

Planetary Science Division Status Report

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NASA, Planetary Science Division
March 31, 2015

Presentation at CAPS

Outline

- Mission events
- Passed FY15 Budget elements
- President's FY16 Budget
- Discovery and New Frontiers Status
- Mars Program Status
- Recent Europa Activities
- Status of PSD R&A program

Planetary Science Missions Events

2014

- July – *Mars 2020* Rover instrument selection announcement * Completed
- August 6 – 2nd Year Anniversary of *Curiosity* Landing on Mars
- September 21 – *MAVEN* inserted in Mars orbit
- October 19 – Comet Siding Spring encountered Mars
- September – *Curiosity* arrives at Mt. Sharp
- November 12 – ESA's *Rosetta* mission lands on Comet Churyumov–Gerasimenko
- December 2/3 – Launch of *Hayabusa-2* to asteroid 1999 JU₃

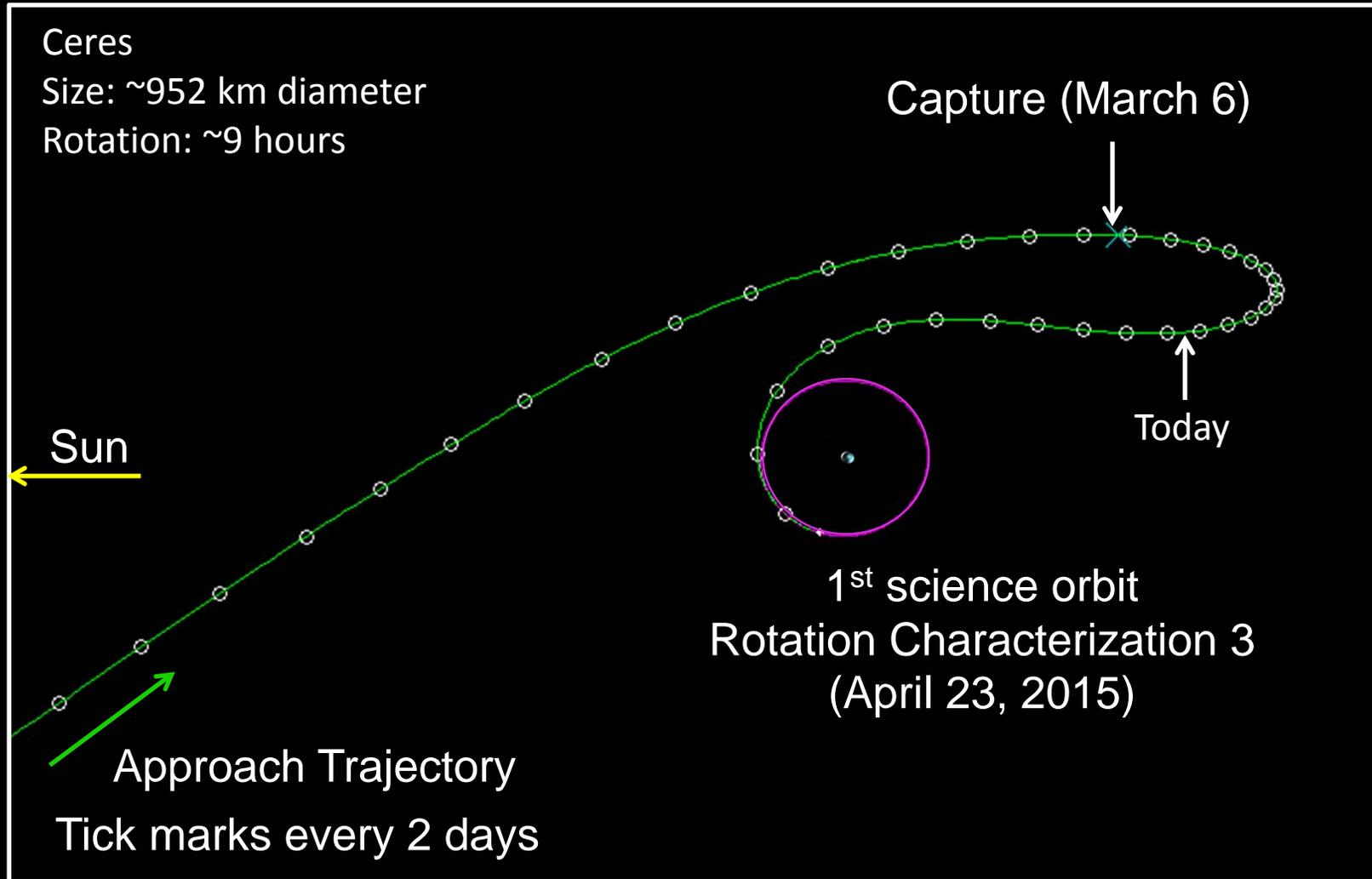
2015

- March 6 – *Dawn* inserted into orbit around dwarf planet Ceres
- Late April – *MESSENGER* spacecraft impacts Mercury
- May – Europa instrument Step 1 selection
- July 14 – *New Horizons* flies through the Pluto system
- September – Discovery 2014 Step 1 selection

2016

- March – Launch of Mars missions *InSight* and ESA's *ExoMars Trace Gas Orbiter*
- March – Europa instrument Step 2 selection
- July – *Juno* inserted in Jupiter orbit
- July – ESA's *Bepi Colombo* launch to Mercury
- September – Discovery 2014 Step 2 selection
- September – *InSight* Mars landing
- September – Launch of Asteroid mission *OSIRIS – REx* to asteroid Bennu
- September – *Cassini* begins to orbit between Saturn's rings & planet

Dawn's Approach



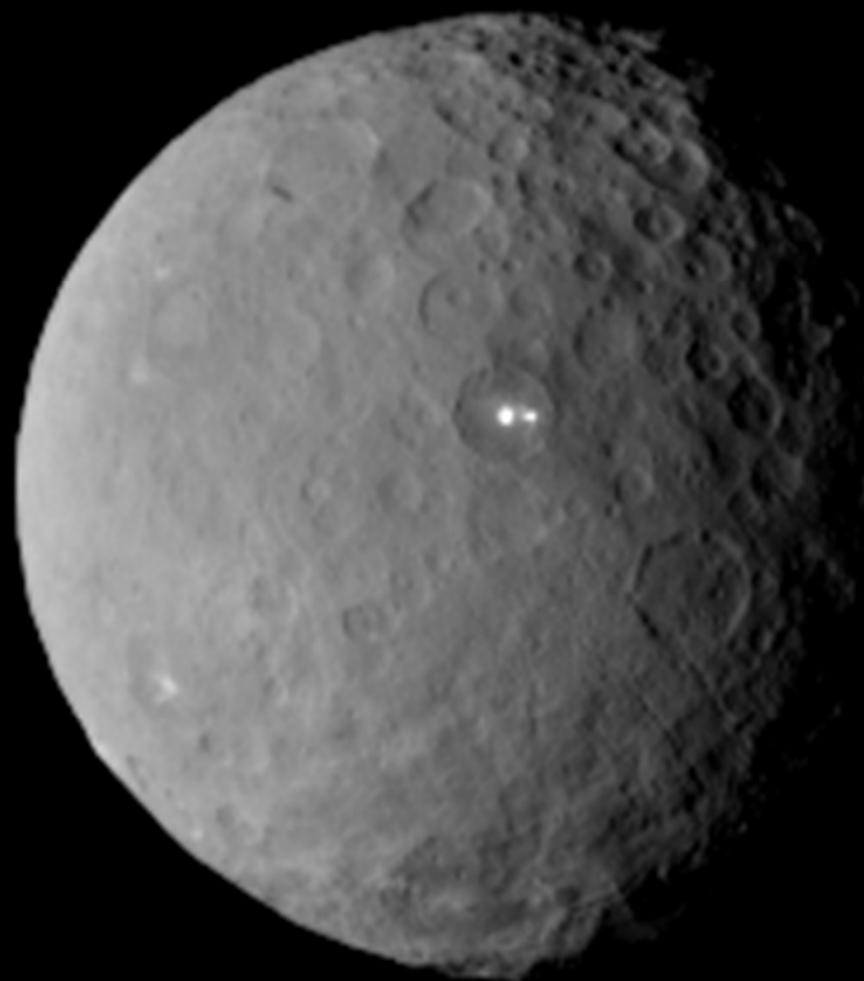
Ceres Approach Timeline

Date	Activity	Distance	Pixels	Comment
Dec 1, 2014	Calibration image of Ceres	1.12M km	8	Complete
Jan 13, 2015	First OpNav Image of Ceres	379,000 km	26	0.8x Hubble resolution
Jan 26, 2015	OpNav #2	201,000 km	43	1.4x Hubble resolution
Feb 4, 2015	OpNav #3	146,000 km	70	2.2x Hubble resolution
Feb 12, 2015	Rotation Characterization 1	84,000 km	121	3.8x Hubble resolution
* Feb 20, 2015	Rotation Characterization 2	46,000 km	221	7x Hubble resolution
Feb 23, 2015	Closest Approach	38,000 km		Begin high-phase Approach
Feb 25, 2015	OpNav #4	40,000 km	253	8x Hubble resolution
Mar 1, 2015	OpNav #5	49,000 km	207	6.5x Hubble resolution
Mar 6, 2015	Capture	60,000 km		Capture into orbit
Apr 10, 2015	OpNav #6	33,000 km	304	9.5x Hubble resolution
Apr 15, 2015	OpNav #7	22,000 km	455	14x Hubble resolution
Apr 23, 2015	Rotation Characterization 3	13,000 km	717	20x Hubble resolution

RC 2

Feb 19

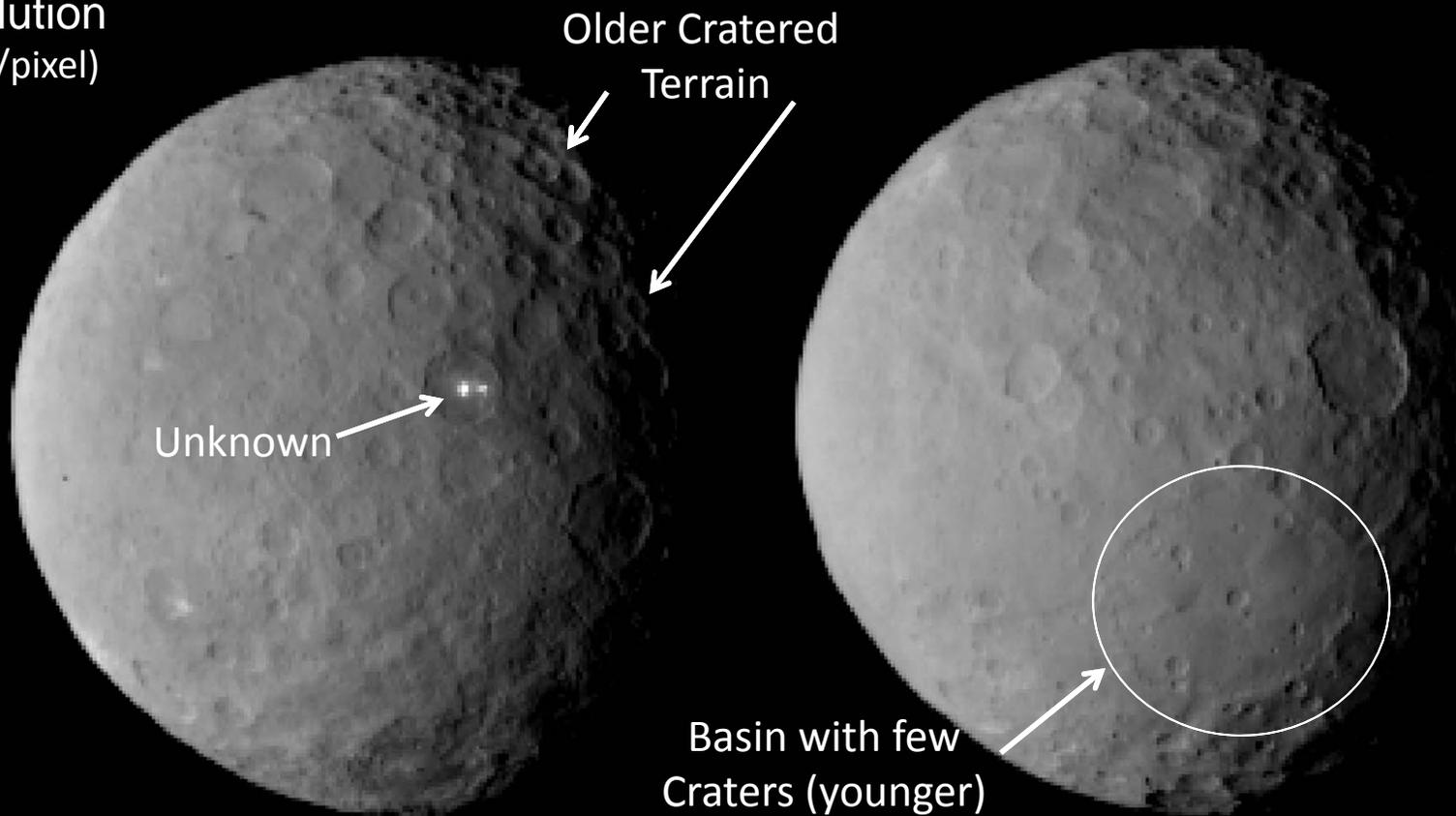
Resolution
4 km/pixel



The Types of Terrain

RC 2 - Feb 19

7 x Hubble
Resolution
(4 km/pixel)



MESSENGER: 10 Years in Space

BY THE NUMBERS*

8 BILLION
miles traveled

29 TRIPS
around
the Sun

255,858
IMAGES
returned to Earth

91,730 MPH
average speed
(relative to the Sun)

60 MILES
from the
surface
at closest
approach

10 TERABYTES
of science data
publicly released

6 FLYBYS
of the
inner planets

35 MILLION
SHOTS
by the Mercury
Laser Altimeter

7 MERCURY
SOLAR DAYS
and

1,232 EARTH
DAYS
in orbit

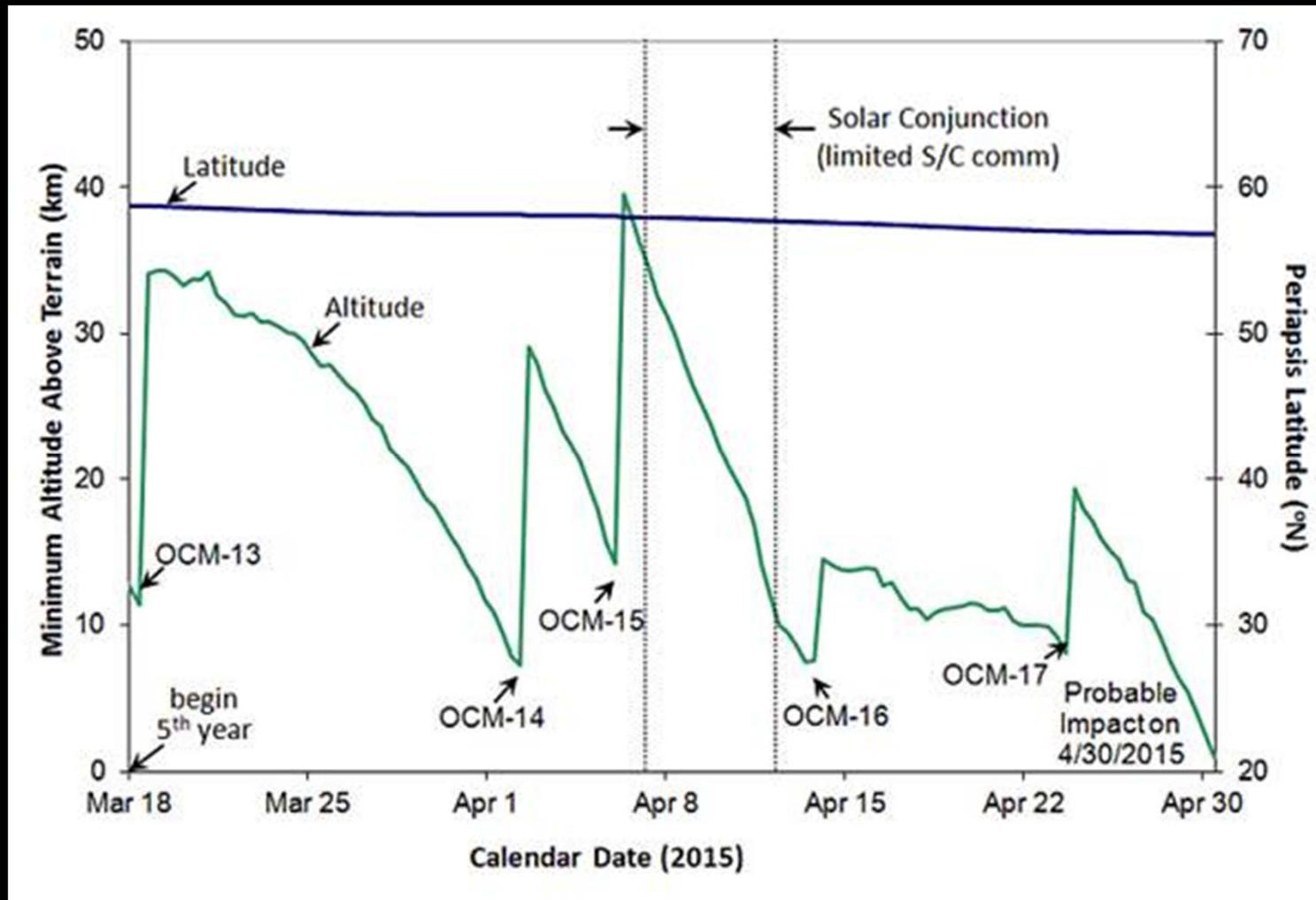
3,308
ORBITS
of Mercury completed



*As of August 1, 2014

1513_14-0231

MESSENGER



The New Pluto System

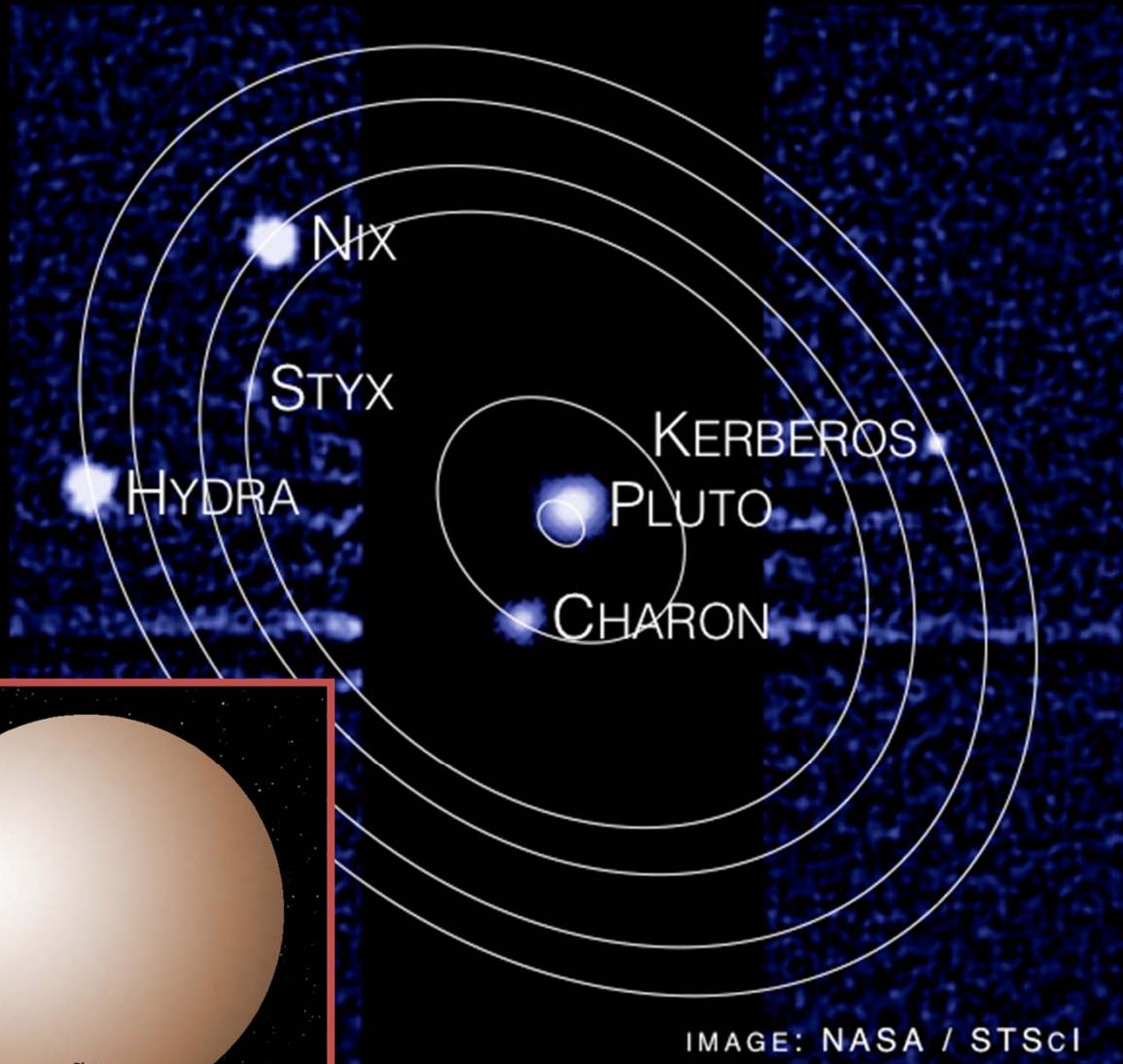
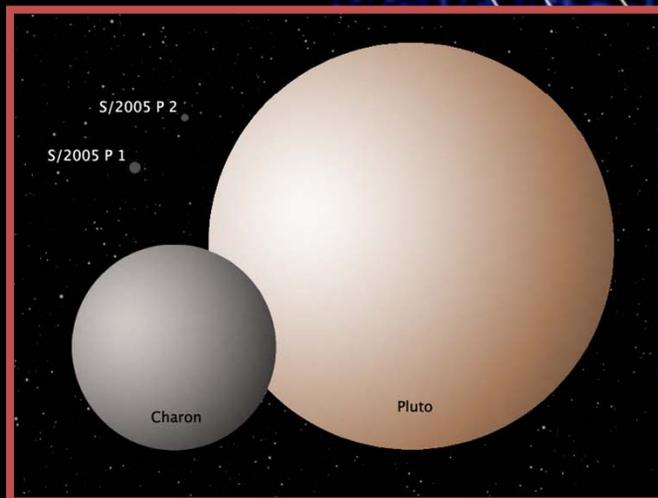


IMAGE: NASA / STSCI

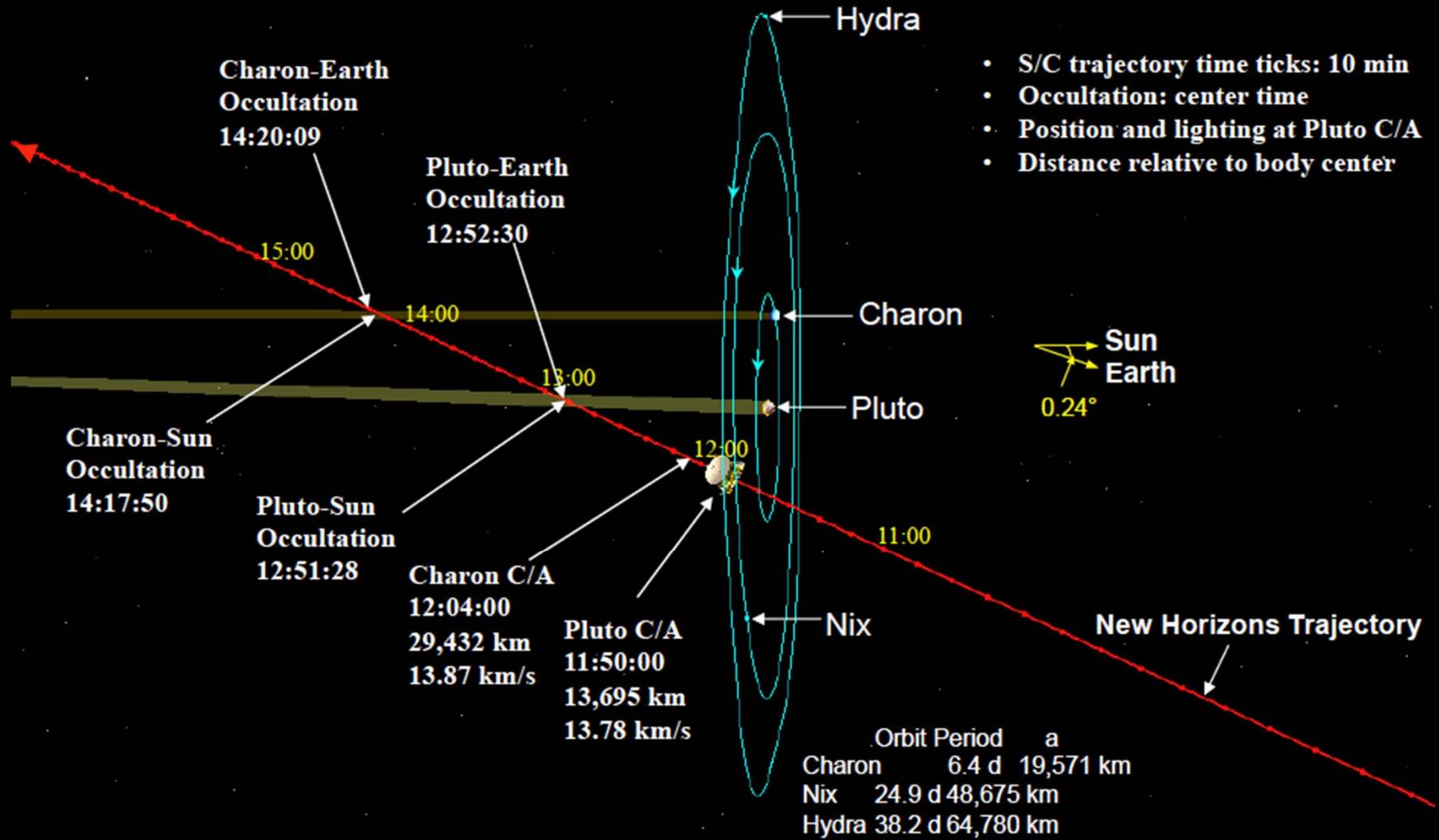


Long-Range Imager Views Pluto-Charon As a Binary Planetary System



NH LORRI OPNAV CAMPAIGN 2
2015-01-25 02:01:00 UTC
DISTANCE TO PLUTO: 202976224 km
(PROPER MOTION)

Closest Approach On July 14, 2015



Next Science Community Challenge!

- 2015 will be a great year for planetary science
- Ceres and Pluto will be observed up close!
- Anticipate tremendous public interest
- PSD CHALLENGE:
 - Learn about these events – be knowledgeable
 - Take every opportunity to discuss with the public
 - When giving public talks always discuss D & NH using material posted
 - Be the local community expert
- Approved project material for D & NH posted on SBAG & OPAG websites
 - <http://www.lpi.usra.edu/sbag/>
 - <http://www.lpi.usra.edu/opag/>

Planetary Budget

Passed FY15 Appropriations Bill

- Planetary Total Budget: \$1,438M
- \$255.8M for Planetary Science Research, including \$165.4M for Research and Analysis and \$40M for Near Earth Object Obs;
- \$255M for Discovery, including not less than \$25M for Future Discovery Missions;
- \$286M for New Frontiers, including not less than \$5M for Future New Frontiers Missions and \$224.8M for OSIRIS-REx;
- \$305M for Mars Exploration, including not less than \$100M for a Mars 2020 Rover that meets scientific objectives laid out in the most recent Planetary Science decadal survey;
- \$181M for Outer Planets, including not less than \$100M for a Jupiter Europa mission as described in the House report; and
- \$155M for Technology, including \$18M for technologies for the study and characterization of the surface and subsurface of Europa

President's FY16 Budget Request (\$M)

[-----Notional-----]

	FY15	FY16	FY17	FY18	FY19	FY20
Planetary Science	<u>\$1,437.8</u>	<u>\$1,361.2</u>	<u>\$1,420.1</u>	<u>\$1,458.0</u>	<u>\$1,502.4</u>	<u>\$1,527.8</u>
Science Research		276.3	282.0	292.0	291.7	285.7
Discovery		156.1	201.6	277.2	337.4	344.9
New Frontiers		259.0	124.0	81.5	85.7	137.8
Mars Exploration		411.9	539.3	561.3	531.5	464.2
Outer Planets		116.2	117.7	81.6	87.6	110.5
Technology		141.7	155.5	164.4	168.5	184.7

Planetary Budget Features: What's Changed

- Initiates formulation for a mission to Jupiter's moon Europa, to explore the most likely host of current life beyond Earth
- Releases the next New Frontiers AO in 2016
- Maintains Stirling technology development to support future radioisotope power systems
- Establishes the Planetary Missions Program Office at MSFC to manage Discovery, New Frontiers, **JUICE** and **Europa** flight projects
- **Lunar Reconnaissance Orbiter** and **Opportunity** rover not funded in 2016 budget
 - Will reassess condition/cost of maintaining LRO & Opportunity this summer
- Increase in funding for Near Earth Object Observation Program to accelerate hazardous asteroid detection and characterization

Planetary Budget Features: What's the Same

- Continues development of **InSight** and **OSIRIS-REx** missions for launches in 2016
- Continues development work on **STROFIO**, **MOMA**, and **JUICE** instruments in collaboration with ESA missions to Mercury, Mars and Jupiter, respectively, as well as on-going operations of **Rosetta** and **Mars Express** with ESA and planned operations of **Akatsuki** and **Hayabusa-2** with JAXA.
- Supports Planetary missions with mission operations and navigation tools, data archiving, and sample curation
- Continues supporting research and technology selections and awards, and maintains DOE capabilities to produce radioisotope power generators and the Plutonium-238 to fuel them

Discovery and New Frontiers Status

Discovery and New Frontiers

- ◆ Address high-priority science objectives in solar system exploration
- ◆ Opportunities for the science community to propose full investigations
- ◆ Fixed-price cost cap full and open competition missions
- ◆ Principal Investigator-led project



- ◆ Established in 1992
- ◆ **\$450M cap** per mission excluding launch vehicle and operations phase (FY15\$)
- ◆ Open science competition for all solar system objects, except for the Earth and Sun

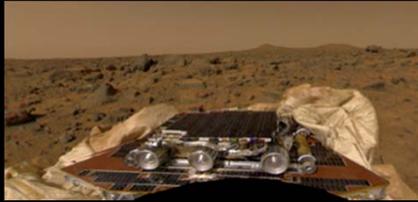


- ◆ Established in 2003
- ◆ **\$850M cap** per mission excluding launch vehicle and operations phase (FY15\$)
- ◆ Addresses high-priority investigations identified by the National Academy of Sciences

Discovery Program

Completed

Mars evolution:
Mars Pathfinder (1996-1997)



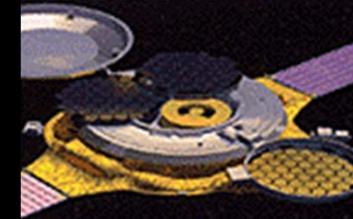
Lunar formation:
Lunar Prospector (1998-1999)



NEO characteristics:
NEAR (1996-1999)



Solar wind sampling:
Genesis (2001-2004)



Completed

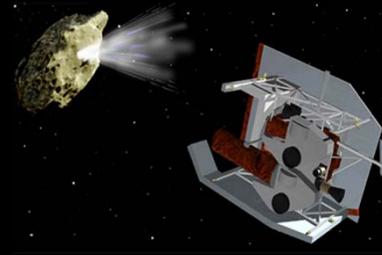
Comet diversity:
CONTOUR (2002)



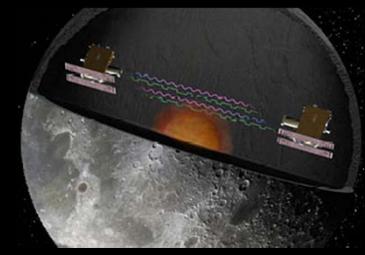
Nature of dust/coma:
Stardust (1999-2011)



Comet internal structure:
Deep Impact (2005-2012)

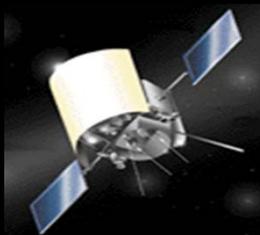


Lunar Internal Structure
GRAIL (2011-2012)



In Flight / In Development

Mercury environment:
MESSENGER (2004-2015)



Main-belt asteroids:
Dawn (2007-2016)



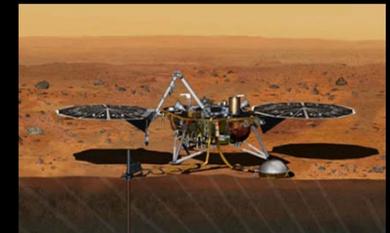
Lunar surface:
LRO (2009-TBD)



ESA/Mercury Surface:
Strofio (2016-TBD)



Mars Interior:
InSight (2016-TBD)



Status of Discovery Program

Discovery 2014 - proposals in review for September Selection

Missions in Development

- InSight: Confirmation to begin ATLO on March 24, 2015
- Strofio: Delivered to SERENA Suite (ASI) for BepiColombo

Missions in Operation

- Dawn: In orbit around Ceres as of March 6

Missions in Extended Operations

- MESSENGER: In low altitude science operations before impact with Mercury in April
- LRO: In stable elliptical orbit, passing low over the lunar south pole.

Future Opportunities – planning for 3-year mission cadence

New Frontiers Program

1st NF mission
New Horizons:

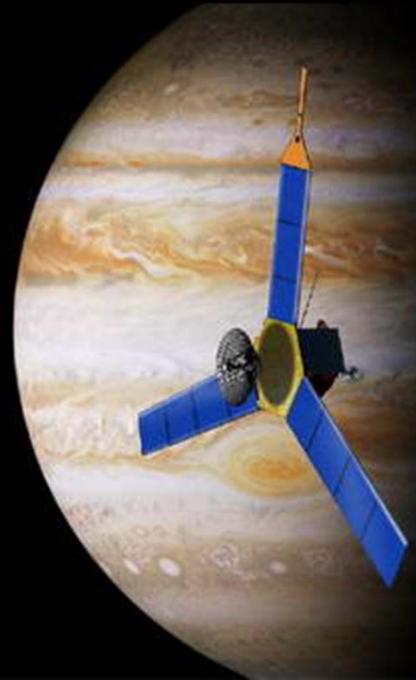
Pluto-Kuiper Belt



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



To be launched: Sept. 2016
PI: Dante Lauretta (UA)

Status of New Frontiers Program

Next New Frontiers AO - to be released by end of Fiscal Year 2016

- New ROSES call for instrument/technology investments to prepare
- Candidate mission list and nuclear power sources under consideration

Missions in Development - OSIRIS REx

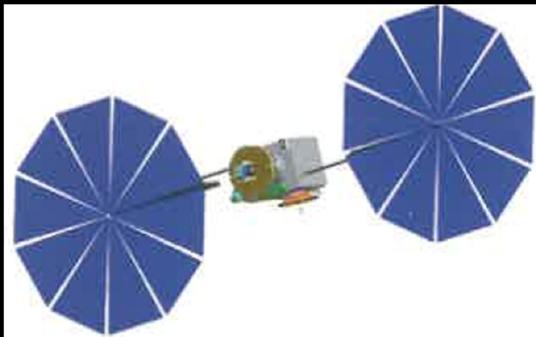
- Launch in Sept 2016 & encounter asteroid Bennu in Oct 2018.
- Operate at Bennu for over 400 days.
- Returns a sample in 2023 that scientists will study for decades with ever more capable instruments and techniques.

Missions in Operation

- New Horizons:
 - Spacecraft is 32 AU from the sun and <1 AU from Pluto
 - Pluto system encounter July 14, 2015
 - HST identified 2 KBO's beyond Pluto for potential extended mission
- Juno:
 - Spacecraft is 4.5 AU from the sun and 1.5 AU from Jupiter
 - Orbit insertion is July 4, 2016

New Frontiers #4 Focused Missions

Comet Surface
Sample Return



Lunar South Pole
Aitken Basin Sample
Return



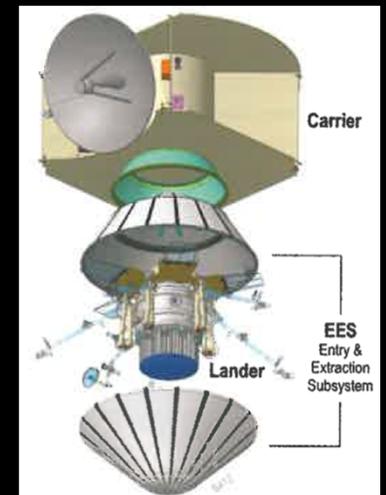
Trojan Tour &
Rendezvous



Saturn Probes



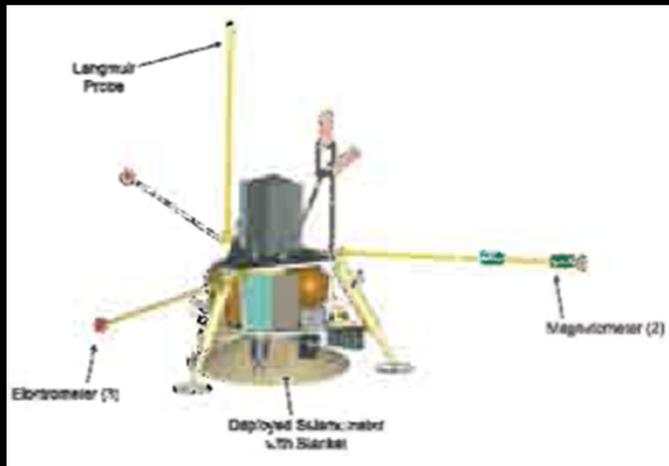
Venus In-Situ Explorer



New Frontiers #5 Focused Missions

- Added to the remaining list of candidates:

Lunar Geophysical Network



Io Observer



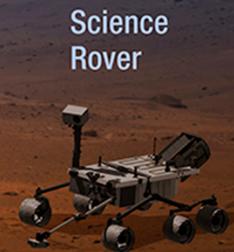
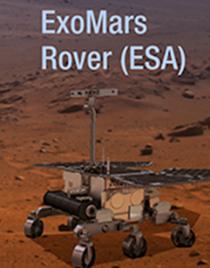
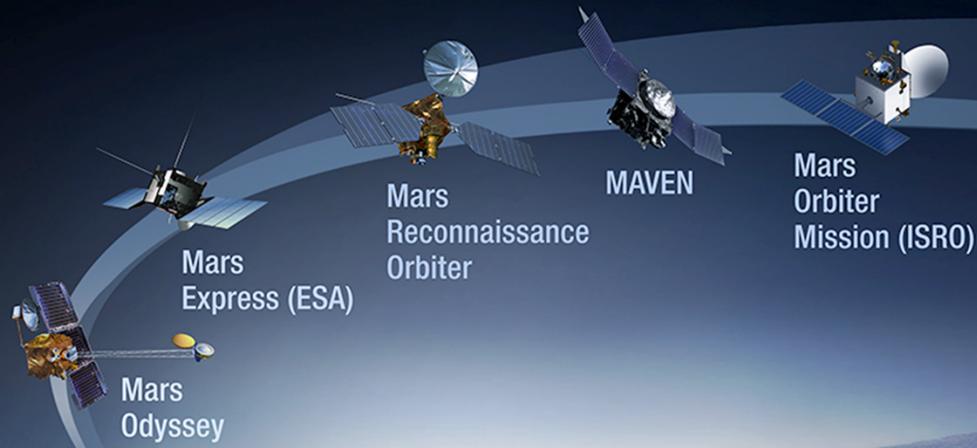
Mars Program Status

Operational 2001–2015

2016

2018

2020



Follow the Water

Explore Habitability

Seek Signs of Life

Prepare for Future Human Explorers

MARS-A-THON ROVER: OPPORTUNITY

First Marathon "Run"
on Another Planet

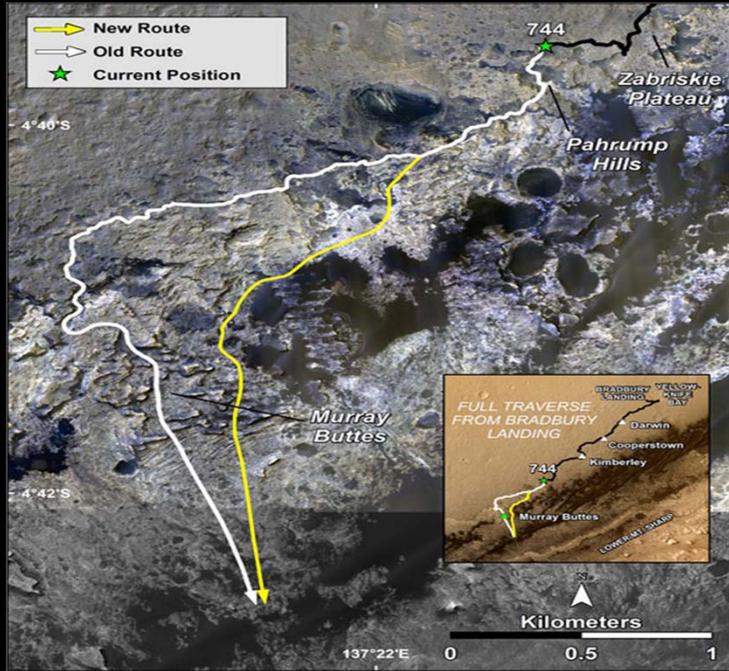
Distance: 26.2 miles

Time: 11 years, 2 months

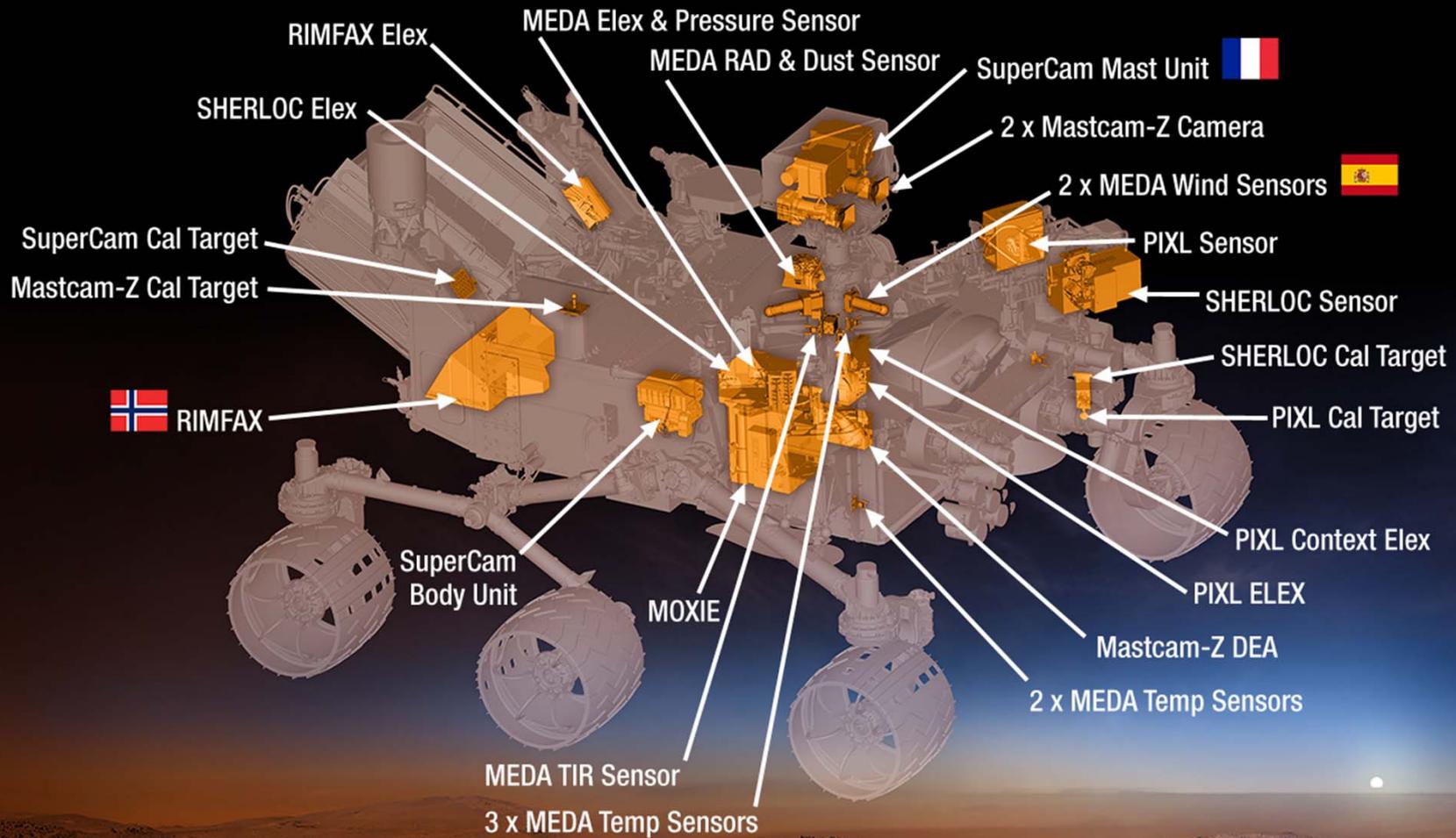
#JOURNEYTOMARS



Curiosity Arrives at Mt. Sharp



Mars 2020 Rover



Europa Activities

Recent Europa Activities

- Europa mission formulation in the President's FY16 Budget
- Instrument selections for Europa mission expected in May
 - Released SALMON 2 PEA in July 2014 to solicit instrument investigations for an unspecified Europa mission
 - 33 proposals evaluated
- Dedicated Hubble time to verify existence of Europa plumes
 - Not confirming their existence does not mean they don't exist. Variability factors are currently not understood.
- Workshop Feb. 18, 2015 with leading astrobiologists and Europa scientists to discuss how to look for life
 - Previous 'plume' workshop fully endorsed mission concept and payload
 - Identify 'best' instruments and mission concepts to maximize likelihood of detecting current life if it exists
- Europa mission formulation continues
 - Solar power system selected as baseline
 - Highly successful Mission Concept Review held
 - Key Decision Point A to kick off formulation in planning

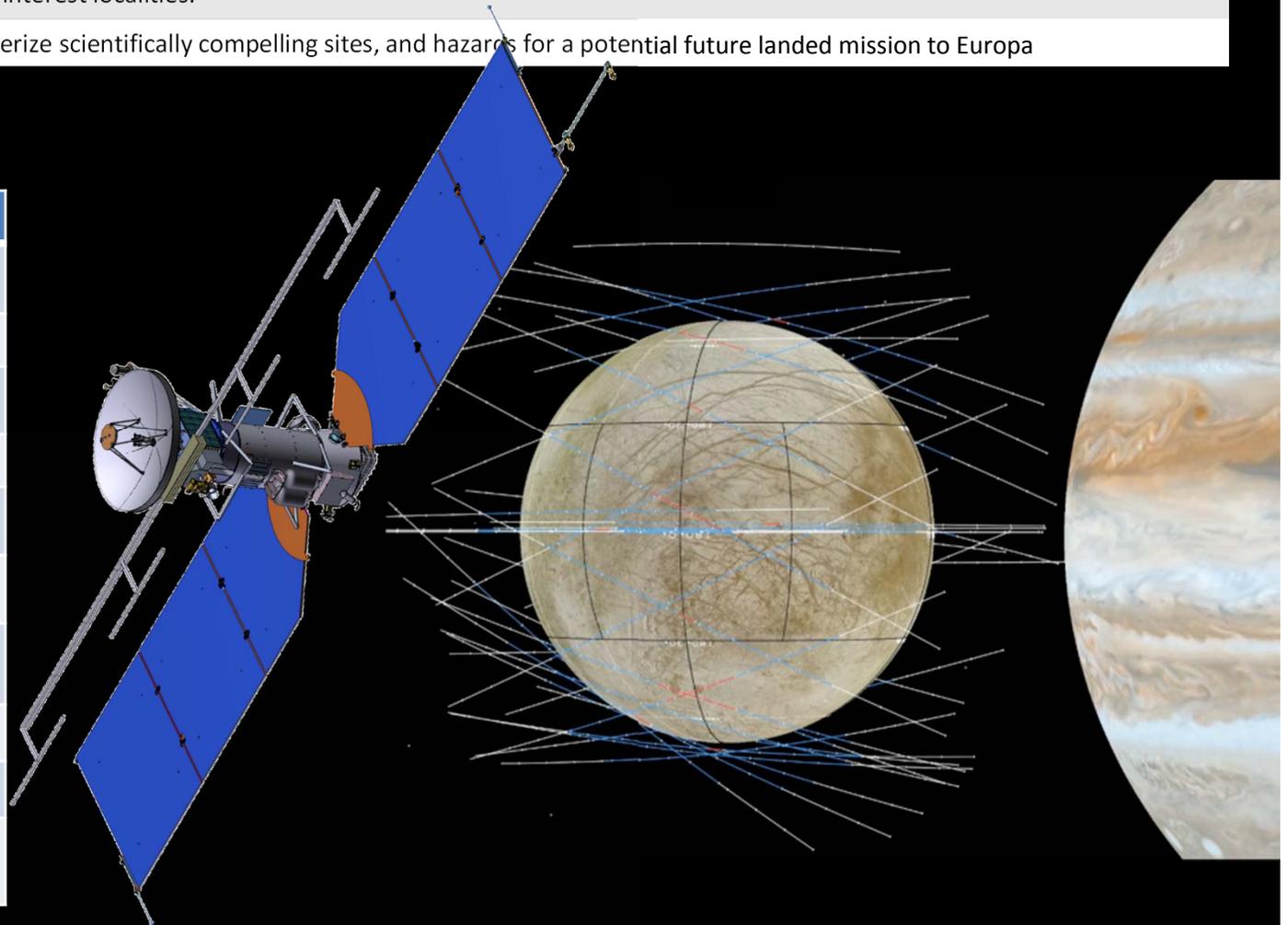
Europa Flyby Concept Overview

Science Objectives

Ice Shell & Ocean	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange
Composition	Understand the habitability of Europa's ocean through composition and chemistry.
Geology	Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.
Recon	Characterize scientifically compelling sites, and hazards for a potential future landed mission to Europa

Model Payload

	<u>Instrument Type</u>
1	Ice Penetrating Radar
2	Shortwave Infrared Spectrometer
3	Topographical Imager
4	Neutral Mass Spectrometer
5	Reconnaissance Camera
6	Thermal Imager
7	Magnetometer
8	Langmuir Probe
9	Gravity Science



Research and Analysis Status

Findings from the NRC report: An Enabling Foundation for NASA's Earth and Space Science Missions (2010)

- NASA should ensure that SMD mission-enabling activities are linked to the strategic goals of the agency and of SMD.
- NASA's SMD should develop and implement an approach to actively managing its portfolio of mission-enabling activities.
- NASA should increase the number of scientifically and technically capable program officers so that they can devote an appropriate level of attention to the tasks of actively managing the portfolio of research... [we have addressed this concern, but not through reorganization of the portfolio]
- **NASA response was in agreement with these recommendations**

“By explicitly tying the ROSES solicitations...to the SMD Science Plan research objectives, SMD ensures that sponsored research contributes directly and substantially to Agency goals.”



New Core Research Programs Defined

The five new core programs are aligned with PSD's goals/objectives.

How did the Sun's family of planets, satellites, and minor bodies form and evolve?



Emerging Worlds

How do the chemical and physical processes active in our solar system operate, interact and evolve?



Solar System Workings

What are the characteristics of the solar system that lead to habitable environments?



Habitable Worlds

How did life originate and evolve here on Earth and can that guide our search for life elsewhere?



Exobiology

What are characteristics of planetary objects and environments that pose threats to, or offer potential resources for, humans as we expand our presence into the solar system?



Solar System Observations

Calls from previous ROSES Years

New Programs for ROSES 2014

Origins of Solar Systems

Cosmochemistry

Planetary Geology & Geophysics

Planetary Atmospheres

Lunar Adv. Sci & Exp Research

Outer Planets Research

Mars Fundamental Research

Exobiology & Evolutionary Biology

Planetary Observations

Near-Earth Object Observations

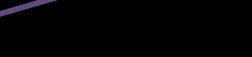
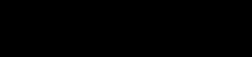
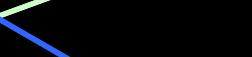
Emerging Worlds

Solar System Workings

Habitable Worlds

Exobiology

Solar System Observations



Calls from previous ROSES Years

Lunar Adv. Sci & Exp Research

A very small component of all DAPS

Planetary Geology & Geophysics

Moon, Mars Analog Mission Activities

Astrobio Sci & Tech for Exploring Planets

Origins of Solar Systems

Planetary Atmospheres

New Programs for ROSES 2014

Lunar Data Analysis Program

Planetary Data Archiving, Restoration, and Tools (PDART)

Planetary Science & Technology from Analog Research (PSTAR)

Exoplanets

Reorganization at a glance

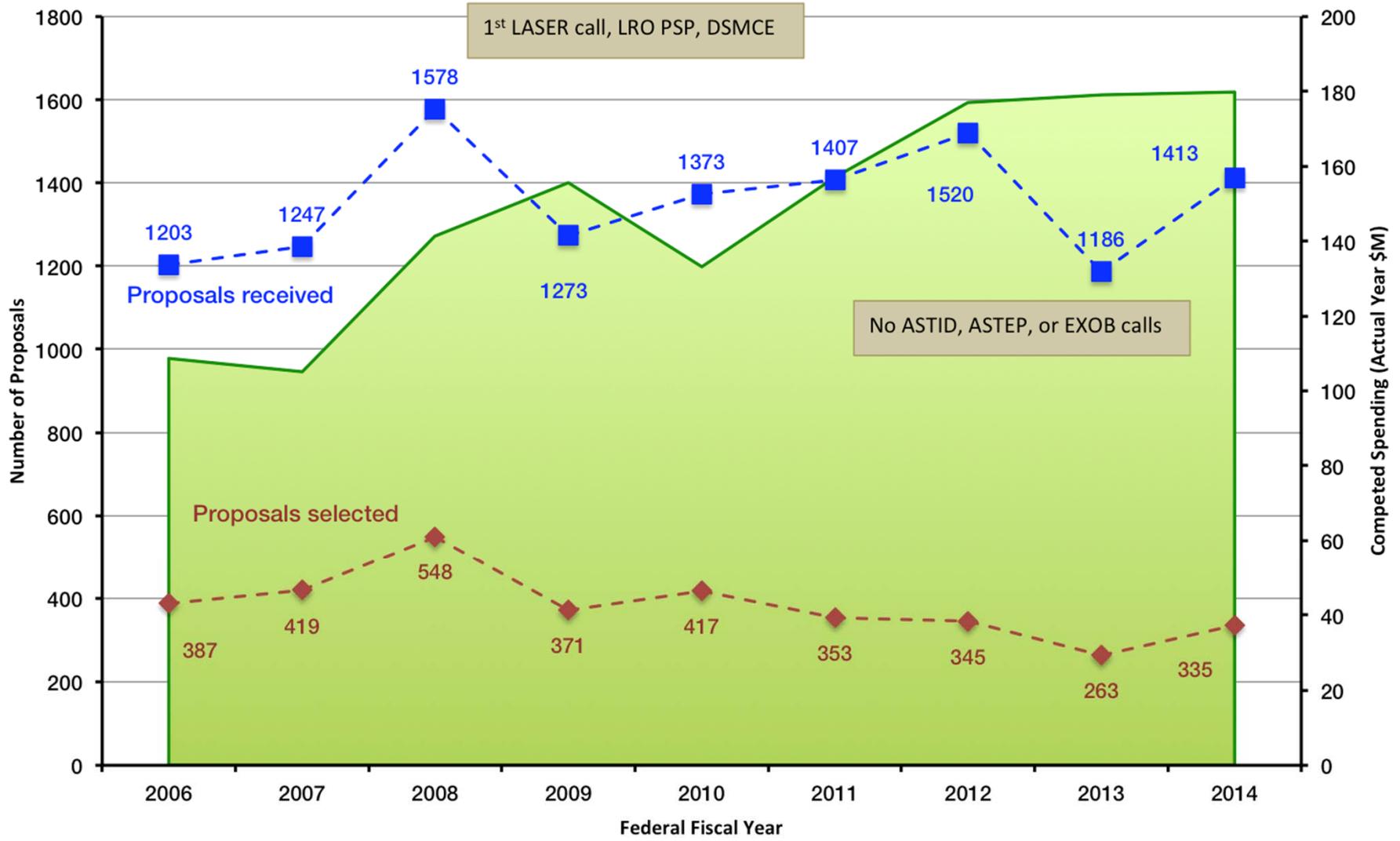
- ROSES13 has 20 calls; ROSES14 will have 17 calls with 8 that remain the same
- All calls address division science goals supporting NASA's strategic plan
- Strategic programs are more narrow in scope and address certain strategic needs
- Focused programs are narrow in scope and limited in time. They may be called for only one year or several, but not indefinitely. This provides flexibility the previous program did not have.

Core Research	Strategic	Focused
Emerging Worlds	PDART (data archiving, tools)	ETIPS (emerging topics)
Solar System Workings	PSTAR (analogues)	LDAP (lunar data analysis)
Habitable Worlds	Exoplanets (joint with Astro)	CDAP
Exobiology	DDAP	
Solar System Observations	LARS	
Core Technology	MDAP	New program Not solicited in ROSES 2014
MatISSE	Planetary Protection	Unchanged
PICASSO	NAI (not solicited in ROSES)	
Planetary Major Equipment	SSERVI (not solicited in ROSES)	

PSD R&A ROSES 14

Program Name	Step-1 Due Date	Step-2 Due Date
Emerging Worlds (EW)	<i>03/31/2014</i>	<i>06/04/2014</i>
Exoplanets (XRP)	<i>03/31/2014</i>	<i>05/23/2014</i>
Exobiology	<i>04/14/2014</i>	<i>06/03/2014</i>
Solar System Obs. (SSO)	<i>04/07/2014</i>	<i>06/06/2014</i>
MatISSE (mid-TRL instruments)	<i>04/21/2014</i>	<i>06/20/2014</i>
Laboratory Analysis of Returned Sample (LARS)	<i>04/28/2014</i>	<i>06/27/2014</i>
Solar System Workings (SSW)	<i>05/23/2014</i>	<i>07/25/2014</i>
Planetary Data Archiving, Resto, Tools (PDART)	<i>07/17/2014</i>	<i>09/17/2014</i>
Discovery Data Analysis (DDAP)	<i>07/21/2014</i>	<i>09/19/2014</i>
Planetary Sci./Tech. Thru Analog Research (PSTAR)	<i>07/25/2014</i>	<i>09/26/2014</i>
Cassini Data Analysis (CDAP)	<i>07/28/2014</i>	<i>09/26/2014</i>
Mars Data Analysis (MDAP)	<i>08/04/2014</i>	<i>10/03/2014</i>
Lunar Data Analysis (LDAP)	<i>08/29/2014</i>	<i>10/24/2014</i>
PICASSO (low-TRL instruments)	<i>09/15/2014</i>	<i>11/14/2014</i>
Habitable Worlds (HW)	<i>11/24/2014</i>	<i>01/23/2015</i>

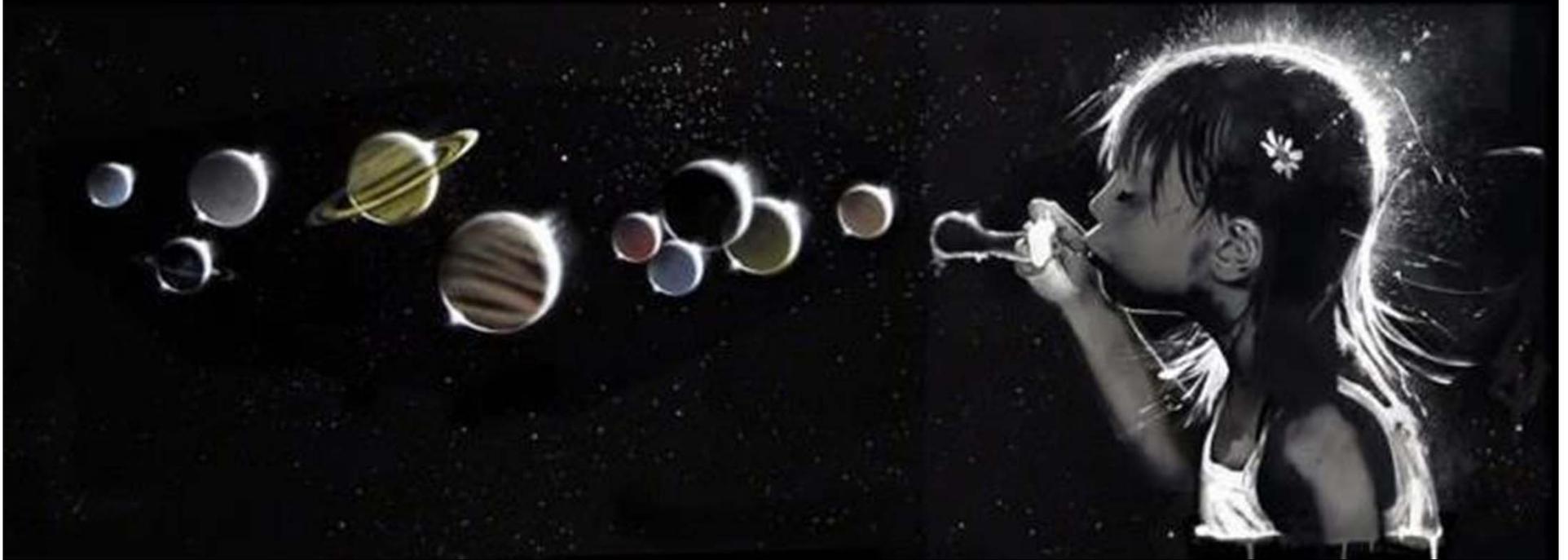
Proposal Pressure and Budgets



R&A Summary

- R&A restructuring is in line with the NAS R&A report & the NAS Decadal and has been executed with the full knowledge and support of the Administration and Congress
 - R&A restructuring directly & explicitly supports NASA goals and objectives
- R&A budget has been level funded even though PSD's budget has been significantly below FY12 budget level
 - We still select about the same number of proposals each year
- Declining selection *rates* are largely due to the dramatically increasing proposal pressure
 - With fewer new missions and the completion of other missions more planetary scientists will propose
 - Selection rates are approximately ~22% across the board

Questions?



Proposal Decisions

Program Name	Step-1 Submissions	Step-2 Submissions	Selected (* Pending)
EW	219	159	32
SSW	509	384	56*
Exobiology	186	144	Pending
SSO	99	71	21
PDART	143	100	20*
CDAPS	101	78	19*
DDAP	32	27	10
LARS	29	24	9
XRP	168	134	21
MDAP	139	104	Pending
LDAP	82	51	Pending
PSTAR	69	46	7
HW	110	72	Review Pending
MatISSE	55	44	5*
PICASSO	112	96	Pending