Planetary Science Division Program Overview

James L. Green, Director
Planetary Science Division
July 15, 2013

Outline

- Upcoming Planetary Events
- Planetary Budget Status
- Planetary Missions Status
- Campaign Science
- R&A Opportunities
- Radioisotope Power Systems & DoE

Planetary Science Missions and Events *as of 07/05/13*

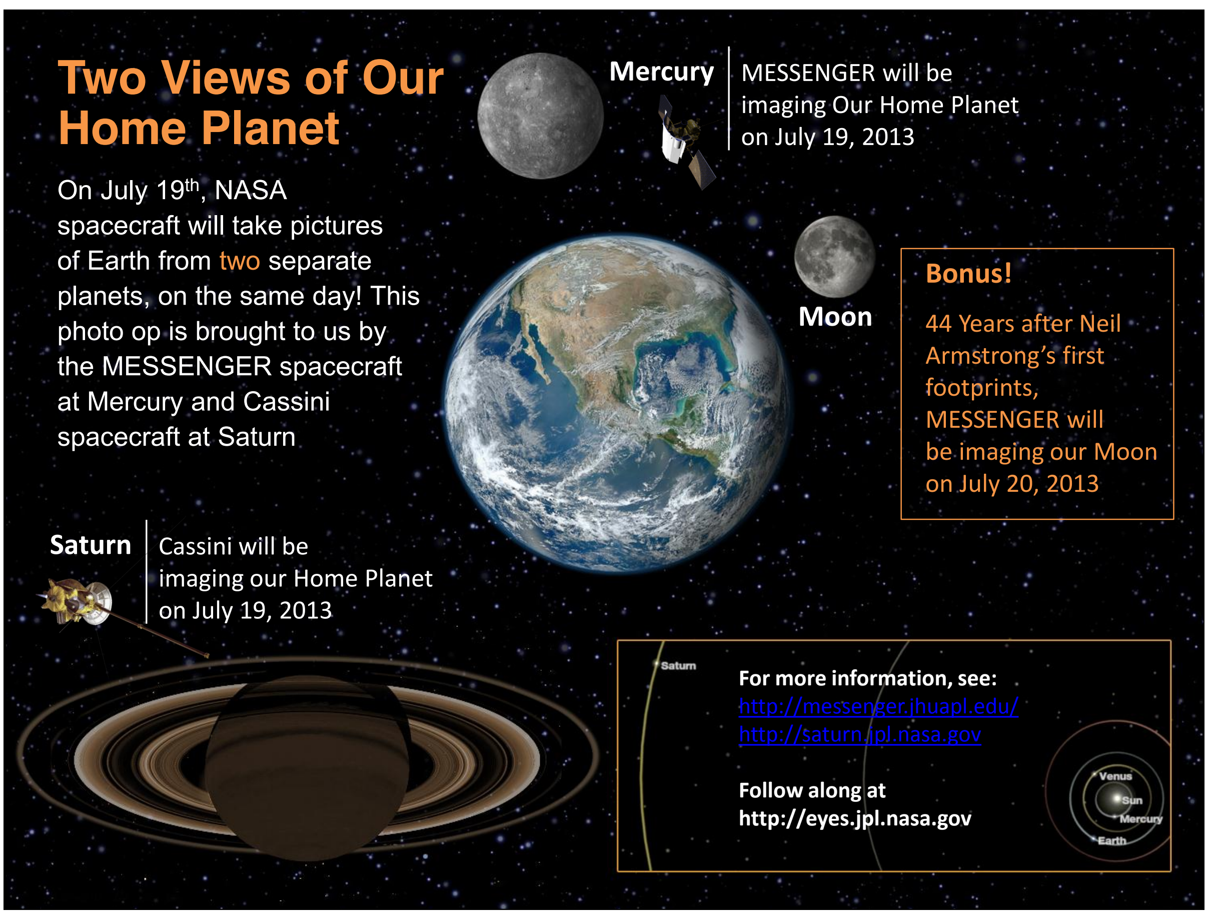
*** Completed**

2013

July 19 – Wave at Saturn (Cassini's Imaging of Earth from Beyond Saturn)
July 25-28 – Intrepid Spacefest, NYC
July 26 – NASM Mars Day
July 31 – Curiosity Day on the Hill
August 5 – One Year Anniversary of Curiosity Landing on Mars
September 6 – LADEE launch from Wallops Flight Facility, VA
October 1 – Close approach of Comet ISON to Mars – *Campaign Science*
October 9 – Juno flyby of Earth
October 12 – International Observe the Moon Night
November 4 – VESPER rocket launch observing Venus
November 19 - Launch of MAVEN from Cape Canaveral, FL
November 28 – Comet ISON Perihelion. Brightest view from Earth of Comet ISON

2014

January – EXCEED-HST observations of Io – *Campaign Science*

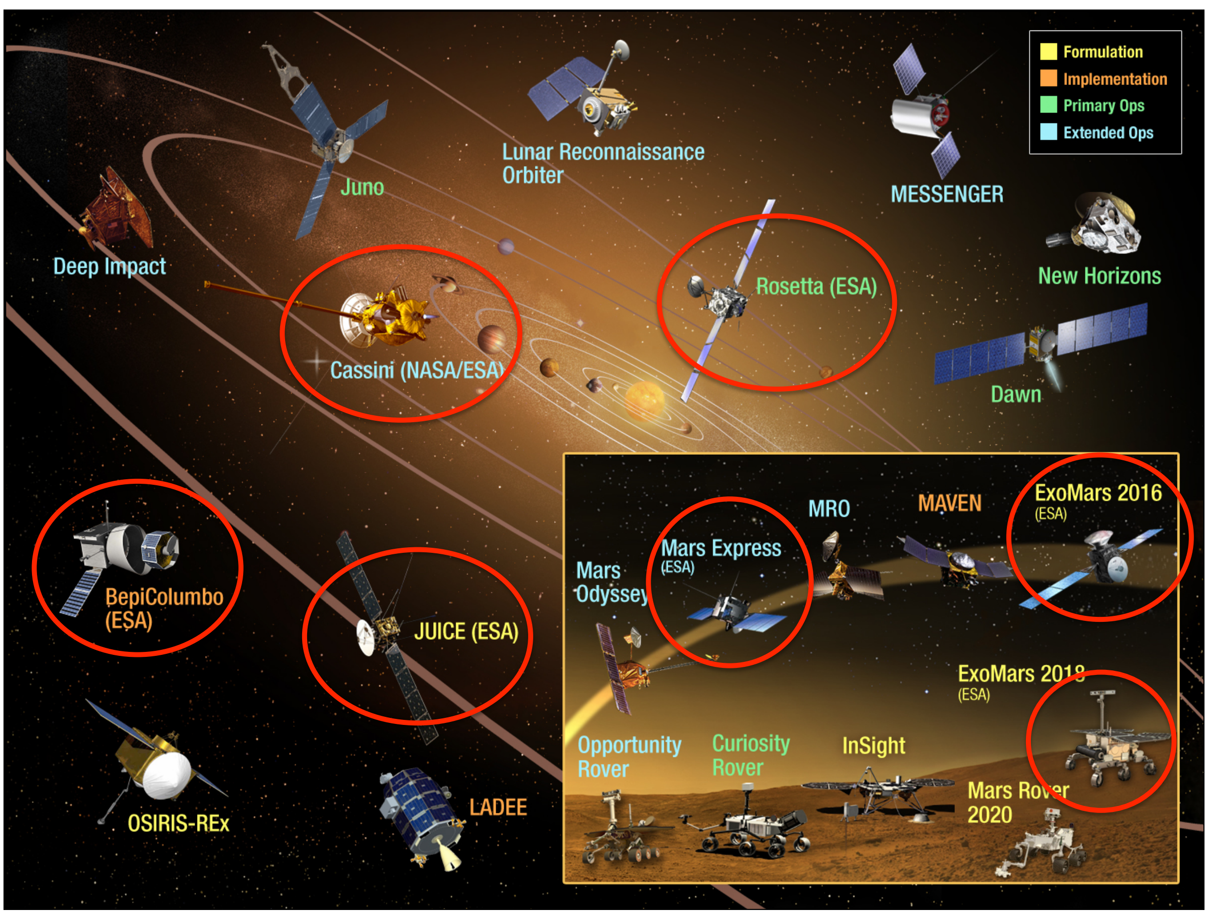


President’s FY14 Planetary Science Budget

* Notional

Planetary Science Division	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Planetary Research	$174,087	TBD	$220,600 *	$233,300	$229,100	$230,400	$232,200
Lunar Quest	$139,972		$17,700	$0	$0	$0	
Discovery	$172,637		$257,900	$268,200	$242,300	$187,500	$215,000
New Frontiers	$143,749		$257,500	$297,200	$266,500	$151,000	$126,200
Mars Exploration	$587,041		$234,000	$227,700	$318,400	$504,700	$513,200
Technology	$161,899		$150,900	$142,800	$144,700	$154,400	$140,000
Outer Planets	$122,054		$79,000	$45,600	$24,400	$26,400	$26,000
	$1,501,439		**$1,217,600**	**$1,214,800**	**$1,225,400**	**$1,254,400**	**$1,252,600**

- Congress passed a budget for PSD at $1.415B but it must be reduced based on sequestration/rescission
- Total Planetary Budget for FY13 will be determined after the current Operations Plan has been approved

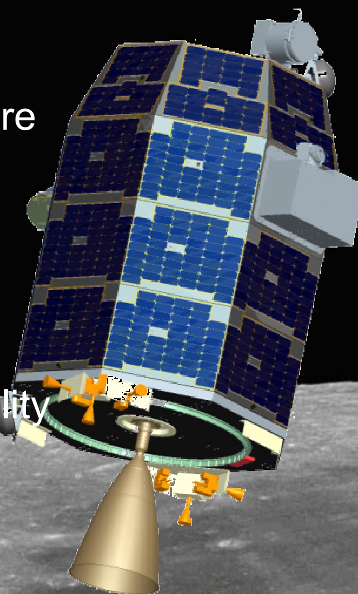


Lunar Atmosphere and Dust Environment Explorer

Objective:
• Measure the lofted Lunar dust
• Composition of the thin Lunar atmosphere

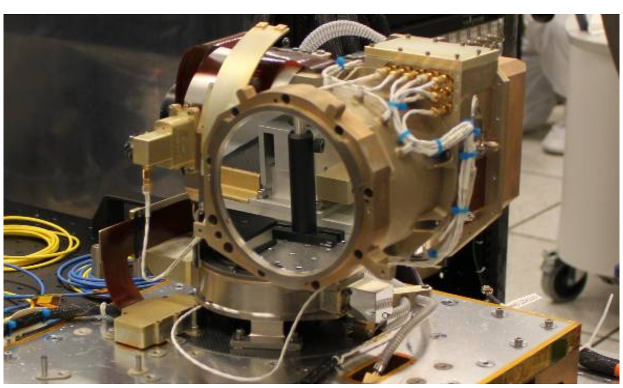
Instruments:
• Science: NMS, UVS, and LDEX
• Technology: Laser Communications

Launch: Sept. 6, 2013 Wallops Flight Facility



LADEE - A Mission of Firsts

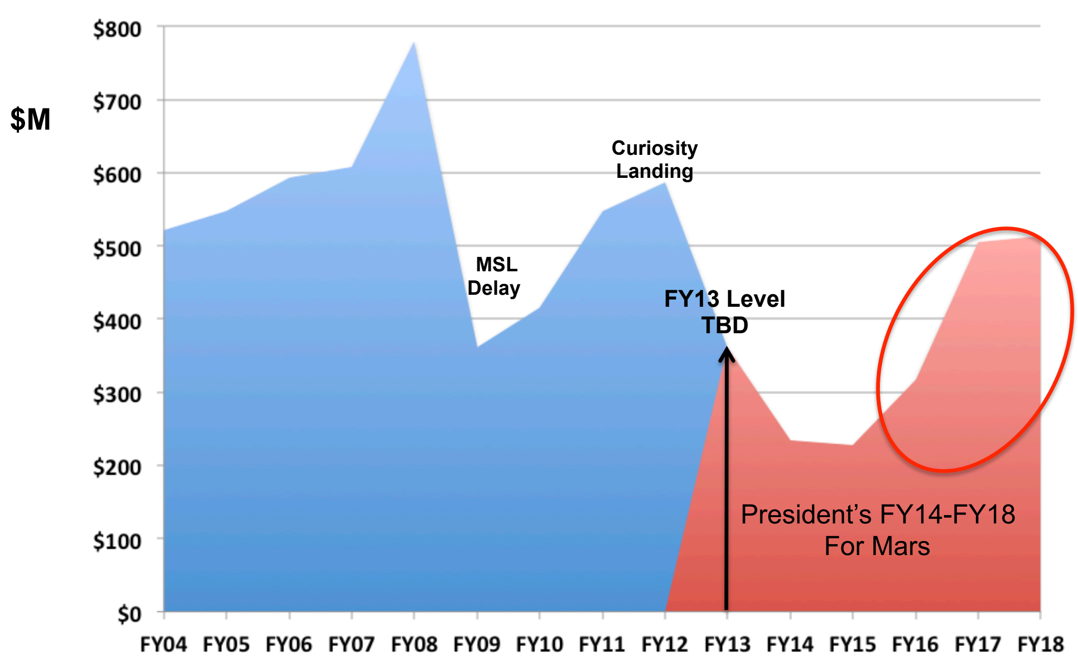
- First Moon launch from WFF
- First launch of Minotaur V rocket from WFF
- First demo of Laser Communications



LLCD (Lunar Laser Communications Demonstration) will demonstrate transferring data at a rate of 622 megabits per second, which is about five times the current state-of-the-art from lunar distances.

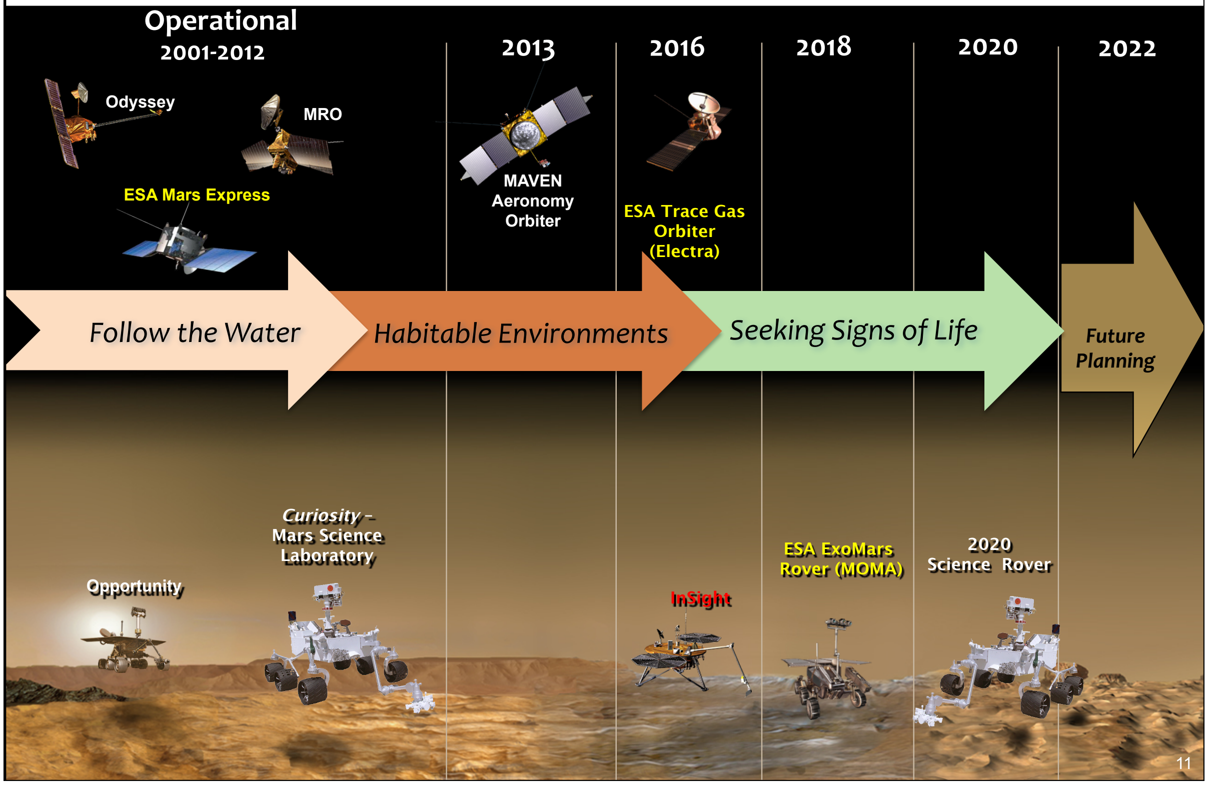
Mars Missions

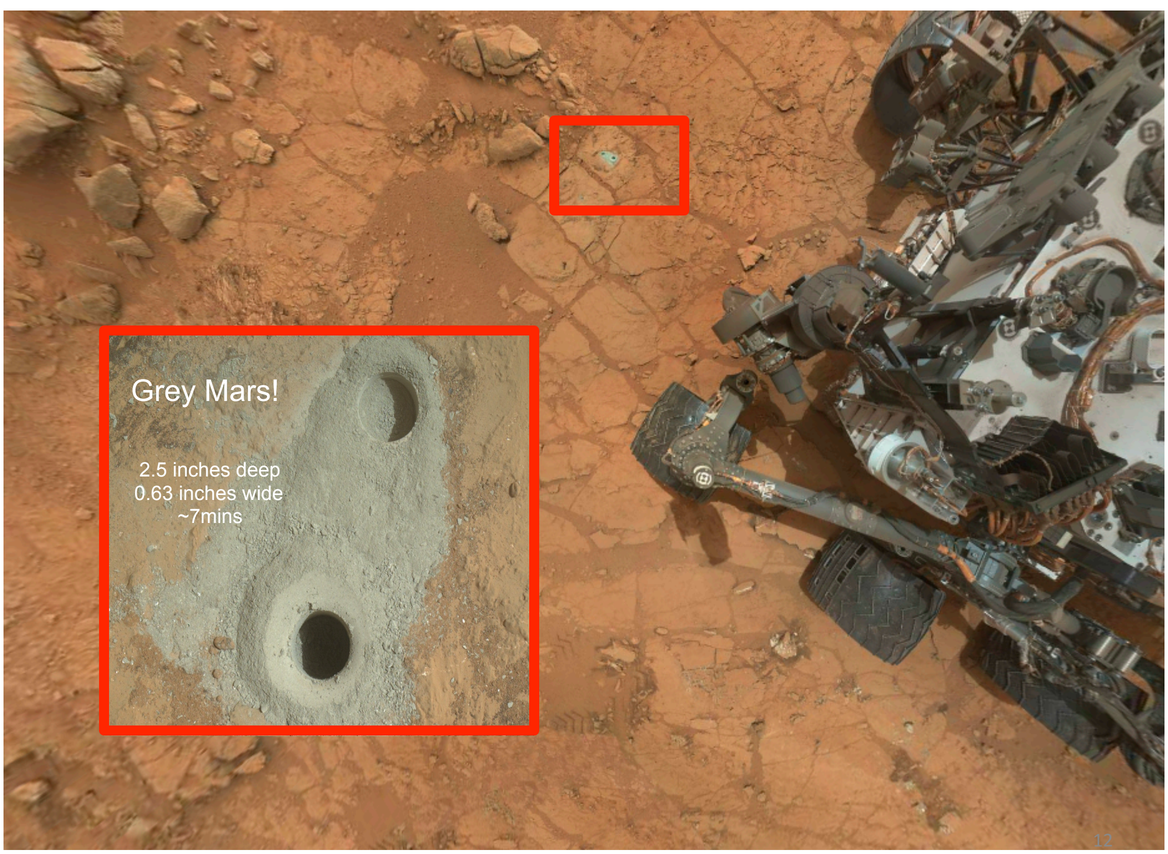
Mars Budget Analysis FY04 through FY18



	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18
Passed Budget	$521	$547	$593	$607	$780	$362	$416	$547	$587	$361	$0	$0	$0	$0	$0
President's FY14 proposed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$361	$234	$228	$318	$505	$513

Future Mars Missions





An Ancient Habitable Environment at Yellowknife Bay

- The regional geology and fine-grained rock suggest that the John Klein site was at the end of an ancient river system or within an intermittently wet lake bed
- The mineralogy indicates sustained interaction with liquid water that was not too acidic or alkaline, and low salinity. Further, conditions were not strongly oxidizing
- Key chemical ingredients for life are present, such as carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur
- The presence of minerals in various states or oxidation would provide a source of energy for primitive biology

MAVEN

Mars Atmosphere and Volatile EvolutioN (MAVEN) Mission

Launch November, 2013 Cape Canaveral

- Mars orbit insertion in Sept. 2014

Science:

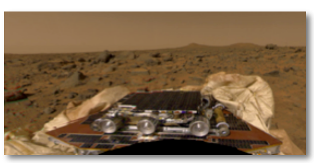
- Determine the structure and composition of the Martian upper atmosphere today
- Determine rates of loss of gas to space today
- Measure properties and processes that will allow us to determine the integrated loss to space through time

Solar System Exploration Programs

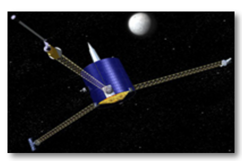
Discovery Program

Completed

Mars evolution:
Mars Pathfinder (1996-1997)



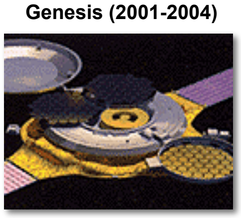
Lunar formation:
Lunar Prospector (1998-1999)



NEO characteristics:
NEAR (1996-1999)

Completed

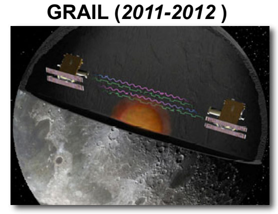
Solar wind sampling:
Genesis (2001-2004)



Comet diversity:
CONTOUR

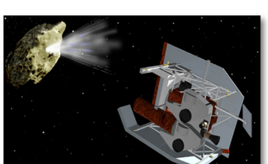
Nature of dust/coma:
Stardust (1999-2011)

Lunar Internal Structure
GRAIL (*2011-2012*)



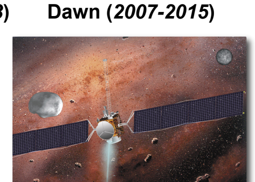
In Flight--Development

Comet internal structure:
Deep Impact (2005-2012)

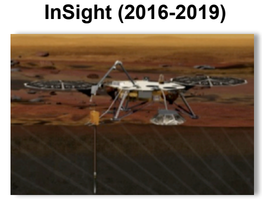


Mercury environment:
MESSENGER (2004-*2013*)

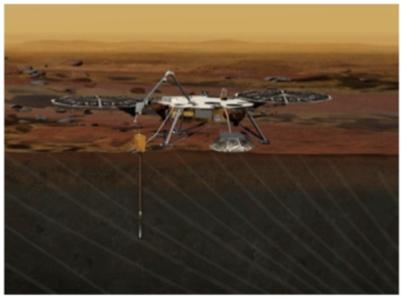
Main-belt asteroids:
Dawn (*2007-2015*)



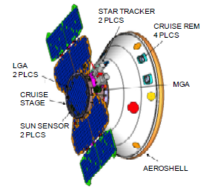
Mars interior structure:
InSight (2016-2019)



InSight: Interior Structure from Seismic Investigations, Geodesy and Heat Transport



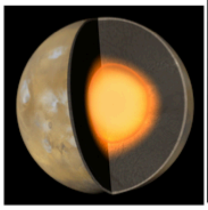
Mission & Science Team:
PI: Bruce Banerdt, JPL
PM: Tom Hoffman, JPL
Deputy PI: Sue Smrekar, JPL
Management: JPL
Spacecraft: Lockheed-Martin
Operations: JPL/LM
Payload: CNES (France), DLR (Ger.), JPL



Mission:
- Geophysical lander mission on Mars using Phoenix heritage spacecraft

Goals:
- Understand formation/evolution of terrestrial planets via interior structure/processes of Mars
- Determine present tectonic activity and meteorite impact rate

Payload:
- Seismic Experiment for Interior Structure (SEIS)
- Rotation & Interior Structure Experiment (RISE)
- Heat Flow & Physical Properties Probe (HP^3)
- Instrument Deployment System



Mission Details:
- Flight: 3/2016 launch w/ELV, 4m fairing; 9/2016 landing; ~6.5 mo cruise, 1 Mars yr surface ops
- System Features (Phoenix-based design): Phoenix EDL architecture, solar power, UHF relay comm with X-band backup, updated RAD 750-based avionics
- Mass: 597.6kg dry launch, margin ≥31% (depending on ELV)
- Schedule: 43.5 mo B/C/D, 105 days sched. reserve
- Threshold Mission: Descope: HP^3, SEIS SP sensors

New Frontiers Program

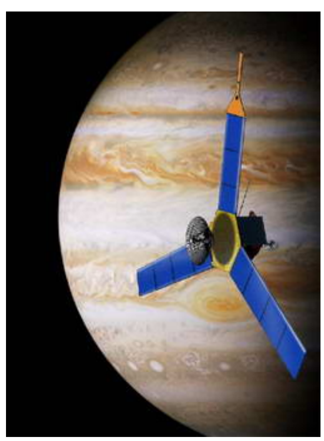
1st NF mission
New Horizons:

Pluto-Kuiper Belt

Launched January 2006
Arrives July 2015
PI: Alan Stern (SwRI-CO)

2nd NF mission
JUNO:

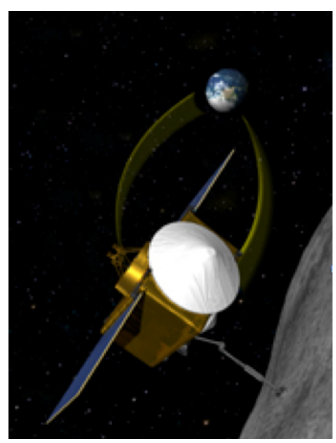
Jupiter Polar Orbiter



Launched August 2011
Arrives July 2016
PI: Scott Bolton (SwRI-TX)

3rd NF mission
OSIRIS-REx

Asteroid Sample Return

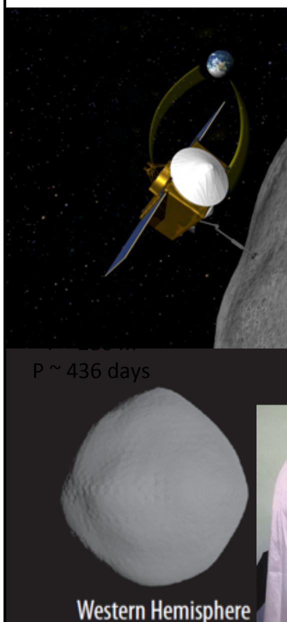


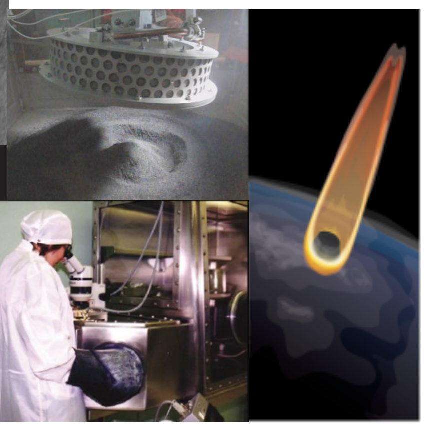
Sept. 2016 LRD
PI: Dante Lauretta (UA)

Origins-**S**pectral **I**nterpretation-**R**esource **I**dentification-**S**ecurity-**R**egolith **Ex**plorer (OSIRIS-REx)

<u>Science Objectives:</u>

- Return and analyze a sample of pristine carbonaceous asteroid
- Map the global properties, chemistry, and mineralogy
- Document in situ the properties of the regolith at the sampling site
- Characterize the integrated global properties to allow comparison with ground-based telescopic data of entire asteroid population
- Measure the Yarkovsky effect





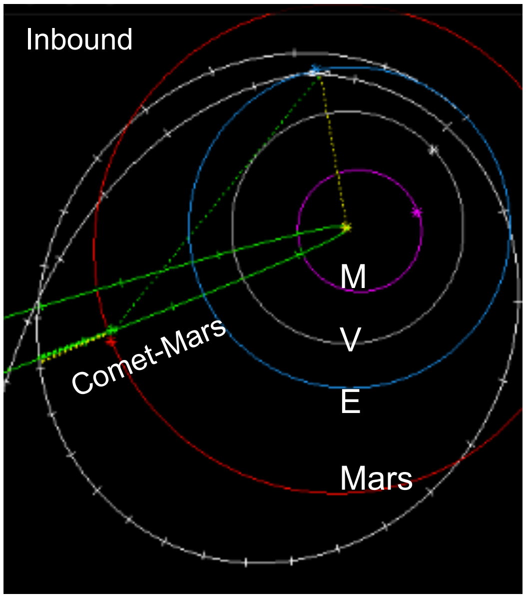
<u>Mission Overview:</u>

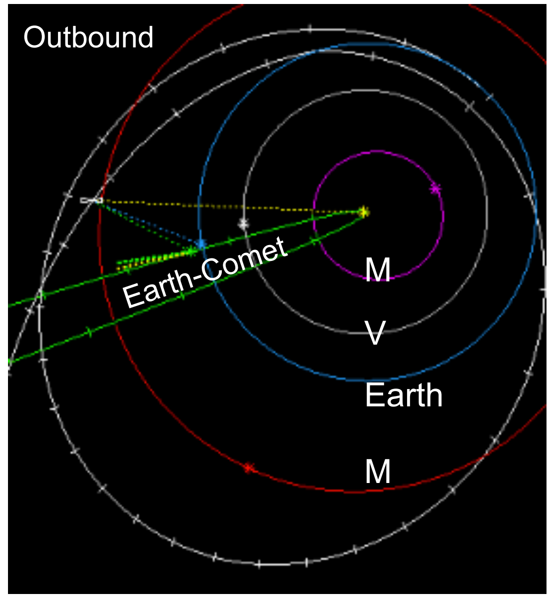
- Launch in <u>September 2016</u>
- Encounter asteroid (101955) 1999 RQ36 in October 2019
- Study RQ36 for up to 505 days, globally mapping the surface
- Obtain at least 60 g of pristine regolith/surface material
- Return sample to Earth in September 2023 in a Stardust-heritage capsule
- Deliver samples to JSC curation facility for world-wide distribution

Campaign Science:

Maximize the Science using multiple coordinated observations

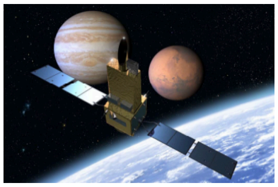
Comet ISON Observing Campaign



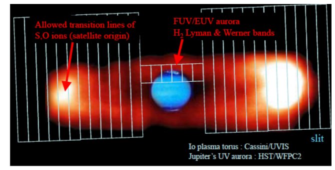


- In: Mars-Comet closest approach ~0.08 AU (Oct 1)
- Out: Earth-Comet closest approach ~0.44AU (Jan 2)

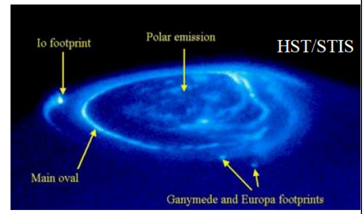
Space-Based Observations of the Jovian System



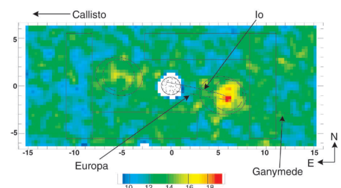
- SPRINT-A/EXCEED – LRD Aug. 22nd
  - 50 min. of every 100-min. orbit from November 2013-April 2014
  - FUV spectra of the Io torus and Jovian aurora
  - composition/electron temperature of torus; energy of auroral electrons)



- HST/STIS
  - 14 orbits in early Jan. 2014
  - Imaging & spectroscopy of Jupiter's FUV aurora
  - Global morphology & incident auroral electron energy

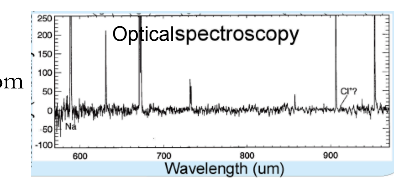


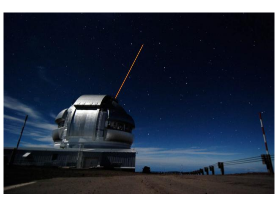
- Chandra X-Ray Observatory/ XMM-Newton
  - 160 ksec in April 2014
  - Imaging & spectra of X-ray emissions from Jupiter and the Io torus
  - Global morphology and energy of auroral x-rays



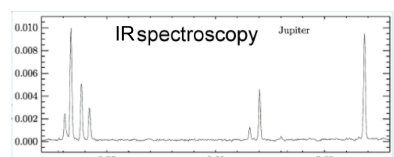
Ground-Based Observations of the Jovian System

- KPNO 4m
  - 7 half-nights in early Jan. 2014
  - Spectra of optical S^+ & Na emissions from the Io plasma torus (IPT)
  - Electron density in the IPT

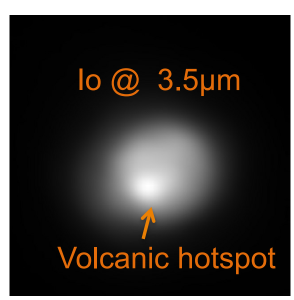




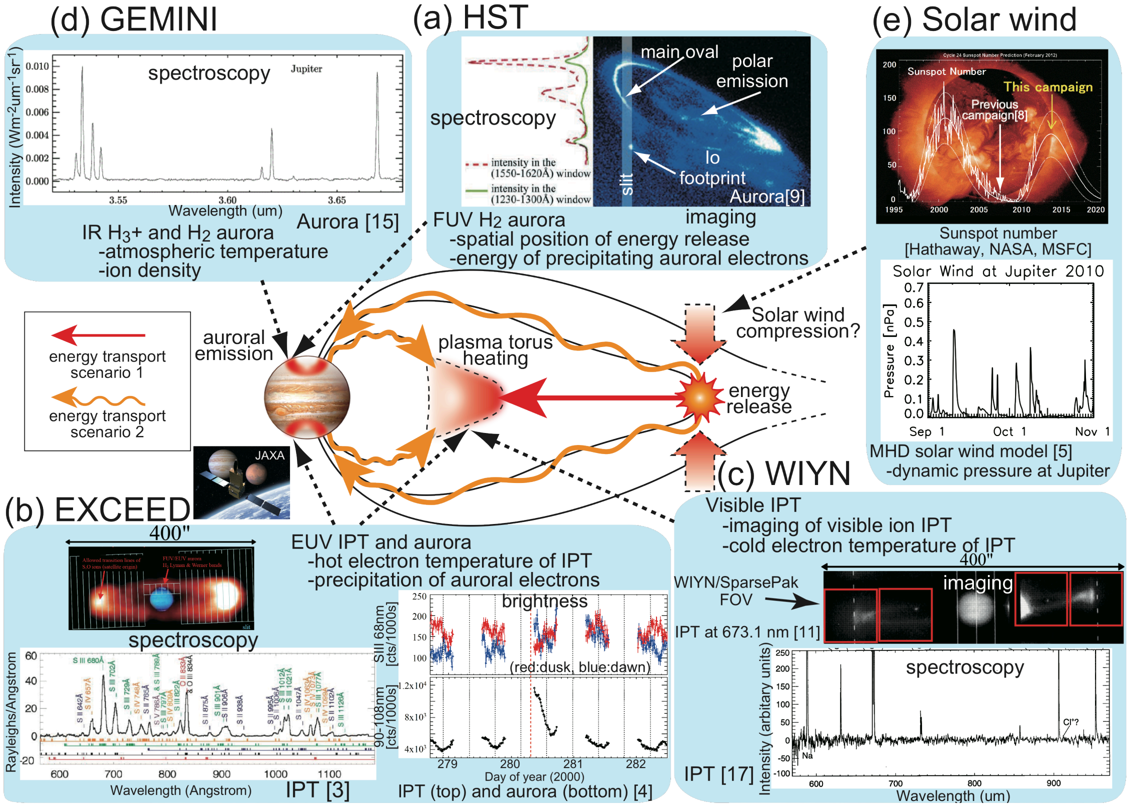
- Gemini North
  - 14 hours in early Jan. 2014
  - H_3^+ and H_2 Near-IR emissions from the Jovian aurora
  - Spatially-resolved atmospheric temperature, column density, and auroral electron energy



- NASA IRTF
  - 3 separate accepted proposals:
  - 1-5 μm imaging of thermal emission from Io's volcanoes
  - Observe Jupiter's aurora H_3^+ @ 4μm
  - Io 3-5 μm spectral monitoring.



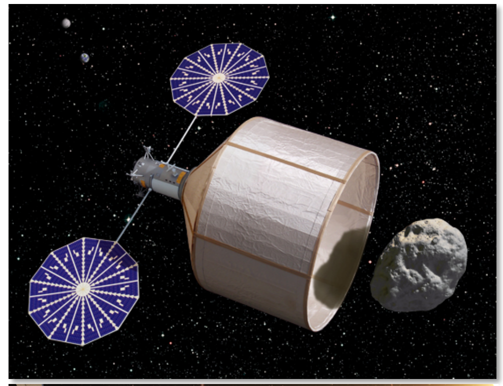
Jupiter Observing Strategy: Jan 2014

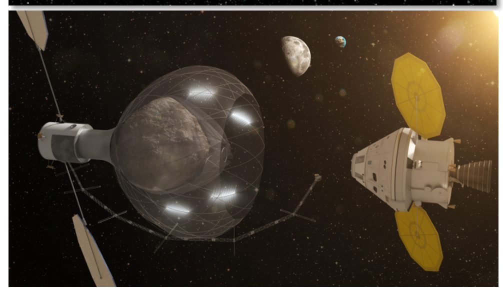


NASA’s Asteroid Initiative

Capture and Retrieve an Asteroid

- Capture and transport a 7-meter diameter, 500-1000 ton near-Earth asteroid (NEA) to cis-lunar space
- Enable astronaut missions to the asteroid by as early as 2021
- Obtain valuable information for exploration, planetary defense, science, and *in situ* resource utilization (ISRU)
- Parallel and forward-leaning development approach
- Under Review by SBAG

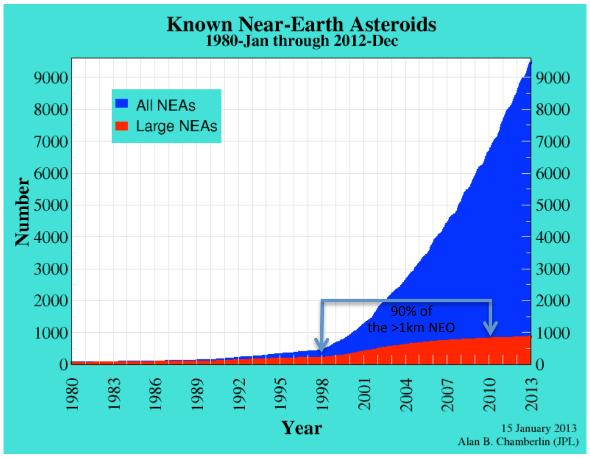


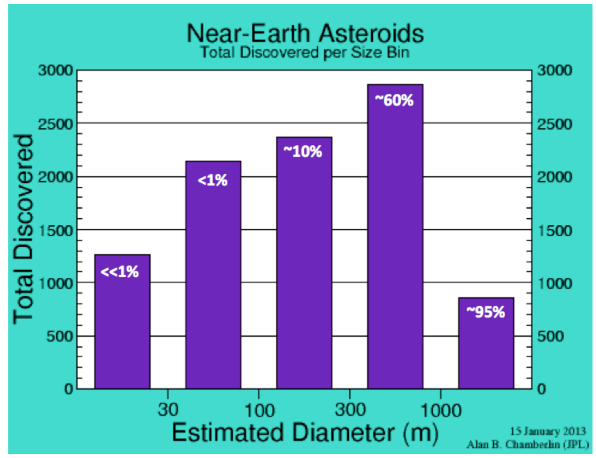


Asteroid Mission Would Consist of Three Main Segments

Identify	Redirect	Explore
		
Asteroid Identification Segment:	**Asteroid Redirection Segment:**	**Asteroid Crewed Exploration Segment:**
Ground and space based NEA target detection, characterization and selection	Solar electric propulsion (SEP) based asteroid capture and maneuver to trans-lunar space	Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid

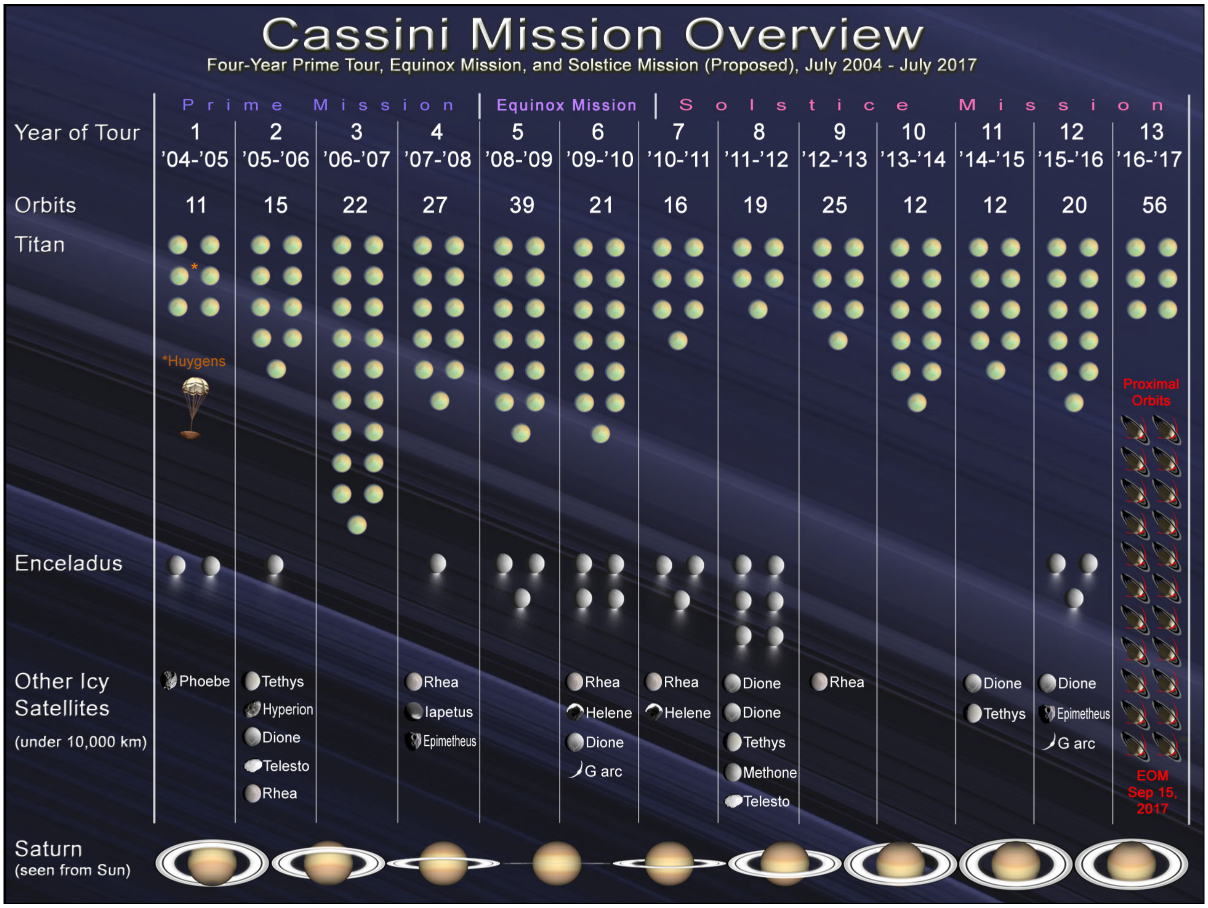
Quick Status of the NEO Survey Program





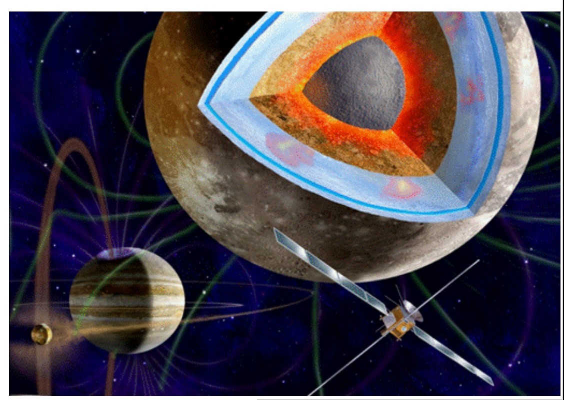
- Congressional Bill 1998 – Find 90% of the >1km NEO within 10 yrs
- Congressional Bill 2005 – Find 90% of the >140m NEO within 15 yrs

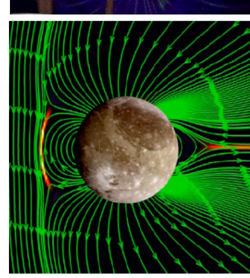
Outer Planets

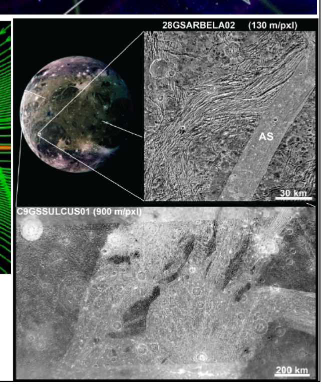


The JUpiter ICy moons Orbiter Mission

- ESA's first Large-class mission in Cosmic Vision Program
- The JUICE mission will investigate the emergence of habitable worlds around gas giants, characterizing Ganymede, Europa, and Callisto as planetary objects and potential habitats, and will also explore the Jupiter system as an archetype for gas giants.
- JUICE will first orbit Jupiter for ~2.5 years, providing 13 flybys of Callisto and 2 of Europa, and then will orbit Ganymede for 9 months
- Launch is scheduled for 2022 with Jupiter arrival in 2030 and Ganymede orbit insertion in 2032
- Three NASA investigations selected







Europa Clipper Mission Concept

Objectives:

- **Ocean:** Existence, extent, salinity
- **Ice Shell:** Water within or beneath; nature of surface-ice-ocean exchange
- **Composition:** Key compounds; links to ocean composition
- **Geology:** *S*urface feature formation; sites of recent or current activity
- **Reconnaisance:** Surface characteristics at lander scales

Model Payload:

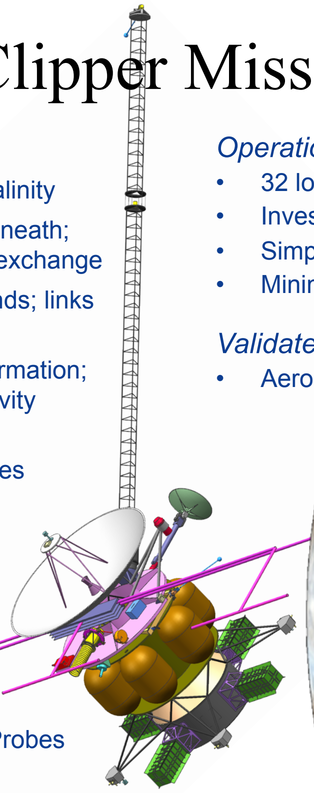
- Ice-Penetrating Radar
- Stereo Camera
- Infrared Spectrometer
- Neutral Mass Spectrometer
- Gravity Science Antenna
- Magnetometer & Langmuir Probes
- Reconnaissance Camera
- Thermal Imager

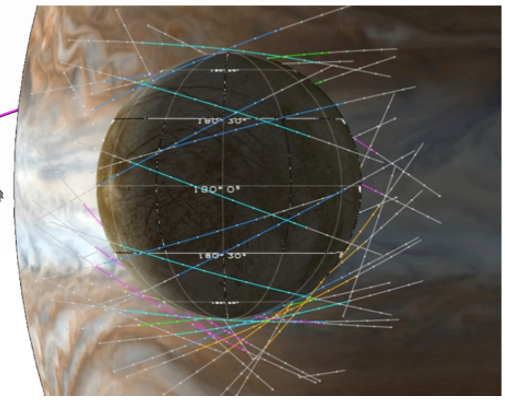
Operations Concept:

- 32 low-altitude flybys from Jupiter orbit
- Investigation of globally distributed regions
- Simple repetitive science operations
- Minimal time in high radiation environment

Validated Cost Estimate:

- Aerospace validated cost: $2B ($FY15, w/o LV)





Planetary Supporting Research and Analysis Program

<u>*Opportunities*</u>

Solar System Exploration Research Virtual Institute (SSERVI)

•SSERVI expands on the success of NLSI to include all near term targets for human exploration

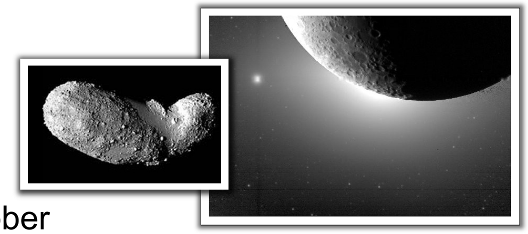
- Target bodies: Moon, NEAs, Phobos and Deimos
- Anticipate selecting 7 teams at level of $1-1.5M/yr for 5 yrs
- New Cooperative Agreement Notice (CAN) anticipated every 2-3 yrs

•Substantial HEOMD/SMD collaboration

- Addresses key HEOMD Strategic Knowledge Gaps (SKGs)
- Focus on planetary and exploration science along with astrophysics and heliophysics research uniquely enabled by the target bodies

•Time Line:

- CAN released Jan 10th 2013
- 32 NOI's received as of Feb
- Proposals Due April 10th
- Panel Review (target) late July
- Teams announced at DPS in October
- Teams funded and initial SSERVI launch Dec 2013



NASA Astrobiology Institute - Cycle 7

• CAN Cycle 7 will maintain a multidisciplinary institute by selecting focused, interdisciplinary teams that complement without replicating the strengths of the continuing teams.

• The teams selected in Cycle 7 (no more than 6-7) will replace the teams selected in Cycle 5, whose five-year Cooperative Agreements are expiring.

• Important Dates:	
• Draft Cooperative Agreement Notice	July 3, 2013
• Comment Due Date	July 31, 2013
• CAN Release Date	September TBD, 2013
• Preproposal Conference:	October TBD, 2013
• Step 1 Proposal Due:	November TBD, 2013
• Step 2 Proposals Due:	January TBD, 2014

CAN 5 Teams (Rolling Off)

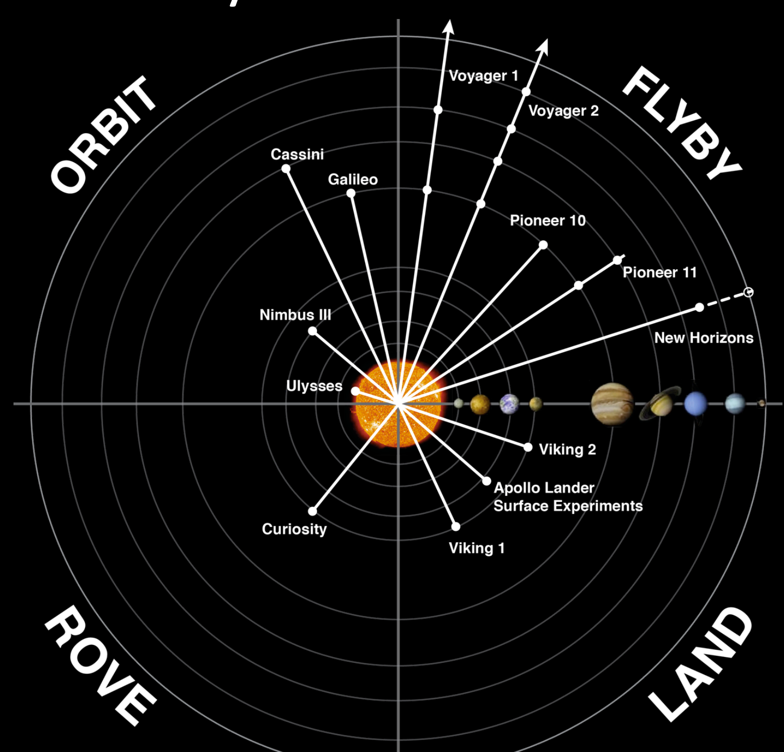
Jet Propulsion Laboratory	Astrobiology of Icy Worlds: Habitability, Survivability, and Detectability
Jet Propulsion Laboratory	Titan as a Prebiotic Chemical System
Georgia Tech	Center for Ribosome Adaptation and Evolution
Rensselaer Polytechnic Institute	Setting the Stage for Life: From Interstellar Clouds to Early Earth and Mars
University of Hawaii, Manoa	The Origin, History, and Distribution of Water and Its Relation to Life in the Universe
Ames Research Center	Early Habitable Environments and the Evolution of Complexity
Arizona State University	Follow the Elements
Goddard Space Flight Center	Origin and Evolution of Organics in Planetary Systems
Pennsylvania State University	Signatures of Life From Earth and Beyond
Carnegie Institution of Washington	Astrobiological Pathways: From the Interstellar Medium, Through Planetary Systems, to the Emergence and Detection of Life

CAN 6 Teams (2013-2017)

Massachusetts Institute of Technology	Foundations of Complex Life: Evolution, Preservation and Detection on Earth and Beyond
University of Illinois at Urbana-Champaign	Towards Universal Biology: Constraints From Early and Continuing Evolutionary Dynamics of Life on Earth
University of Southern California	Life Underground
University of Wisconsin	Habitability, Life Detection, and the Signatures of Life on the Terrestrial Planets
University of Washington	The Virtual Planetary Laboratory

Radioisotope Power Systems/DoE

Over 50 years of RPS Missions



FY14 Funding Realignment for RPS

- In FY14, DOE is to transition to a full cost recovery strategy for RPS
- OMB directed NASA to provide full funding so RPS program requirements and funding are aligned under one Agency
  - Assertion is that NASA is the prime customer for Pu-238
- Funding and justification for sustainment of all necessary supporting infrastructure and capabilities at DOE is to be included in the FY14 NASA budget request
- DOE to maintain responsibility for execution of RPS flight development, production, safety, and management of necessary infrastructure
- To support and advise NASA, a facilities and capability review committee was put together and has started to performing a zero-base review
  - NASA membership: Jim Adams, David Schurr, Hal Bell, Frank Bellinger, Kevin Gilligan
  - Non-NASA consultants: Ralph McNutt (APL), Tim Frazier (former DOE), Aerospace Corporation (Mark Rokey and others)
  - Ex-officio observers: Len Dudzinski (NASA PSD Liaison) and Alice Caponiti (DOE Liaison)
- Review Committee to report findings/recommendations by October 1st

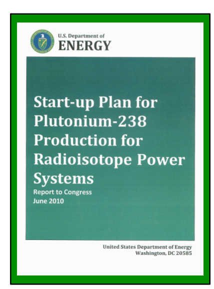
ASRG and Pu-238 Production

<u>Advanced Stirling Radioistope Generator (ASRG)</u>

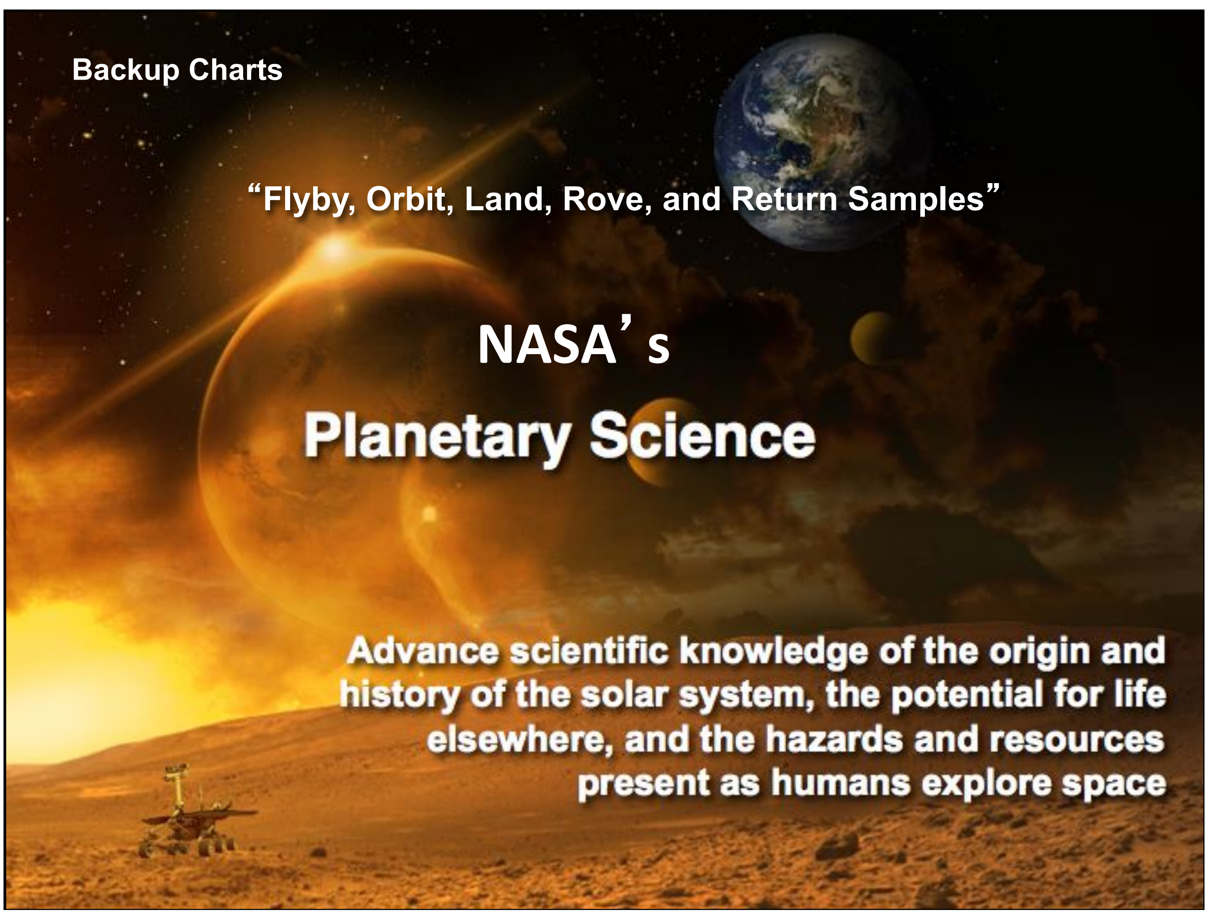
- After Discovery 12 selection, working to identify next ASRG mission
  - Expectation is that Discovery 13 will provide similar opportunities to test mission enabling technologies
  - Two ASRG flight units (F1 and F2) will be completed in 2016
  - The completed flight units will go into bonded storage, unfueled, pending a mission decision for flight use

<u>Plutonium-238</u>

- Technology demonstration activities include:
  - A qualified Neptunium-237 target for irradiation in the High Flux Isotope Reactor *(First Np-237 targets irradiated)*
  - A qualified process for post-irradiation target processing
  - A qualified Pu-238 product
  - A project plan for scale-up to full-scale production at 1.5-2.0 kg/year
- Project baseline and confirmation by December 2013




Planetary Science 2013 Events
Join Us?
Contact: Steven Williams at
WilliamsSH@si.edu
MAVEN Launch to Mars
No earlier than November 18, 2013
From Cape Canaveral, Florida
Comet ISON
Best Visible November 28, 2013
From Northern Hemisphere
LADEE Launch to the Moon
No earlier than September 5, 2013
From Wallops Island, Virginia


Backup Charts
“Flyby, Orbit, Land, Rove, and Return Samples”
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