this decade. As such, the Committees hope the Division of Astronomical Sciences will reconsider its conclusions regarding future funding for the Arecibo Observatory. In addition, the Appropriations Committees directs the Foundation to provide the budget request for operations at its astronomical facilities.



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

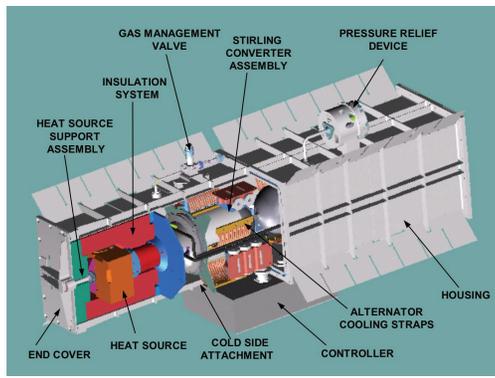


Advanced Stirling Radioisotope Generator Engineering Unit



Lockheed Martin/Sunpower

- 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 (“Pu²³⁸ Bricks”) modules
- Final wiring and connections for ASRG engineering unit underway
- Reliability to be demonstrated by the end of 2009



Paired converters with interconnect sleeve assembly

Outboard Housing and Paired ASC-Es