Planetary Science Division Status Report

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NASA, Planetary Science Division
April 8, 2015

Presentation at NAC SC

Outline

- NAC SC Actions
- Mission events
- Passed FY15 Budget elements
- President’s FY16 Budget
- Discovery and New Frontiers Status
- Mars Program Status
- Recent Europa Activities

Charge from NAC SC (Jan 2015)

1. NEOs Decadal Survey and Large Synoptic Survey Telescope (LSST): NAC SC chair requested that PSD/PSS provide evidence that there is support in the Decadal Survey for a dedicated NEO survey effort before the Science Committee goes forward with a recommendation
   - Has 3 parts: For *Hazard Mitigation, Exploration, & Science*
   - Chaps 4-14, 4-20, 10-10, and 10-13

2. LRO: NAC SC suggested that there should be one science representative in the partnership that reports to both AAs of SMD and HEOMD
   - Our suggestion: HEO Chief Scientist, Ben Bussey

Planetary Decadal - Support of NEO Survey for *Hazard Mitigation*

NASA 2005 Authorization Act calls for discovery, characterization, and hazard mitigation of 90% of the >140m NEOs in 15 yrs

- New optical facilities, such as the Large Synoptic Survey Telescope (LSST) and Panoramic Survey Telescope and Rapid-Response System (Pan-STARRS), can dramatically increase scientific understanding of NEOs by expanding the catalog of known objects and their orbits, thus providing better population statistics and improved predictions for close passages by Earth.
  - Earth-based telescopic observations probe the shapes, sizes, mineral compositions, orbital/rotational attributes, & physical properties of NEOs
  - Critical for extrapolating what is learned from the very limited number of asteroid missions that will be possible to populations of small bodies
- NASA is using Pan-STARRS now but will not meet 15 yr time req.

Planetary Decadal - Support of NEO Survey for *Exploration & Science*

Survey of NEO will allow the following activities:

- Precursor robotic missions to small bodies can be accommodated both human exploration and science goals
- Potentially significant areas of interest include:
  - Identification of hazards requires an understanding of the geophysical behavior of NEOs, a science goal;
  - Development of technologies, especially advanced power systems, for human-precursor missions are similar to those required for science missions; and
  - Resource identification encompassing scientific compositional measurements.
  - Sample return or geophysical reconnaissance missions to easily accessible NEOs

Planetary Science Missions Events

* **Completed**

2014

July – *Mars 2020* Rover instrument selection announcement
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 JU_3

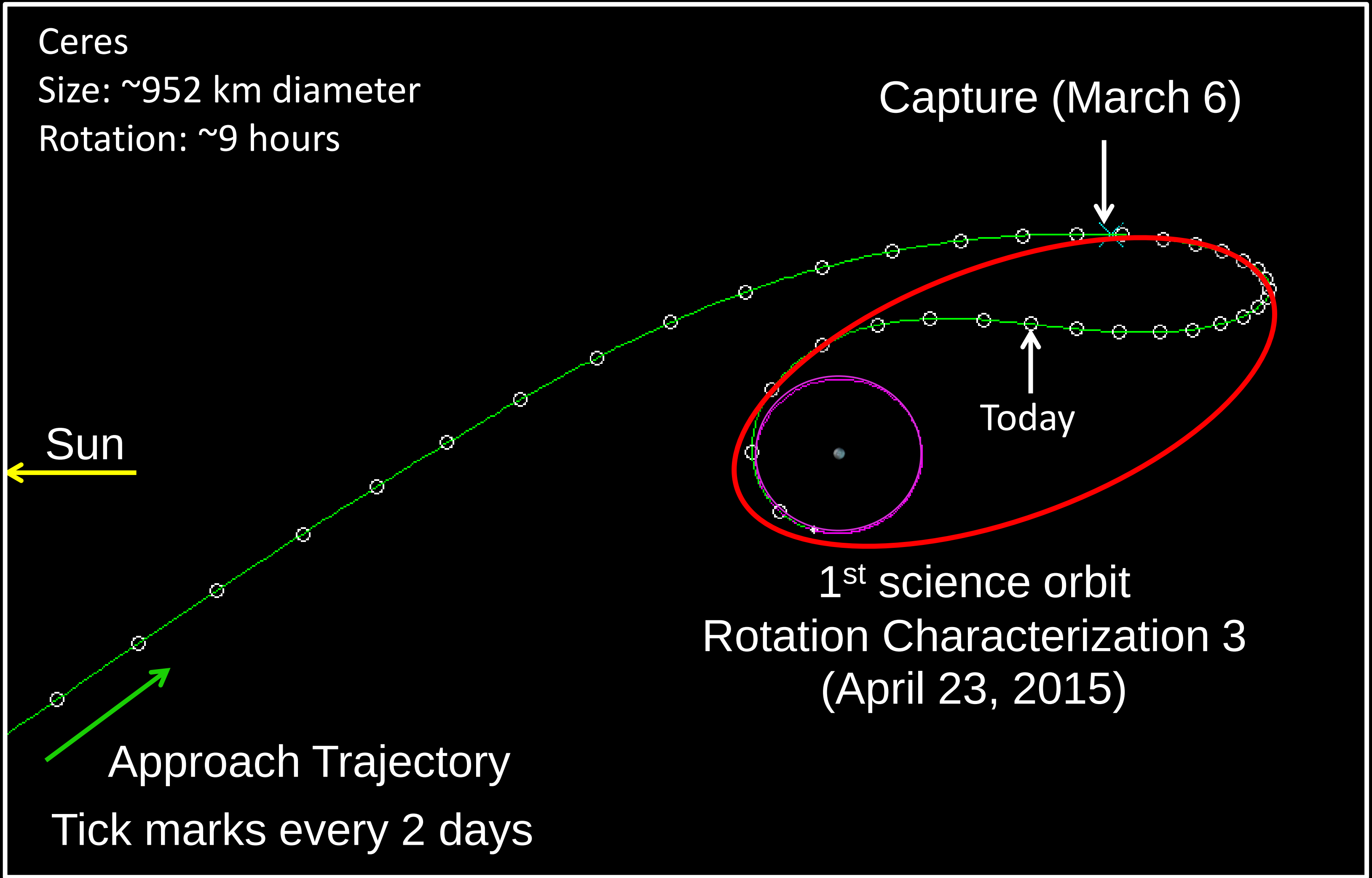
2015

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



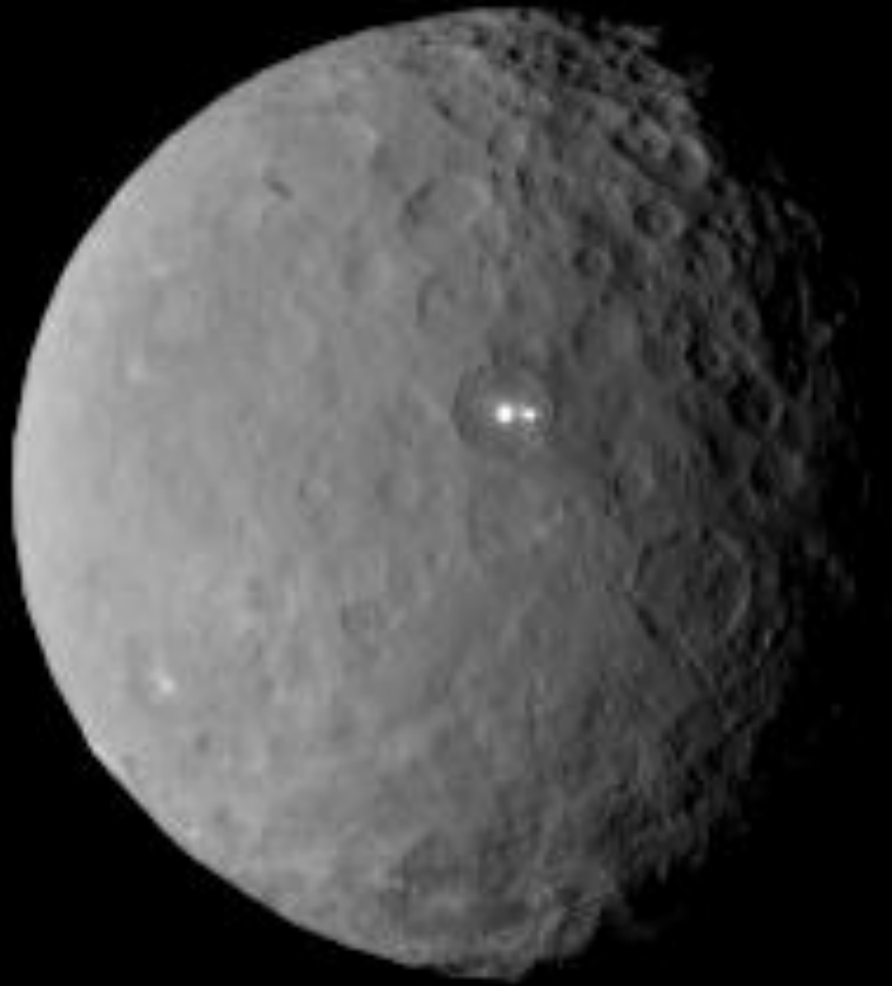
Ceres Approach Timeline

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

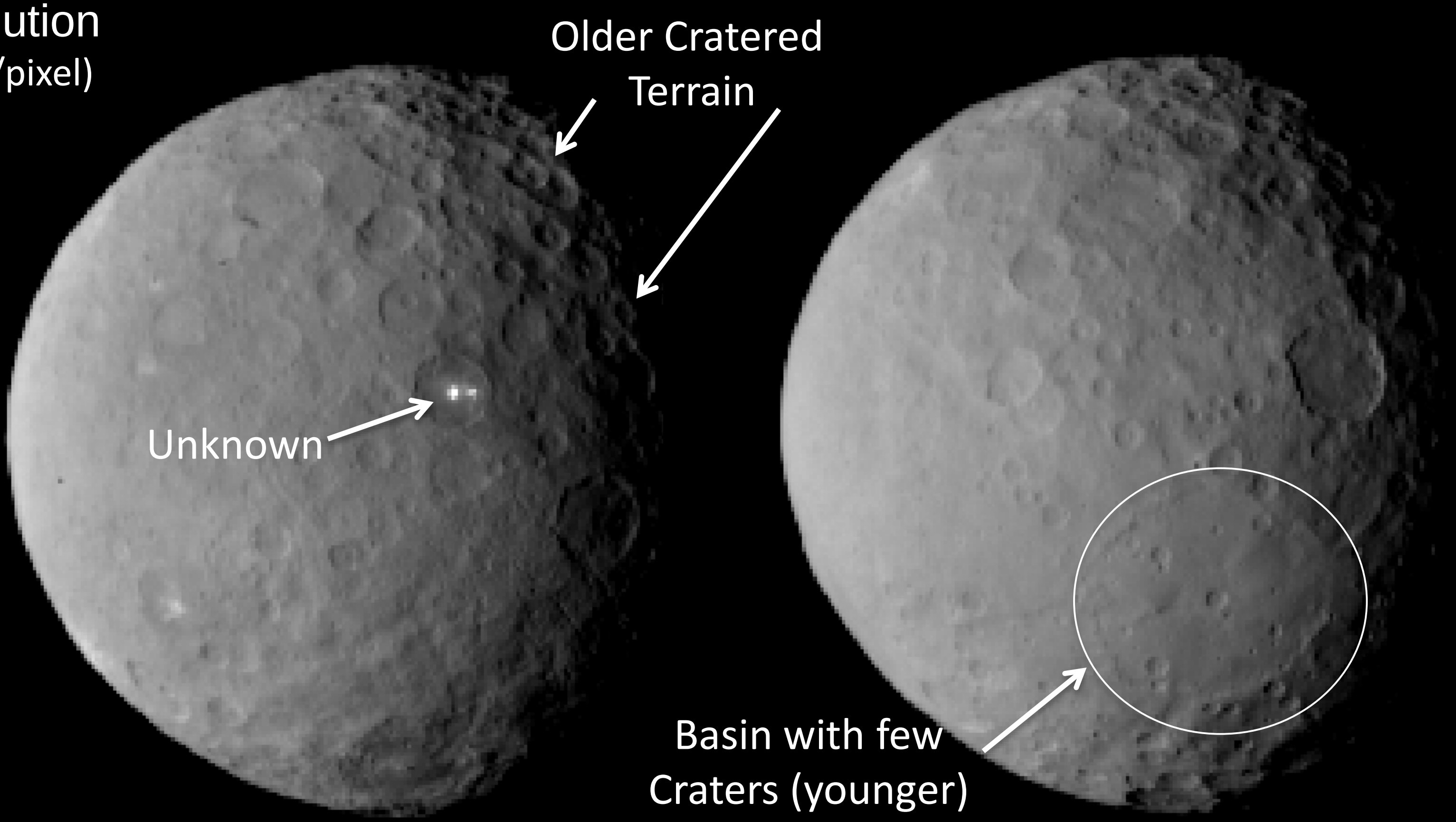
Resolution
4 km/pixel

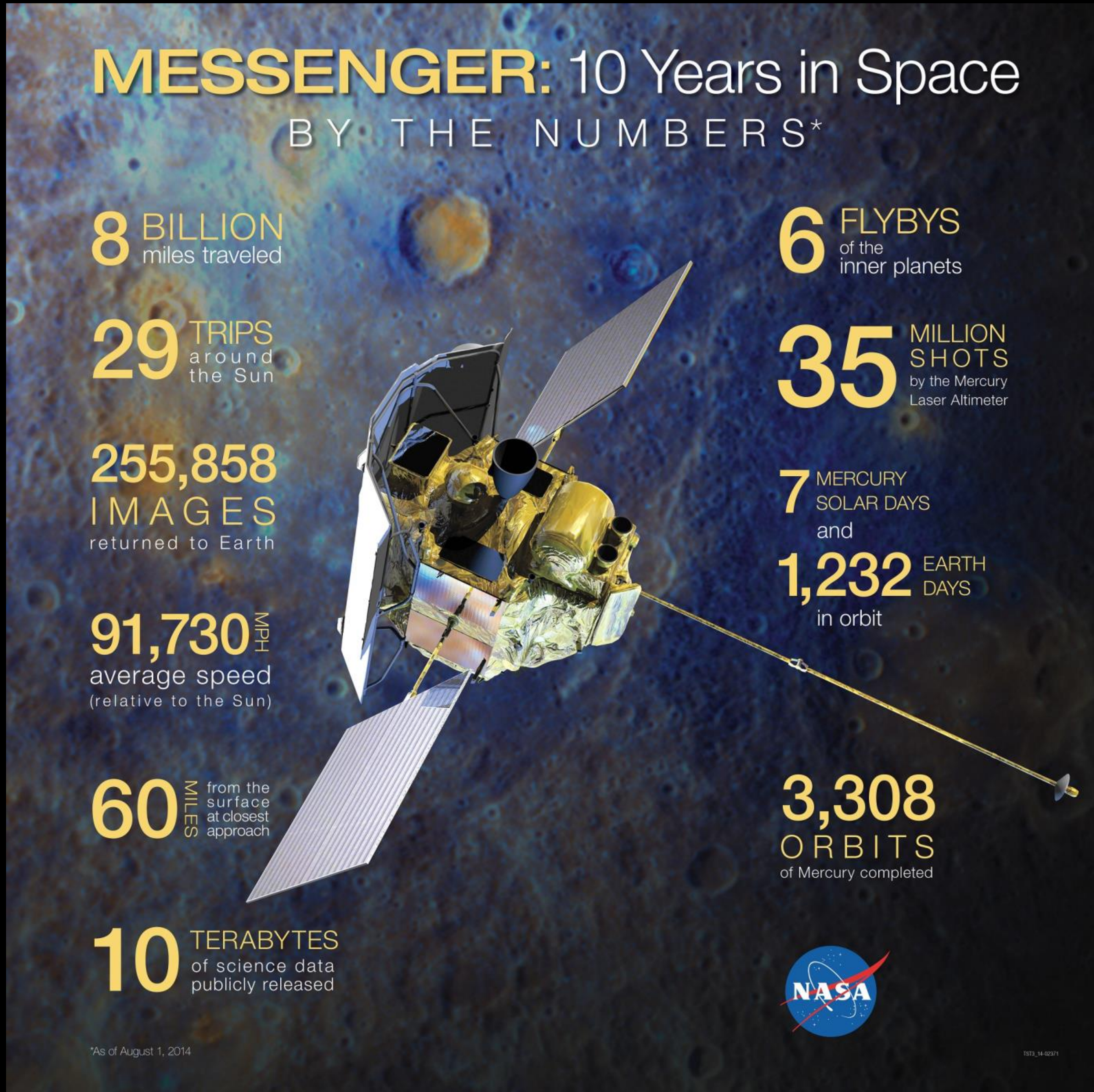


The Types of Terrain

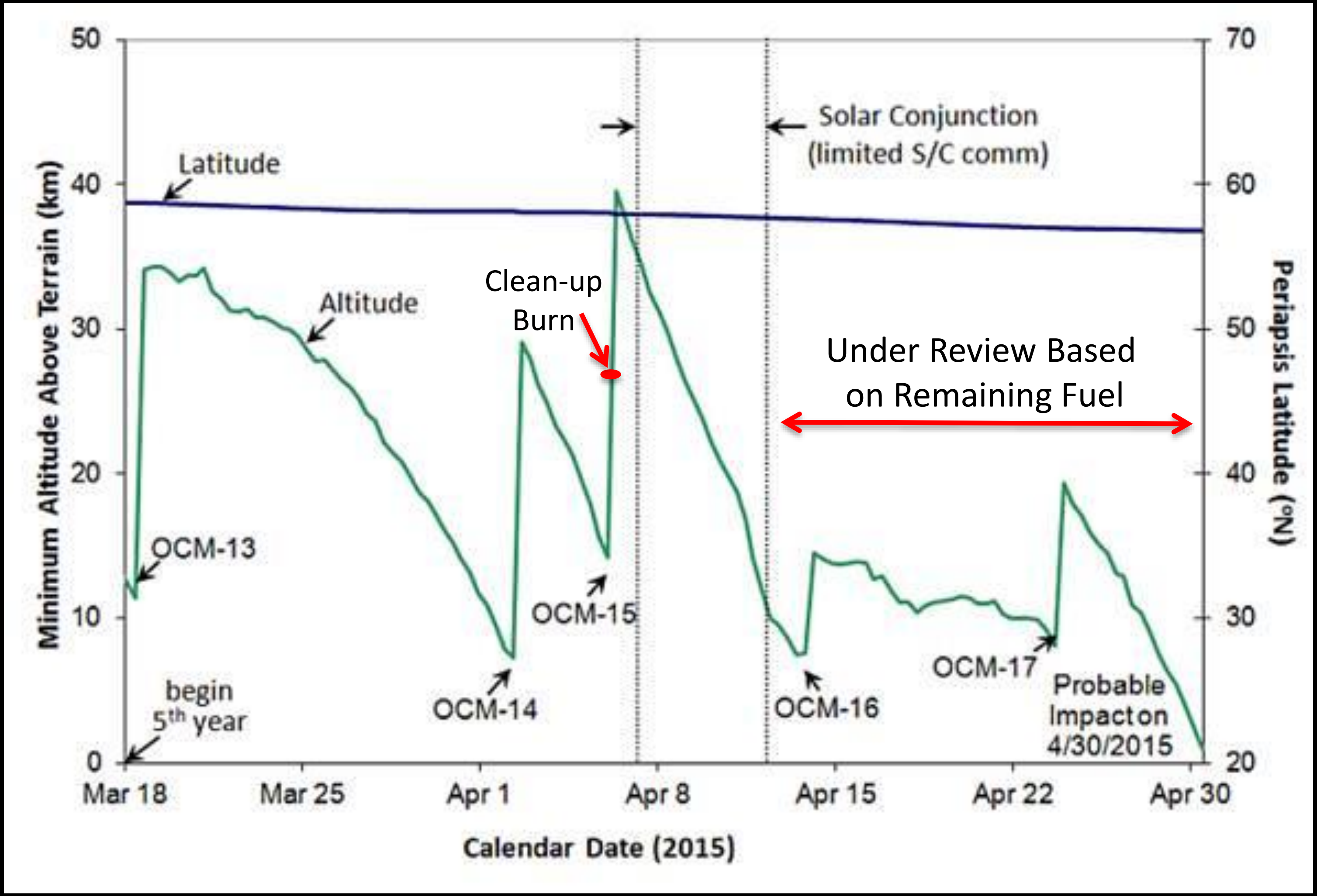
RC 2 - Feb 19

7 x Hubble
Resolution
(4 km/pixel)



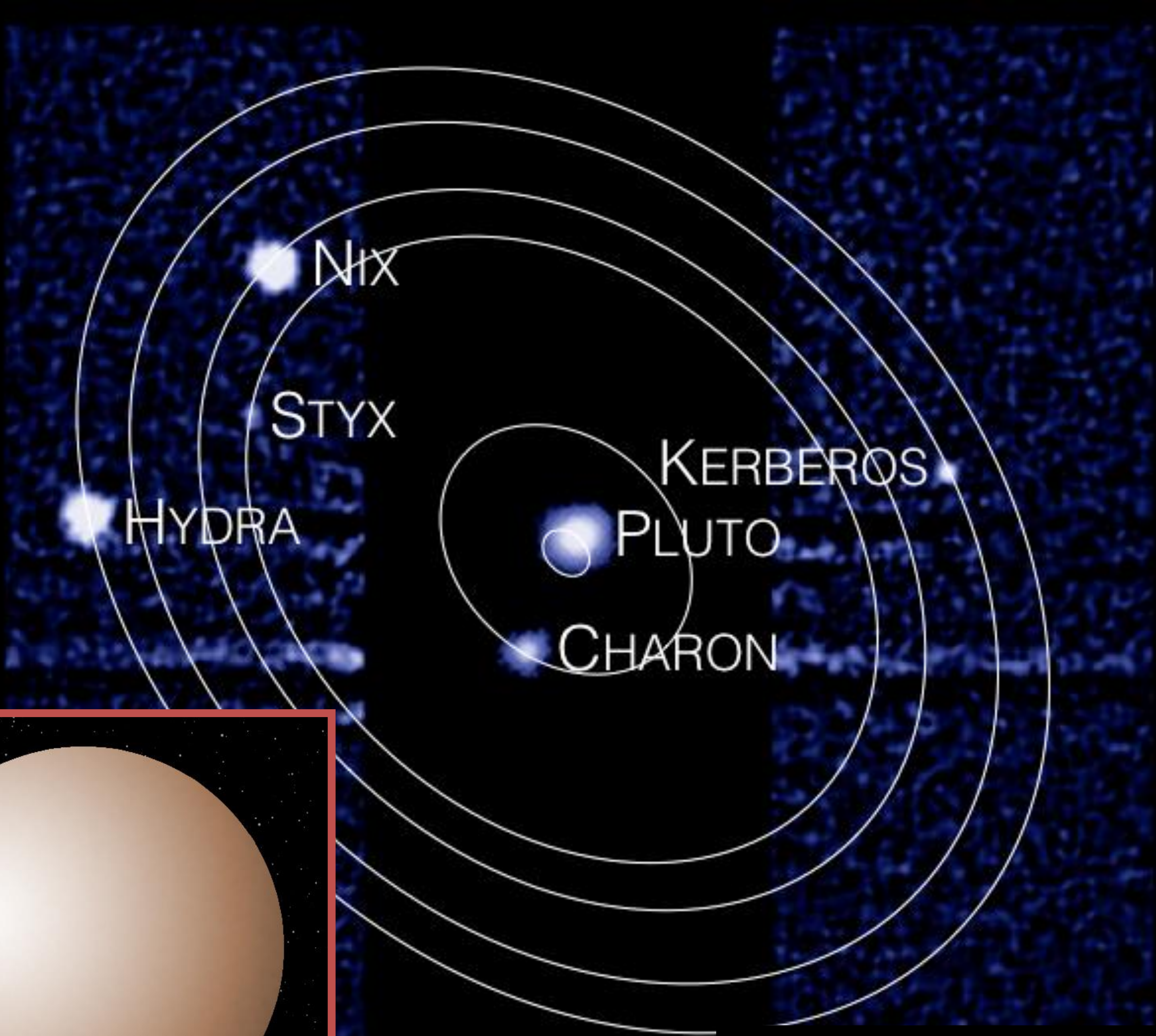

MESSENGER: 10 Years in Space
BY THE NUMBERS*
8 BILLION miles traveled
29 TRIPS around the Sun
255,858 IMAGES returned to Earth
91,730 MPH average speed (relative to the Sun)
60 MILES from the surface at closest approach
10 TERABYTES of science data publicly released
6 FLYBYS of the inner planets
35 MILLION SHOTS by the Mercury Laser Altimeter
7 MERCURY SOLAR DAYS and 1,232 EARTH DAYS in orbit
3,308 ORBITS of Mercury completed
NASA
*As of August 1, 2014

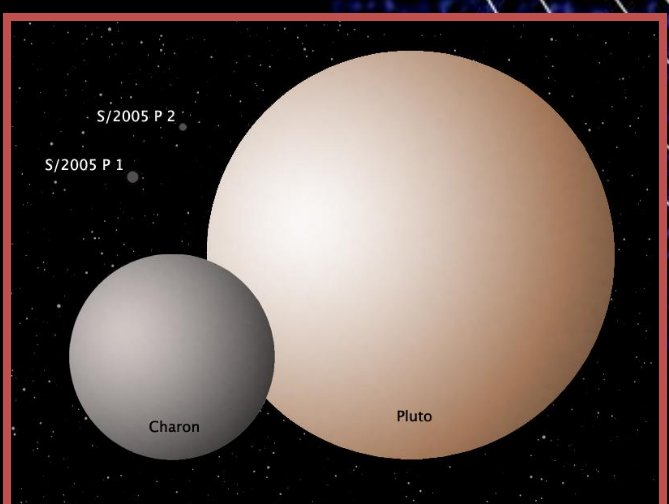
MESSENGER



Minimum Altitude Above Terrain (km)
Periapsis Latitude (°N)
Calendar Date (2015)
Mar 18
Mar 25
Apr 1
Apr 8
Apr 15
Apr 22
Apr 30
50
40
30
20
10
0
70
60
50
40
30
20
Latitude
Altitude
Solar Conjunction (limited S/C comm)
Clean-up Burn
Under Review Based on Remaining Fuel
OCM-13
OCM-14
OCM-15
OCM-16
OCM-17
begin 5th year
Probable Impact on 4/30/2015

The New Pluto System

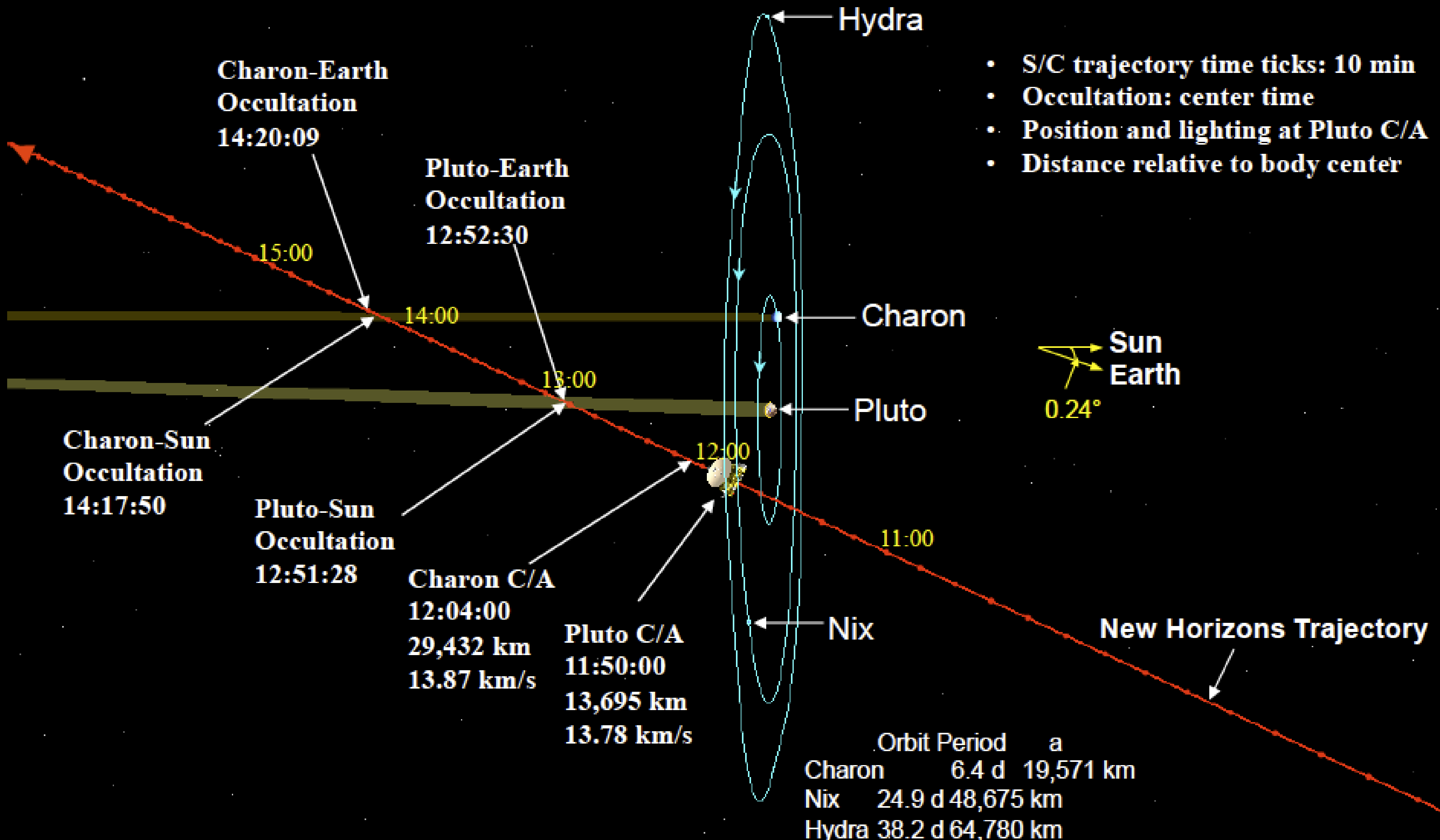




NASA/HST

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

Closest Approach On July 14, 2015



- S/C trajectory time ticks: 10 min
- Occultation: center time
- Position and lighting at Pluto C/A
- Distance relative to body center

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	$1,437.8	$1,361.2	$1,420.1	$1,458.0	$1,502.4	$1,527.8
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

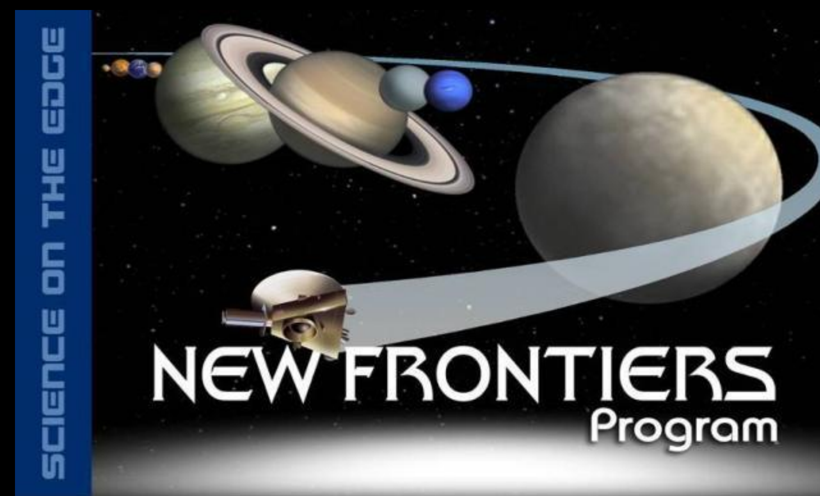
- Continues development of **InSight** and **OSIRIS-REx** missions for launches in 2016
- Continues development work on **STROFIO, MOMA**, and **JUICE** instruments in collaboration with ESA missions to Mercury, Mars and Jupiter, respectively, as well as on-going operations of **Rosetta** and **Mars 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



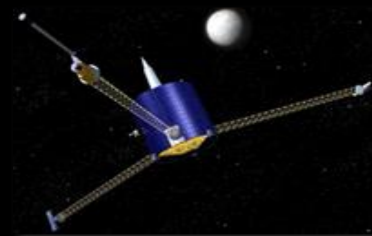
- Established in 2003
- **$850M** cap per mission excluding launch vehicle and operations phase (FY15$)
- Addresses high-priority investigations identified by the National Academy of Sciences

Discovery Program

Completed

Mars evolution:
Mars Pathfinder (1996-1997)

Lunar formation:
Lunar Prospector (1998-1999)



NEO characteristics:
NEAR (1996-1999)

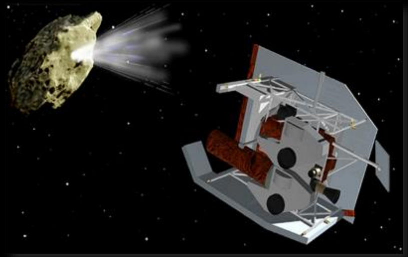
Solar wind sampling:
Genesis (2001-2004)

Completed

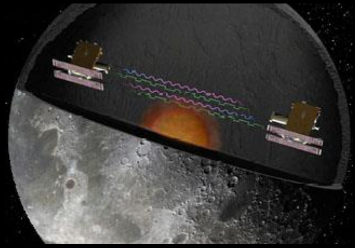
Comet diversity:
CONTOUR (2002)

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

Comet internal structure:
Deep Impact (2005-2012)

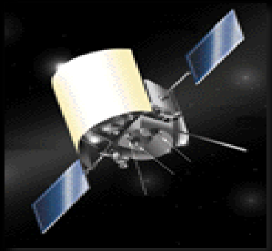


Lunar Internal Structure
GRAIL (2011-2012)

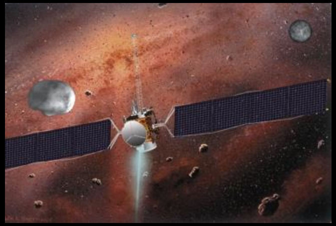


In Flight / In Development

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*)

New Frontiers Program

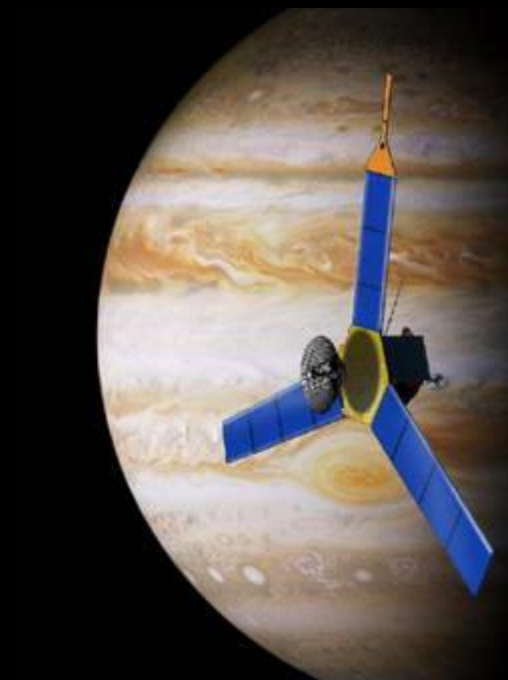
1st NF mission
<u>New Horizons:</u>

Pluto-Kuiper Belt

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

2nd NF mission
<u>JUNO:</u>

Jupiter Polar Orbiter



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

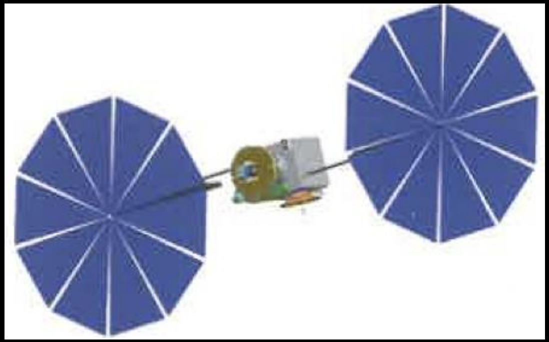
3rd NF mission
<u>OSIRIS-REx:</u>

Asteroid Sample Return

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

New Frontiers #4 Focused Missions

Comet Surface Sample Return

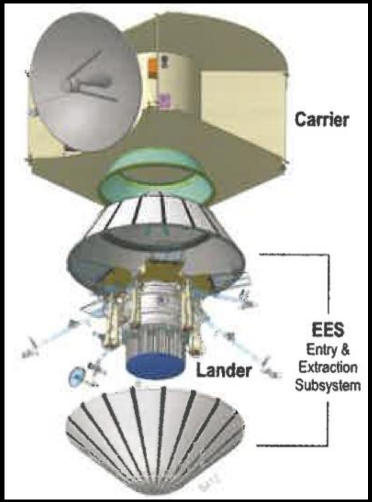


Saturn Probes

Lunar South Pole Aitken Basin Sample Return

Trojan Tour & Rendezvous

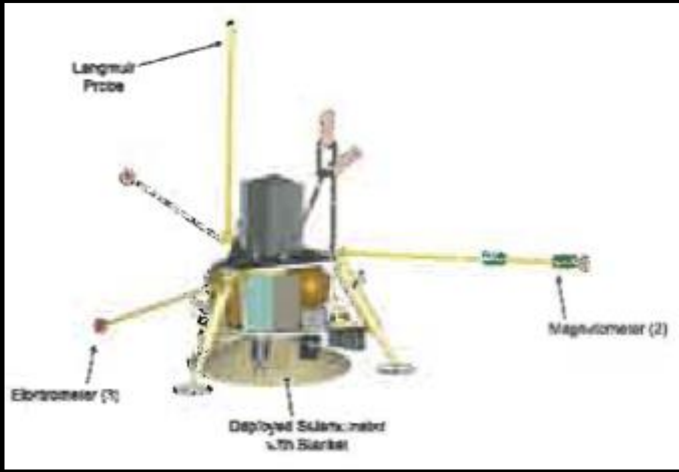
Venus In-Situ Explorer



New Frontiers #5 Focused Missions

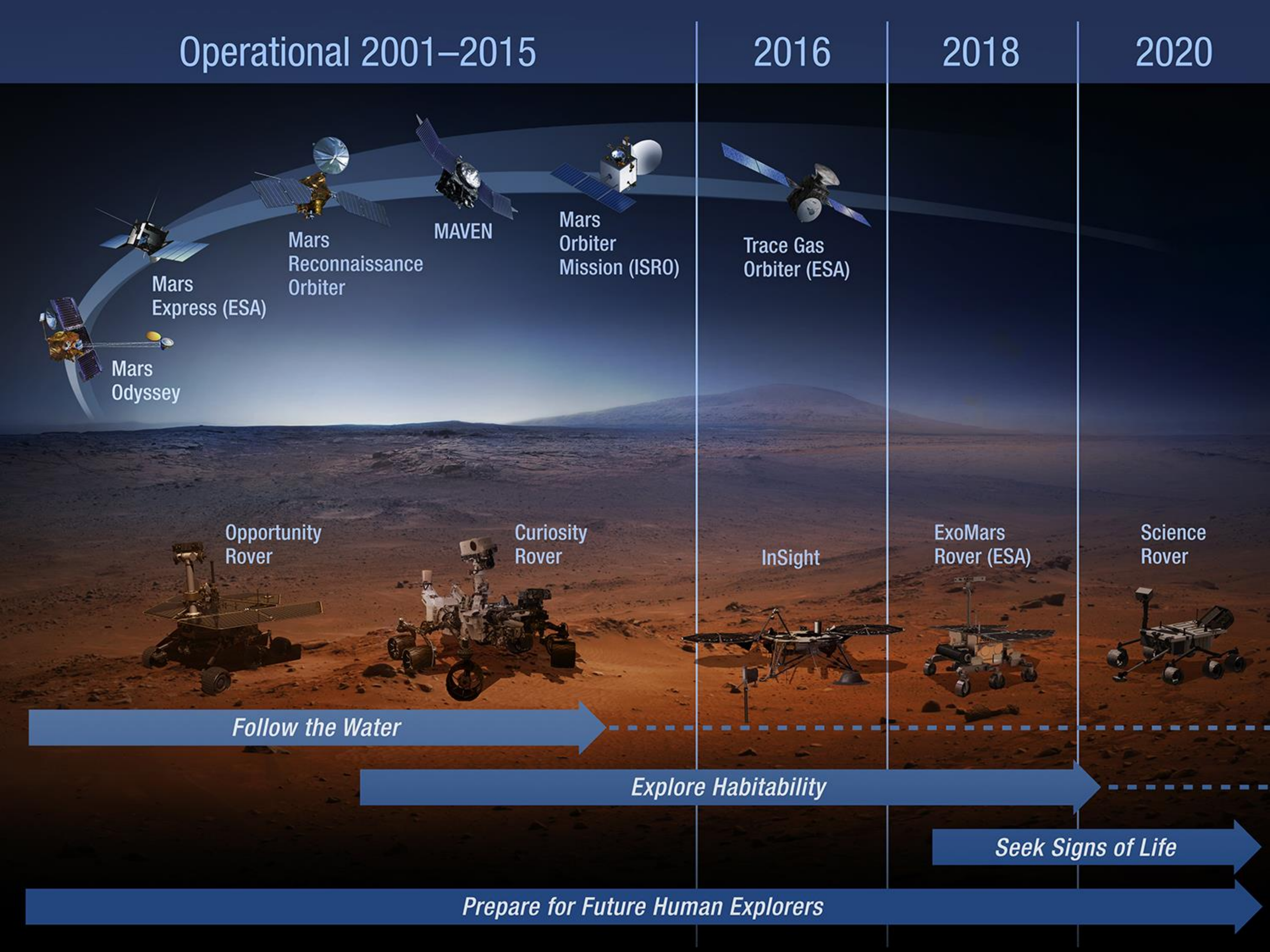
- Added to the remaining list of candidates:

Lunar Geophysical Network



Io Observer

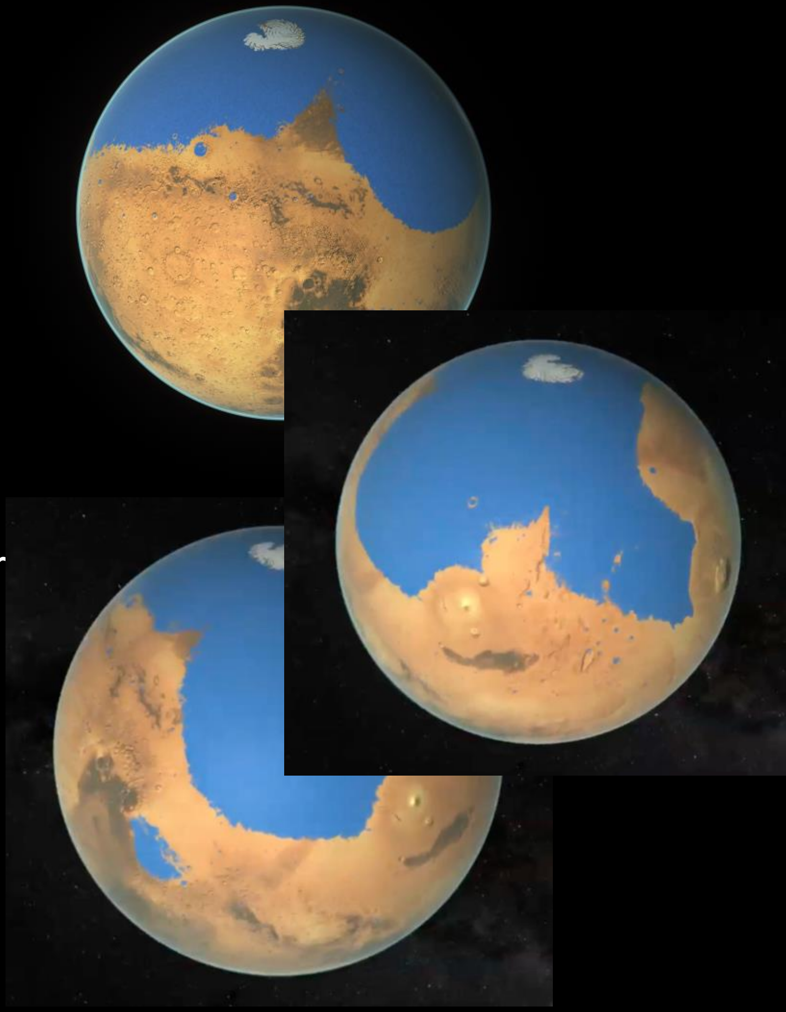
Mars Program Status


Operational 2001–2015
2016
2018
2020
Mars Odyssey
Mars Express (ESA)
Mars Reconnaissance Orbiter
MAVEN
Mars Orbiter Mission (ISRO)
Trace Gas Orbiter (ESA)
Opportunity Rover
Curiosity Rover
InSight
ExoMars Rover (ESA)
Science Rover
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers

Mars Has Lost an Ocean's Worth of Water

We know Mars has water but the question is *how much* and for *how long*?

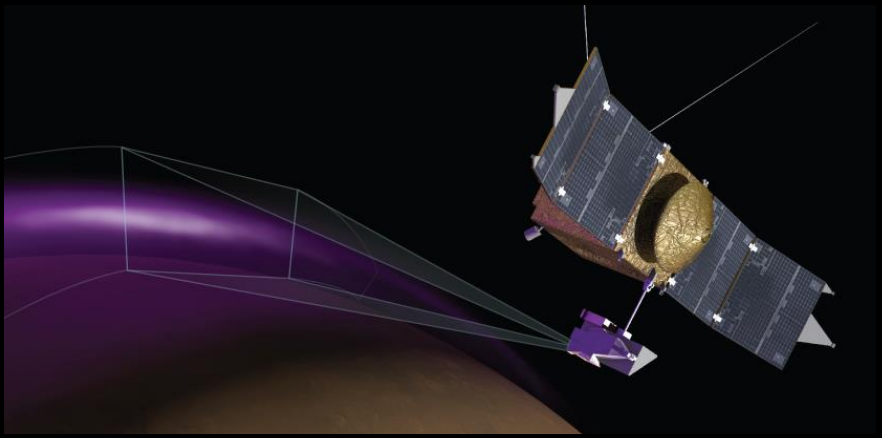
- NASA researchers used 3 ground-based infrared telescopes on Earth to study the remaining water molecules in the Martian atmosphere
- The results showed that a very large amount of heavy water (having the deuterium or D hydrogen) remains on Mars today meaning that Mars has lost a significant amount of normal water (having just hydrogen or H) over time
- This allows an estimate of the total amount of water on Mars to be determined based on the accepted value of D/H
- Result: Today Mars has only 13% of the water it once had losing 87%
- Mars must have kept that water for >1.5 BY
- MAVEN is there now looking into the processes that tell us *how* Mars lost its water

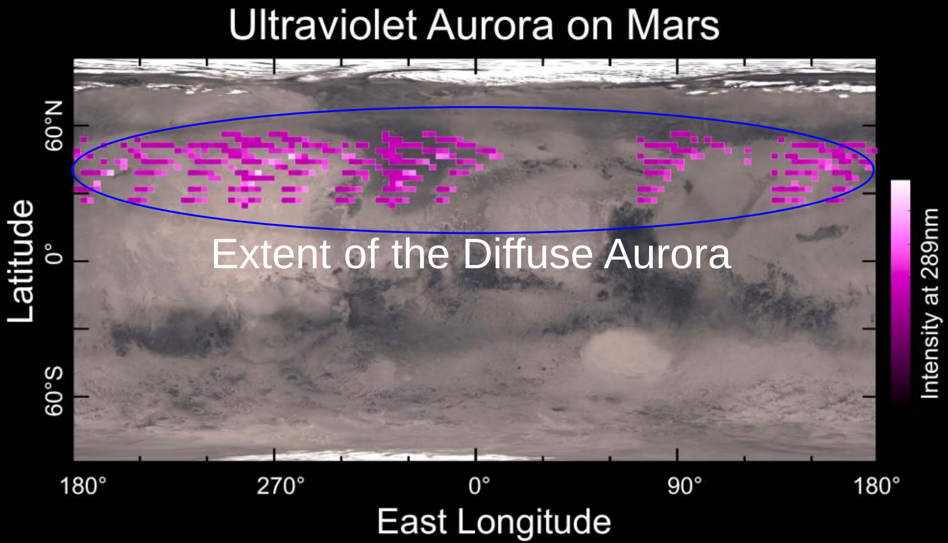


20% of the planet would be covered with water to a maximum depth of 1 mile

MAVEN Detects Unexpected Aurora on Mars

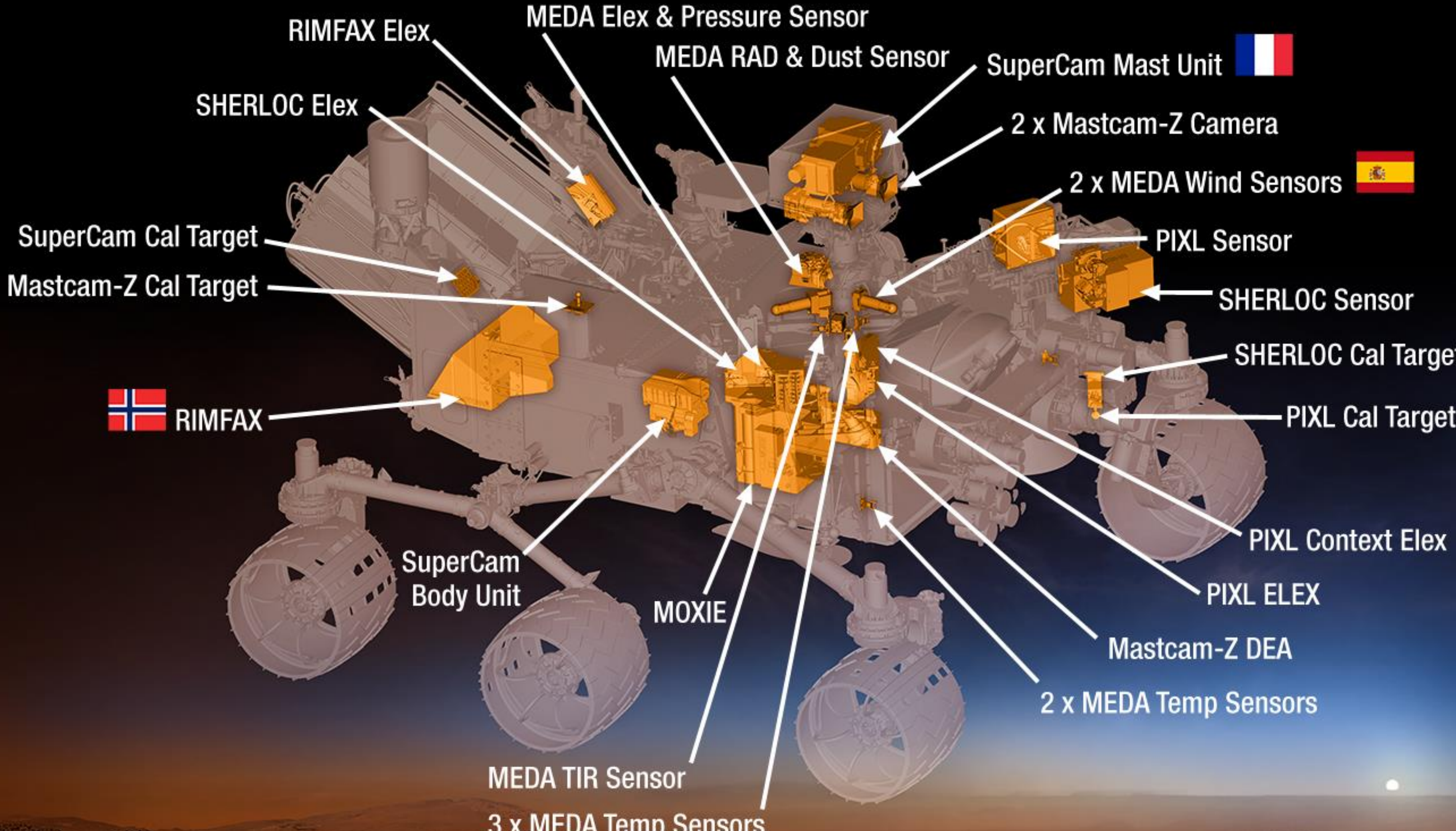
NASA's Mars Atmosphere and Volatile Evolution (MAVEN) mission observed what scientists have named "Christmas lights". For five days just before Christmas 2014, MAVEN’s Imaging Ultraviolet Spectrograph (IUVS) saw a bright ultraviolet auroral glow spanning Mars' northern hemisphere. The diffuse glow is distributed throughout the northern hemisphere and, unlike previous measurements of aurora on Mars, had no connection to magnetic anomalies.





Aurorae are caused by energetic particles like electrons crashing down into the atmosphere and causing the gas to glow. In this case, the source of the energetic particles appears to be the sun. MAVEN's Solar Energetic Particle instrument detected a huge surge in energetic electrons just before the onset of the aurora. These electrons had enough energy to produce aurorae deeper in the upper atmosphere than ever observed on Mars. Billions of years ago, Mars lost a global protective magnetic field like Earth has, so solar particles can directly strike the atmosphere.

Mars 2020 Rover



Europa Activities

Recent Europa Activities

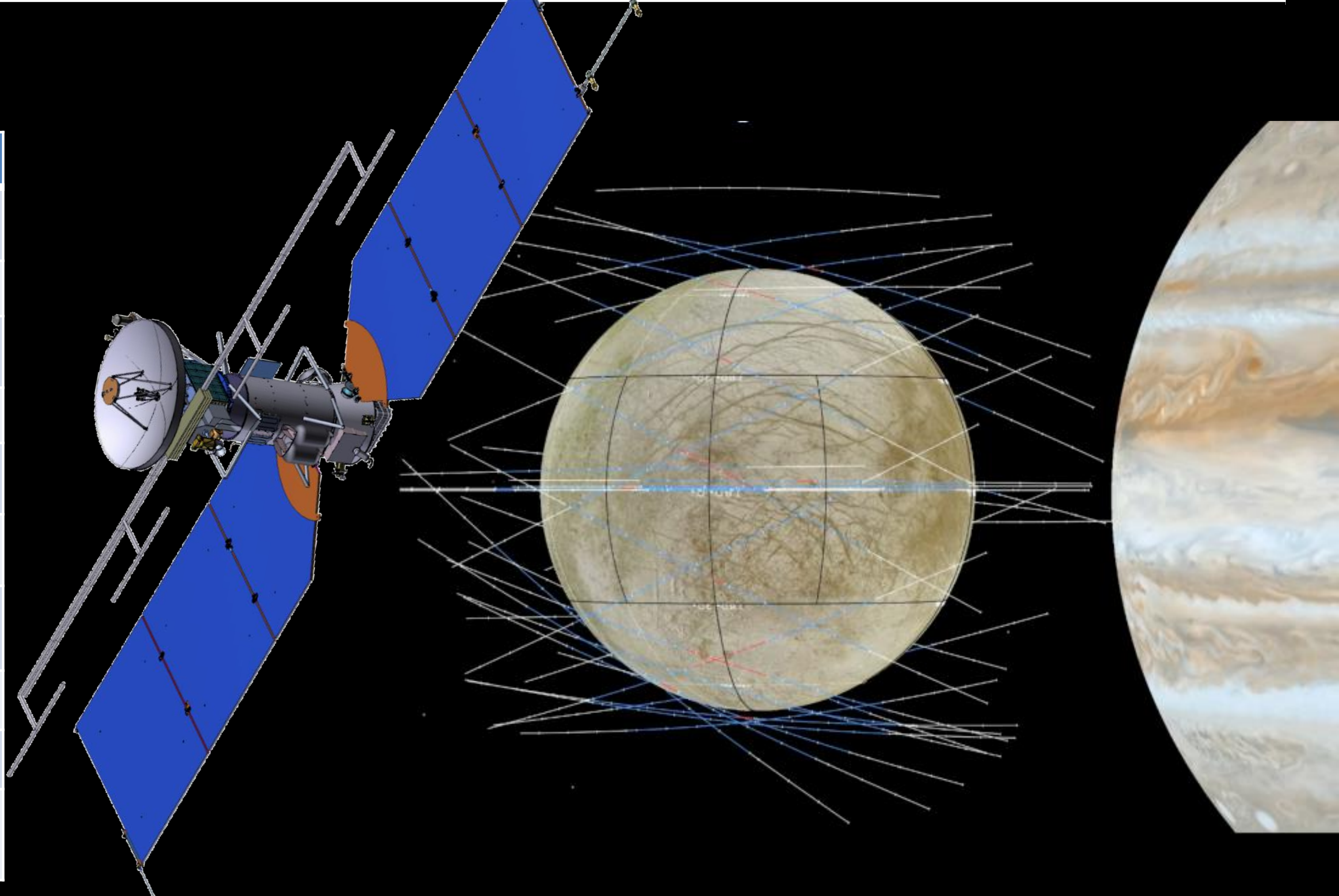
- Europa mission formulation in the President's FY16 Budget
- Instrument selections for Europa mission expected in May
  - Released SALMON 2 PEA in July 2014 to solicit instrument investigations for an unspecified Europa mission
  - 33 proposals evaluated
- Dedicated Hubble time to verify existence of 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

	Instrument Type
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



Questions?

PSD Intra-Divisional Activities

- Missions:
  - w/Helio – MAVEN, Juno, and MESSENGER
  - NEOWISE – Astro space mission doing NEO search
  - Astrophysics telescopes (HST, Chandra, Spitzer, SOFIA)
- Mission Support and R&A program:
  - Jointly coordinate work at IRTF and Keck telescopes
  - Balloon activity
  - Exoplanets (PSD & Astro) – currently
  - Nexus for Exoplanet System Science – NExSS – with Astro & Helio
  - Future: Data analysis on missions with Helio
- Institute Activities:
  - Astrobiology Institute nodes (PSD & Astro)
- Joint SMD Conferences:
  - Comparative Climates of Terrestrial Planets I &II

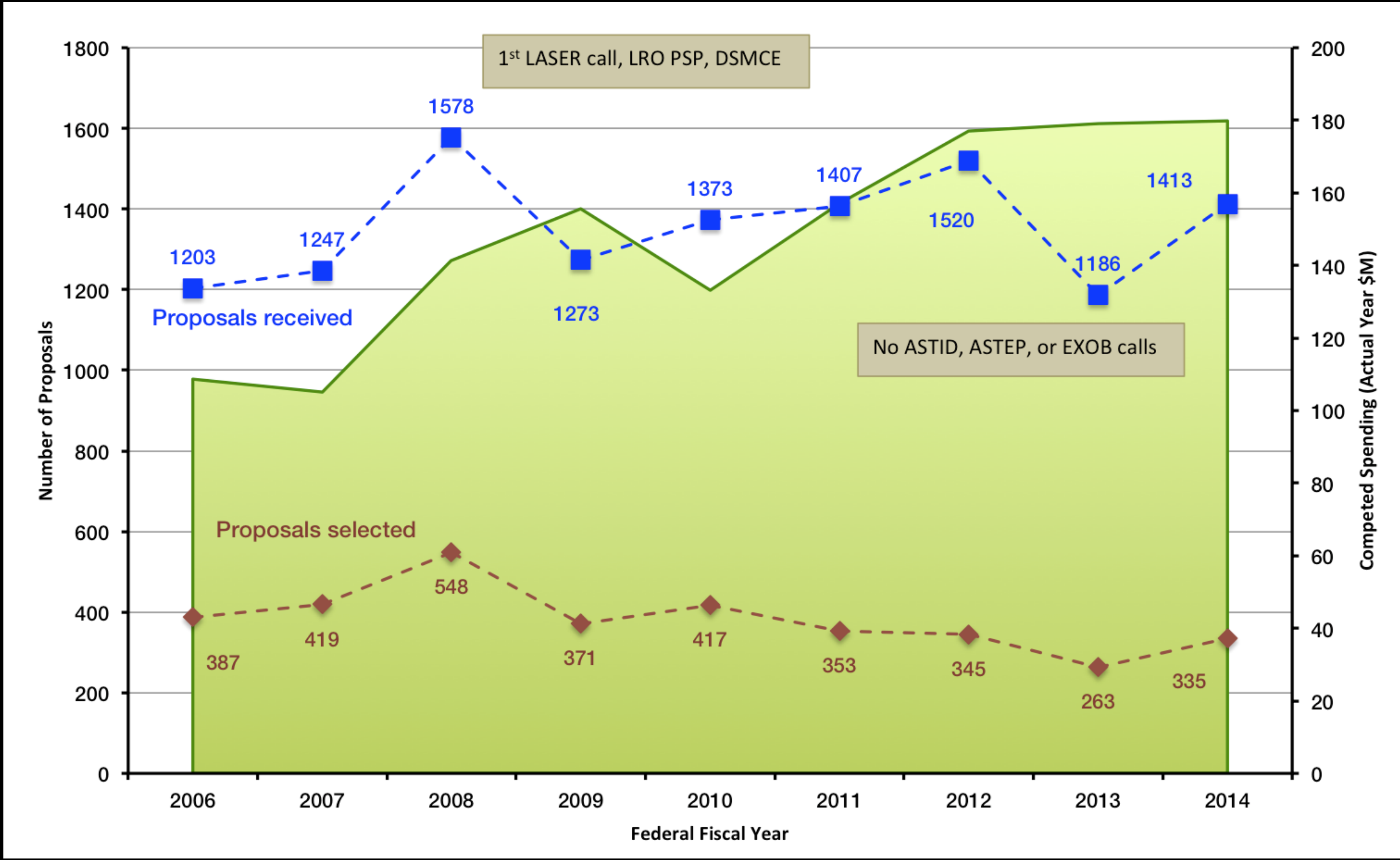
Summary: Joint PSD & HEO/STMD

- Mission Activities:
  - Lunar Reconnaissance Orbiter transitioned from ESMD to PSD
  - LADEE mission tested Laser Communications from the Moon
  - Discovery AO contain technology demonstration activities
- Mission support Activities:
  - Asteroid Redirect Mission - NEO detection and characterization
  - Planetary Radar at Arecibo and Goldstone
- Mars Exploration activities:
  - Odyssey: Mars Radiation Environment Experiment (MARIE)
  - MSL: Radiation Assessment Detector (RAD), Mars Entry Decent and Landing Instrument (MEDLI)
  - Mars2020: MEDLI, in situ resource utilization (ISRU)
  - Strategic Knowledge Gaps (SKG)
  - Candidate Human landing sites on Mars – Rick Davis from JSC detailed to us
- Research & Analysis joint activities:
  - NASA Lunar Science Institute -> Solar System Exploration Research Virtual Institute
  - Lunar Advance Science & Exploration Research – LASER
  - Moon-Mars analog mission activities – MMAMA
- Join AG charters (LEAG, SBAG, MEPAG)
- Collaborative studies and workshops

Future Joint Activities

- Technologies: EDL, Atomic Clock, Ion Engines…
- Mars Missions in the next decade: TBD
  - Optical Com from the Mars to Earth & back
  - High resolution imaging (replace MRO-Hirise)
  - Joint rover or platform: seismic, weather, SAR, ISRU/SKGs ..
- Space Launch System (SLS)

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