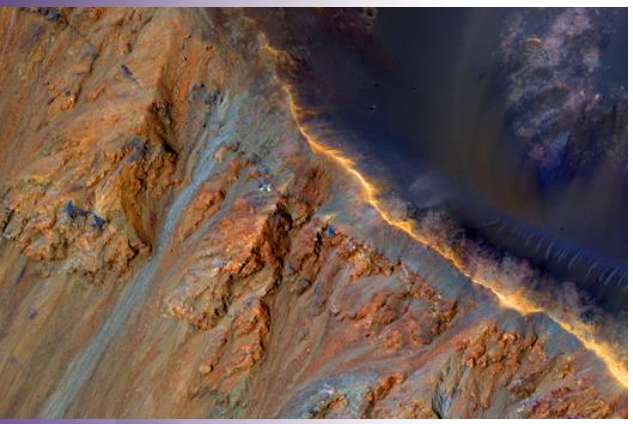
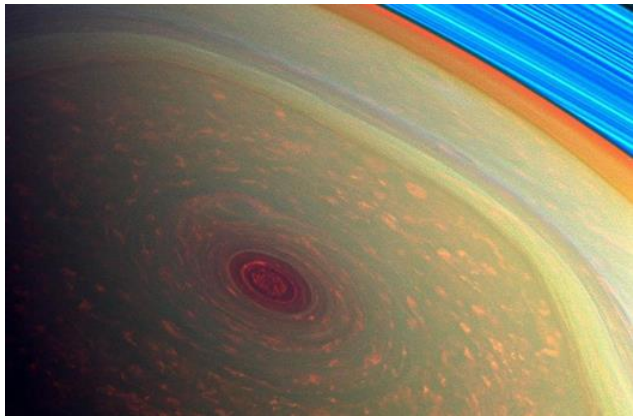
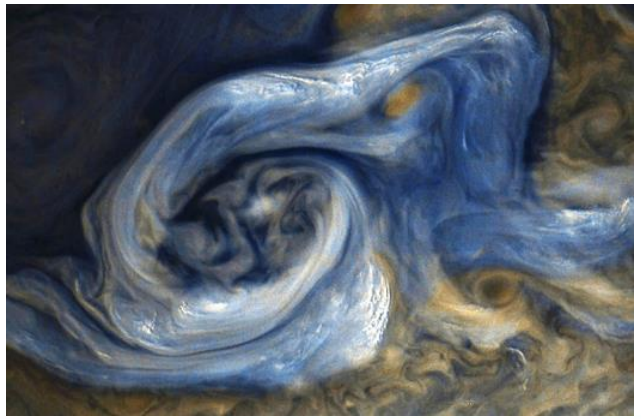
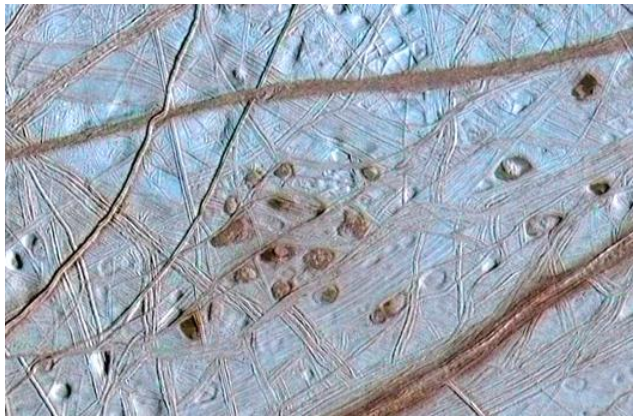
SCIENCE

National Aeronautics and Space Administration

STATUS REPORT

PLANETARY SCIENCE DIVISION

Jim Green

Division Director
Planetary Science Division
Science Mission Directorate, NASA
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April 3, 2018

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Planetary Science Missions: Events

*Completed

2017

January 4 – Discovery Mission selection announced

February 9-20 – OSIRIS-REx began Earth-Trojan search

April 22 – Cassini begins plane change maneuver for the “Grand Finale”

August 21 – Solar Eclipse across America

September 15 – Cassini end of mission at Saturn

September 22 – OSIRIS-REx Earth flyby

October 28 – International Observe the Moon night (1st quarter)

2018

May 5 – Launch InSight mission to Mars

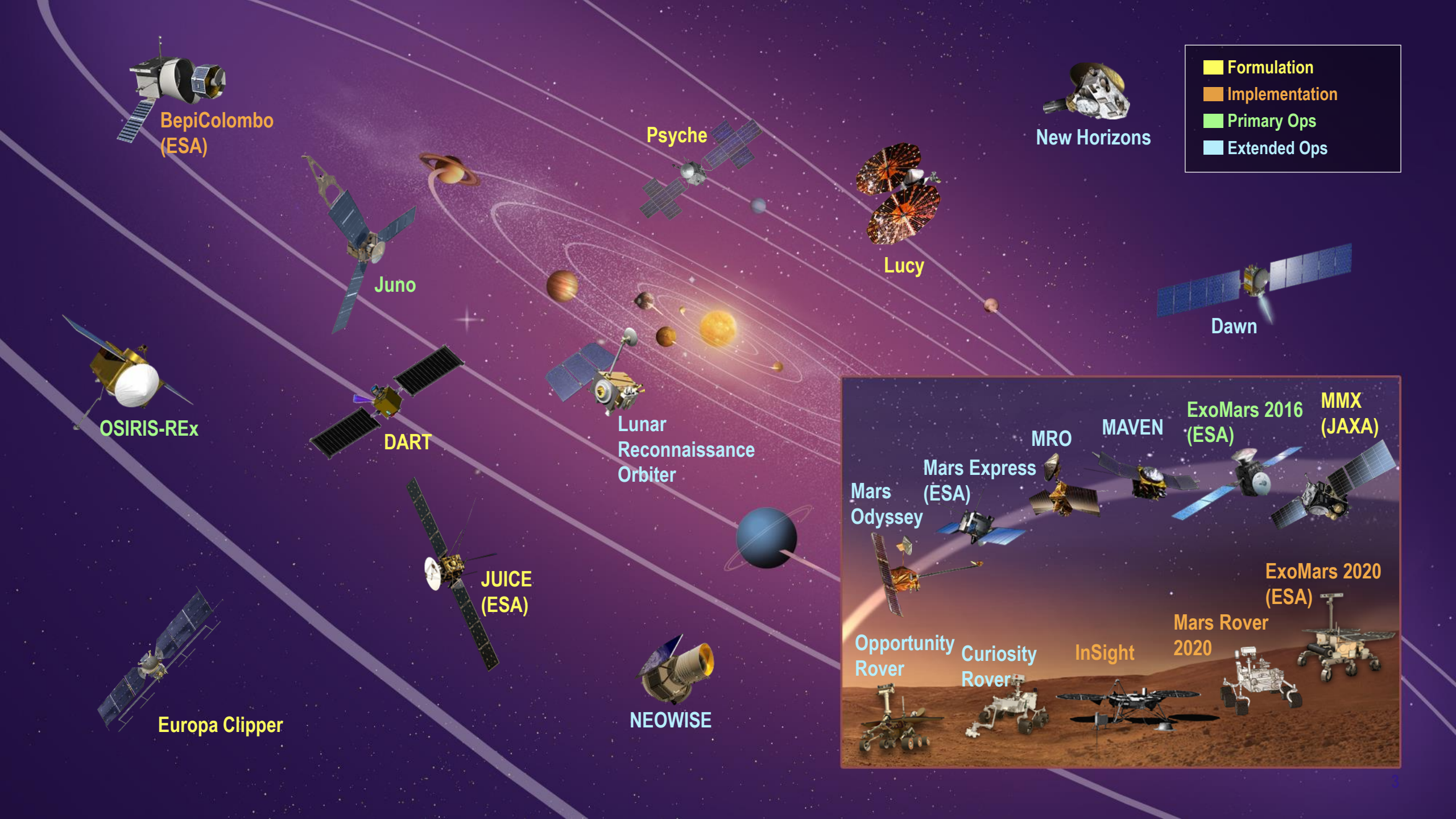
August – OSIRIS-REx begins observing Bennu

October – Launch of ESA’s Bepi Colombo to Mercury

November 26 – InSight landing on Mars

2019

January 1 – New Horizons flyby of Kuiper Belt object Ultima Thule


Formulation
Implementation
Primary Ops
Extended Ops
BepiColombo (ESA)
Juno
Psyche
Lucy
New Horizons
Dawn
OSIRIS-REx
DART
Lunar Reconnaissance Orbiter
JUICE (ESA)
Europa Clipper
NEOWISE
Mars Odyssey
Mars Express (ESA)
MRO
MAVEN
ExoMars 2016 (ESA)
MMX (JAXA)
ExoMars 2020 (ESA)
Mars Rover 2020
Opportunity Rover
Curiosity Rover
InSight

Planetary Science Budget

Planetary Science Program Content

	Actual FY 17	Enacted FY 18	Request FY 19	Notional FY 20	FY 21	FY 22	FY 23
Science	5,762.2		5,895.0	5,859.9	5,841.1	5,822.4	5,803.6
Planetary Science	1,827.5	2,227.9	2,234.7	2,199.6	2,180.8	2,162.1	2,143.3
Planetary Science Research	230.1		258.0	247.6	247.6	247.6	247.6
Planetary Defense	60.0		150.0	150.0	150.0	150.0	150.0
Lunar Discovery and Exploration	19.0		218.0	218.0	218.0	218.0	218.0
Discovery	194.6	335.8	381.2	476.6	375.0	355.6	348.5
New Frontiers	134.0	90.0	130.2	163.7	245.0	327.6	388.4
Mars Exploration	647.0	660.0	601.5	529.7	371.9	290.8	215.3
Outer Planets and Ocean Worlds	359.5		285.6	213.8	373.3	372.5	375.5
Technology	183.3		210.2	200.2	200.0	200.0	200.0

Planetary Science Budget Features

What's Changed

- New Lunar Discovery and Exploration Program supports public-private partnerships and innovative approaches to achieving science and human exploration goals
- New Planetary Defense Program for near-Earth object detection and mitigation includes development of DART and studies a low-cost, space-based near-Earth object detection mission
- Supports trade studies and technology development for returning Mars samples cached by Mars 2020 rover
- Europa Clipper as early as FY25; proposes to fly Clipper on a commercial launch vehicle given cost savings

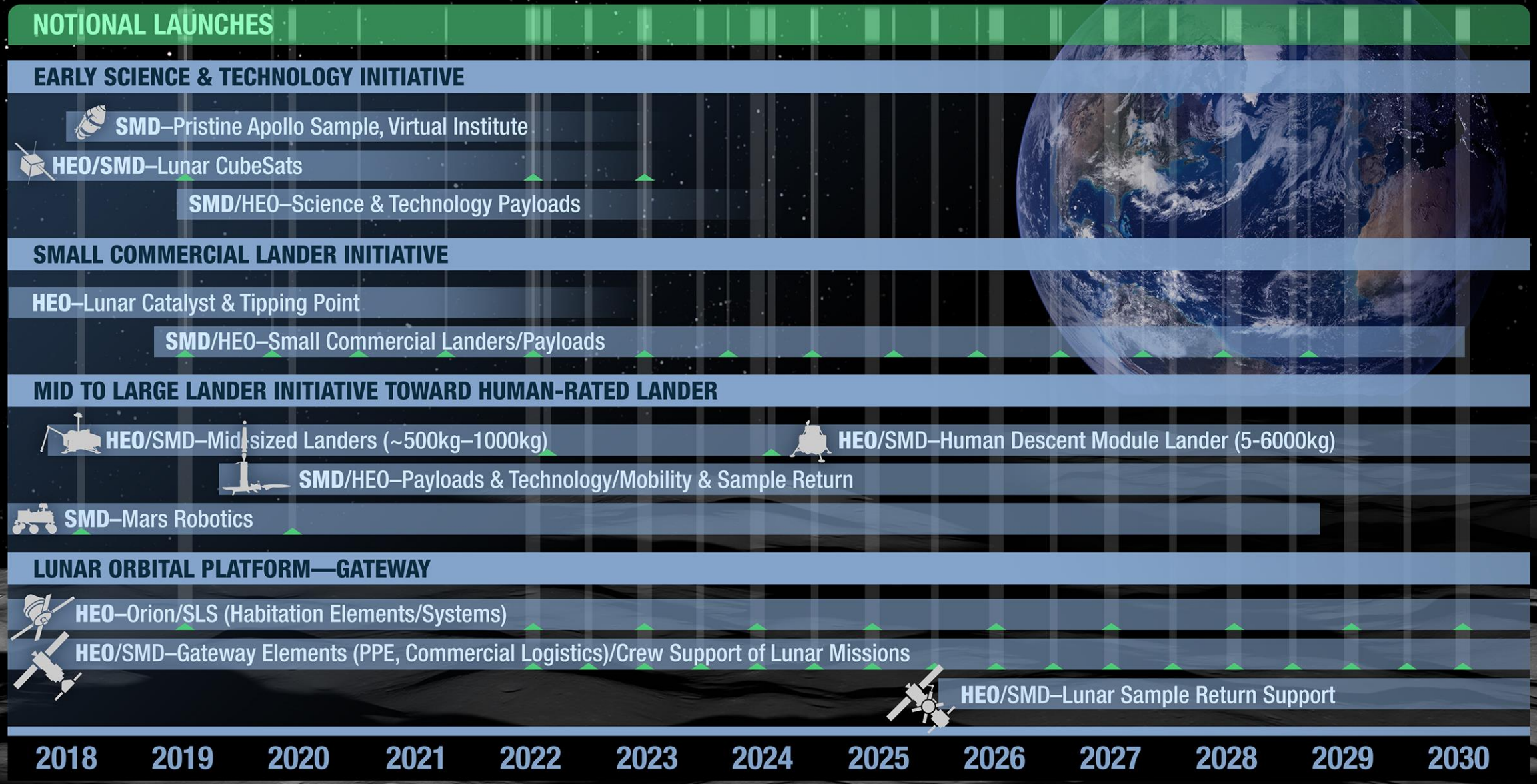
What's the Same

- Supports InSight, Psyche, Lucy, and next New Frontiers selection in FY19
- Funds all operating missions, and completes development of Mars 2020
- DoE production of radioisotope power generators and Pu-238 to fuel missions
- Healthy research program and SmallSat/CubeSat investments

Space Policy Directive-1 (December 11, 2017) amends the National Space Policy to include the following paragraph:

"Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will *lead the return of humans to the Moon* for long-term exploration and utilization, followed by human missions to Mars and other destinations;" (emphasis added)

NASA Exploration Campaign



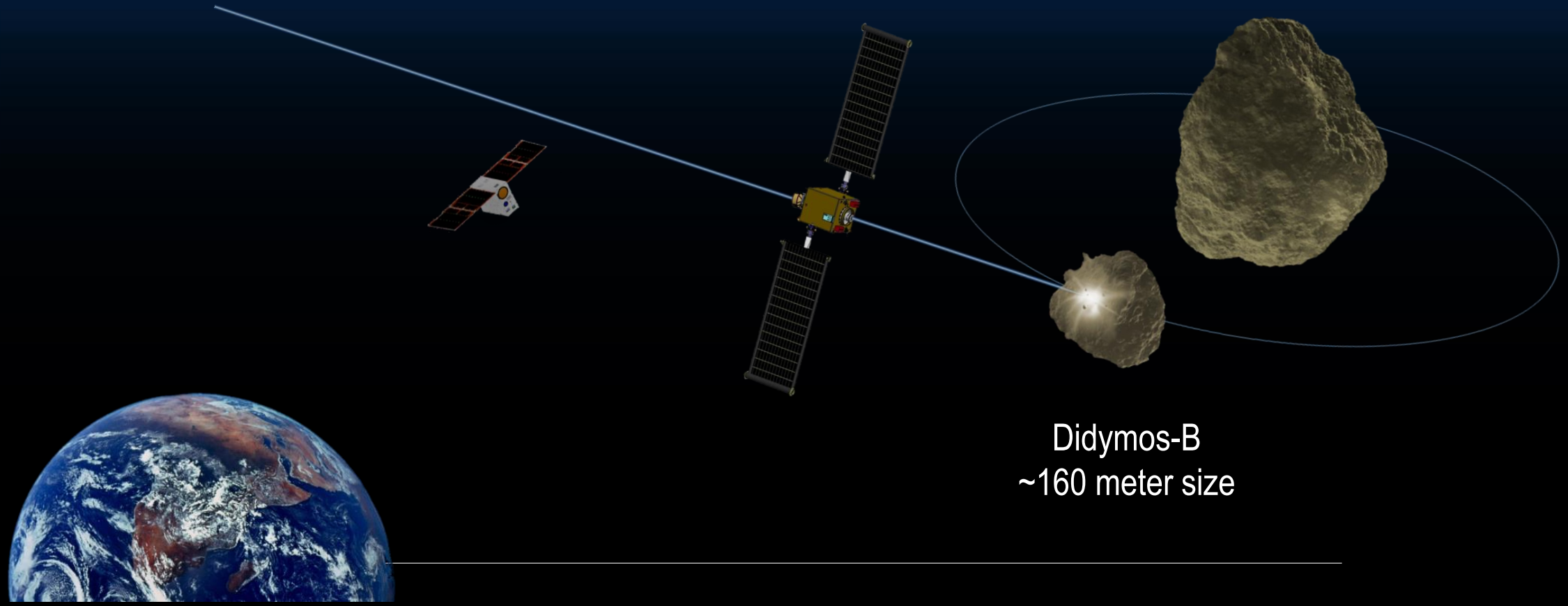
Timelines are tentative and will be developed further in FY 2019

MARCH 2018

IAU
Minor Planet Center
ASSESS
[CENTER FOR NEAR EARTH OBJECT STUDIES]
SEARCH, DETECT & TRACK
[GROUND-BASED & SPACE-BASED OBSERVATIONS, IAWN]
PLANETARY DEFENSE
MITIGATE
[DART, FEMA EXERCISES]
CHARACTERIZE
[NEOWISE, GOLDSTONE, ARECIBO, IRTF]
PLAN & COORDINATE
[SMPAG, PIERWG, DAMIEN IWG]

Double Asteroid Redirection Test (DART)

Mission Concept (with ASI CubeSat)



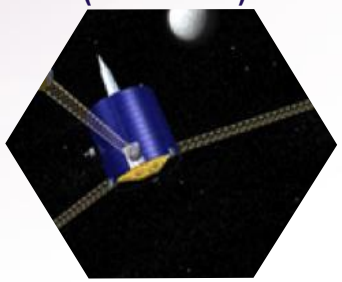
Discovery Program

Discovery Program

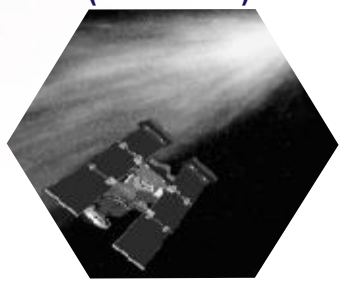
NEO characteristics
NEAR
(1996-1999)

Mars evolution
Mars Pathfinder
(1996-1997)

Lunar formation
Lunar Prospector
(1998-1999)



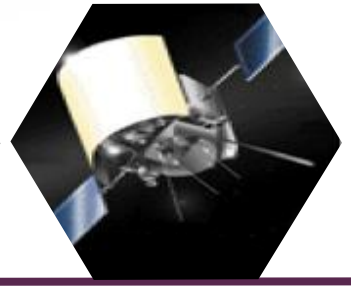
Nature of dust/coma
Stardust
(1999-2011)



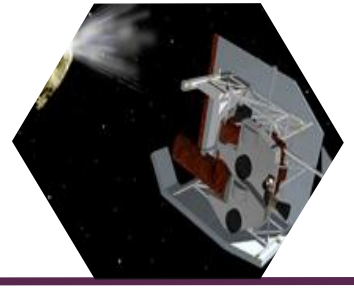
Solar wind sampling
Genesis
(2001-2004)

Comet Diversity
CONTOUR
(2002)

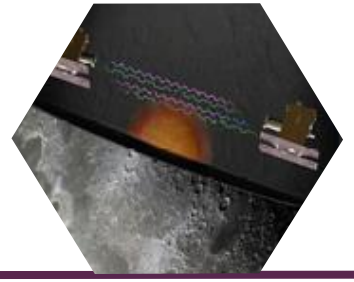
Mercury Environment
MESSENGER
(2004-2015)



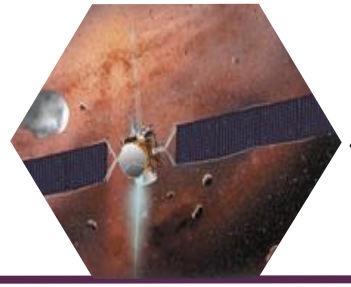
Comet Internal Structure
Deep Impact
(2005-2012)



Lunar Internal Structure
GRAIL
(2011-2012)

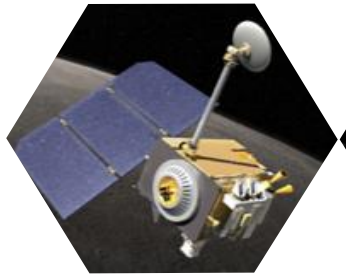


Main-belt Asteroids
Dawn
(2007-TBD)

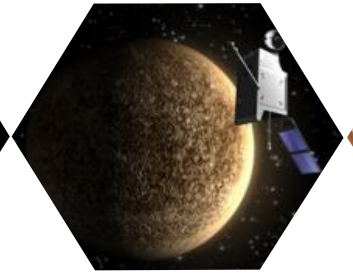


Exoplanets
Kepler
(2009-TBD)

Lunar Surface
LRO
(2009-TBD)



ESA/Mercury
Surface
Strofio

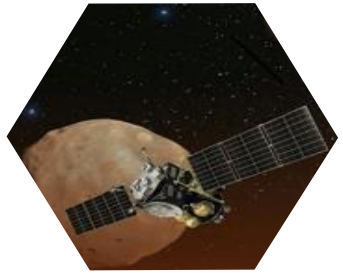


Mars Interior
InSight
(2018)

Trojan Asteroids
Lucy
(2021)

Metal Asteroid
Psyche
(2022)

Martian Moons
MMX/MEGANE
(2024)



Discovery Long-Range Planning

- Cost Cap $495M Phase A-D (FY19) excluding LV
- ~~May not propose the use of radio-isotope power systems (RPS)~~ – UPDATED
- May include radioisotope heater units (RHUs)

Release of draft AO ..... September 2018 (target)

Release of final AO ..... February 2019 (target)

Pre-proposal conference ..... ~3 weeks after final AO release

Proposals due ..... 90 days after AO release

Selection for competitive Phase A studies ..... December 2019 (target)

Concept study reports due ..... November 2020 (target)

Down-selection ..... June 2021 (target)

Launch readiness date ..... NLT December 31, 2026

Reconsideration In the Use of RPS for Discovery

After analysis and consultation with the Department of Energy, NASA's Planetary Science Division is pleased to announce that the ban on the use of Radio-isotope Power Systems (RPS's) by proposers responding to the upcoming Discovery 2018 AO has been removed.

Proposer's will be able to include the use of up to two (2) Multi-mission Radio-Isotope Thermal Generators (MMRTG's) to enable or significantly enhance their mission concept.

Costs to be borne by proposers for the MMRTG's, the related environmental impact assessments, and the required Nuclear Launch Approval process will be announced once determined.

New Frontiers Program

New Frontiers Program

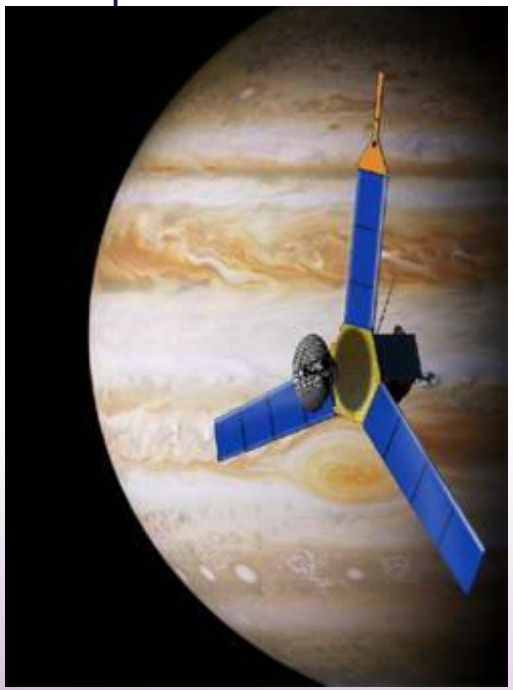
1st NF mission
New Horizons

Pluto-Kuiper Belt

Launched January 2006
Flyby July 14, 2015
PI: Alan Stern (SwRI-CO)

2nd NF mission
Juno

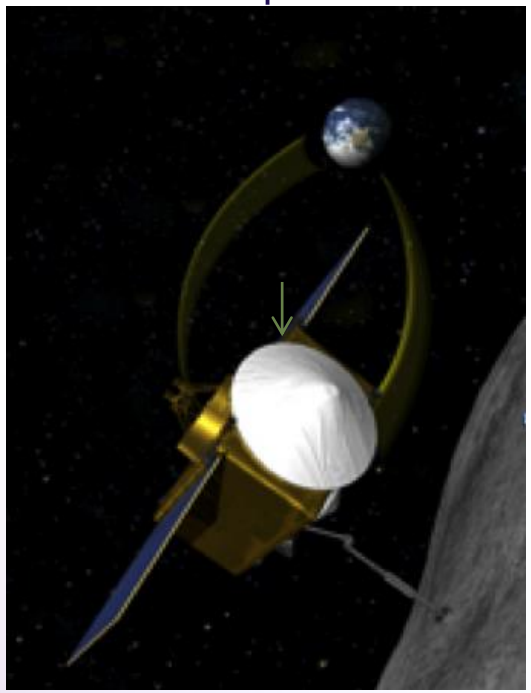
Jupiter Polar Orbiter



Launched August 2011
Arrived July 4, 2016
PI: Scott Bolton (SwRI-TX)

3rd NF mission
OSIRIS-REx

Asteroid Sample Return



Launched September 2016
PI: Dante Lauretta (UA)

New Frontiers 4 AO

Investigations (listed without priority)

- Comet Surface Sample Return
- Lunar South Pole-Aitken Basin Sample Return
- Ocean Worlds (Titan, Enceladus)
- Saturn Probe
- Trojan Tour and Rendezvous
- Venus In Situ Explorer

12 Proposals received on ..... April 28, 2017

Step-1 Selections Announced (target)..... December 2017

Phase A Concept Study Reports due..... December 2018

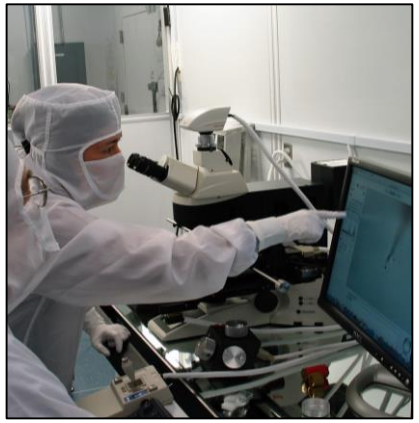
Down selection for Flight (target)..... July 2019

Launch Readiness Date..... NLT December 31, 2025

Comet Astrobiology Exploration Sample Return

- Comets record presolar history, the initial stages of planet formation, and the sources of prebiotic organics and volatiles available for the origin of life.
- Target comet is 67P/Churyumov-Gerasimenko.
- Mission and Sample Acquisition System (SAS) have been designed for the known properties of 67P.
- SAS collects at least 80 g of comet nucleus sample.
- As volatiles evolve from the sample they are transferred to a separate reservoir, preventing sample alteration. Both non-volatile and volatile materials are returned to Earth for analysis.
- Sample stored at -80° to -40° C through return cruise, and below 0° C through entry, descent, landing, and recovery.

PI: Steve Sqyres, Cornell University. CAESAR will return the first sample from the nucleus of a comet. Sample analysis in worldwide laboratories will address questions about Solar System starting materials, and how they came together to form planets and give rise to life.



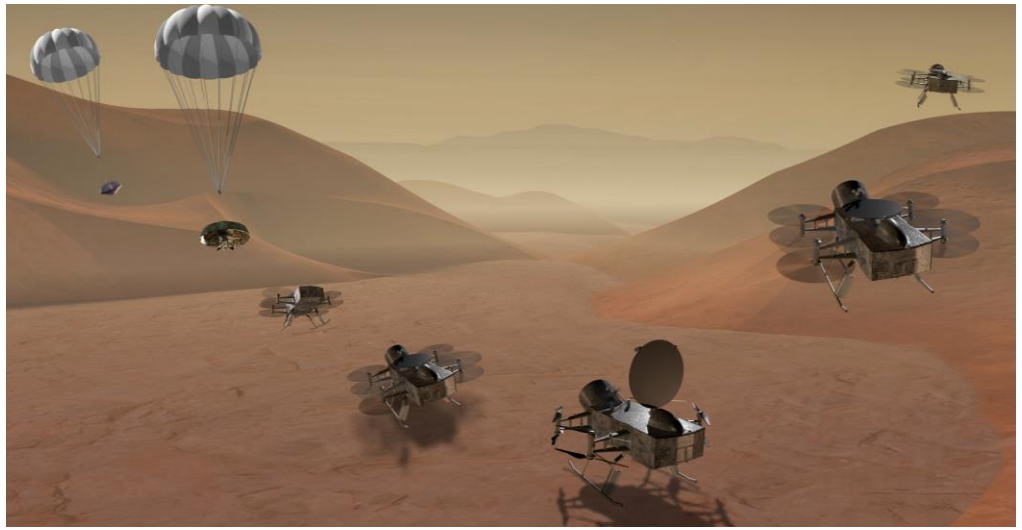
A rotorcraft to explore prebiotic chemistry and habitability on the ocean world Titan

- Flight is highly efficient on Titan, enabling Dragonfly to sample materials in a variety of settings with its **science payload:**
  - Mass spectrometer
  - Gamma-ray and neutron spectrometer
  - Meteorology and seismic sensors
  - Camera suite

Science Objectives:

- Analyze chemical components and processes at work that produce biologically relevant compounds
- Measure atmospheric conditions, identify methane reservoirs, and determine transport rates
- Constrain processes that mix organics with past surface liquid water reservoirs and subsurface ocean
- Search for chemical evidence of water-based or hydrocarbon-based life

Aerial mobility provides access to Titan's diverse materials at a wide range of geologic settings at dozens of sites, 10s to 100s of kilometers apart

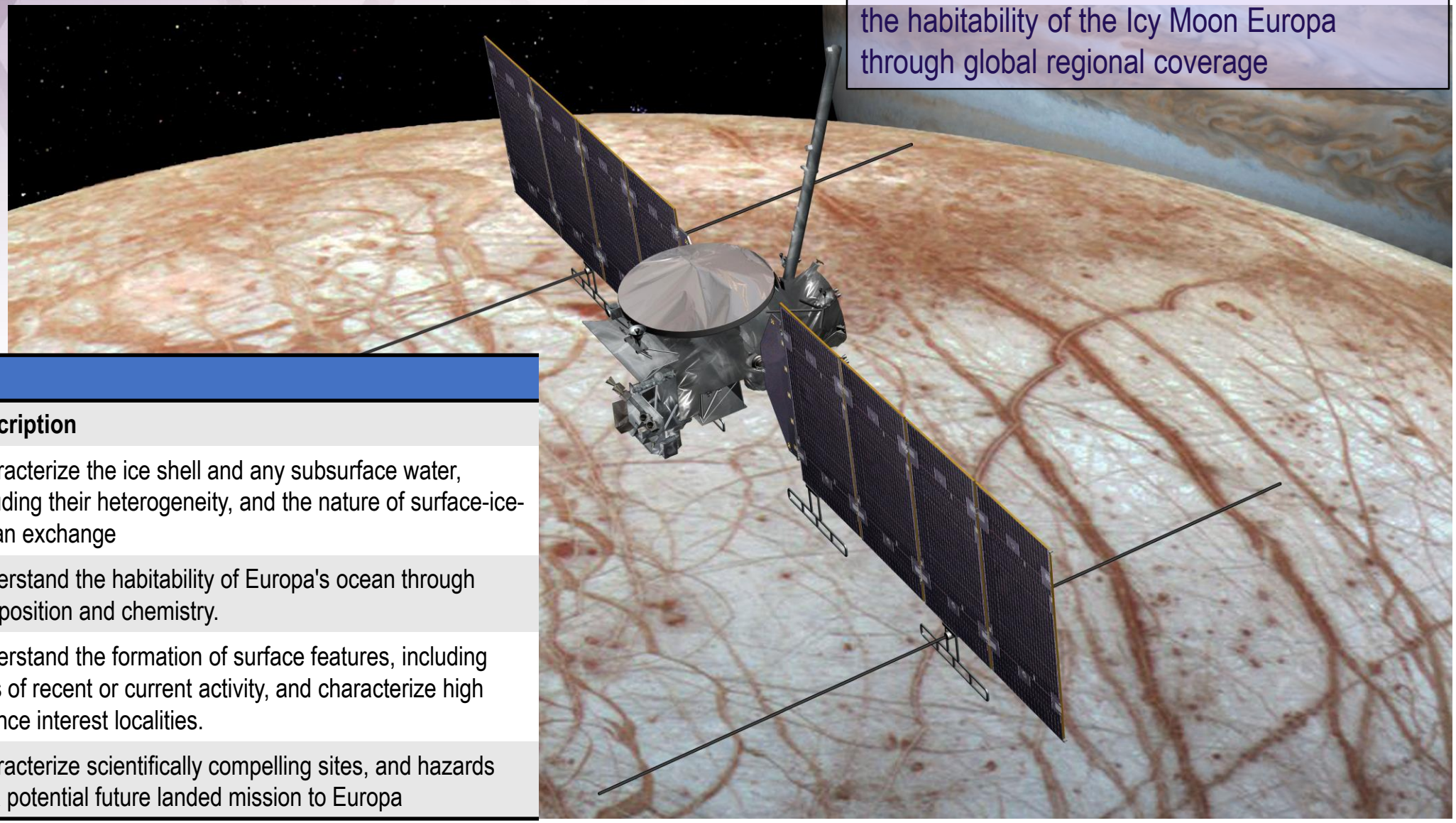


PI: Dr. Elizabeth Turtle at APL
Dragonfly would arrive at Titan in 2034 and explore for over 2 years, performing detailed chemical analyses, measuring the atmosphere and seismic activity, and imaging the surface.

Oceans Worlds

Europa Clipper Overview

Will conduct approximately 45 low altitude flybys (25 – 100 km altitude) to characterize the habitability of the Icy Moon Europa through global regional coverage

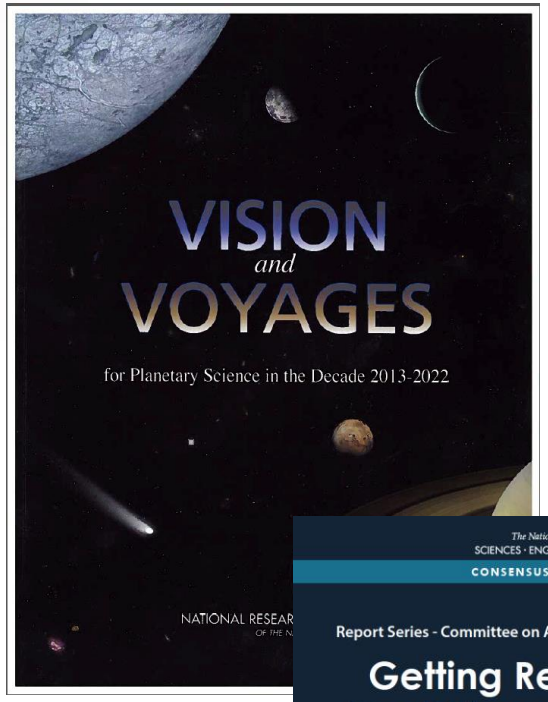


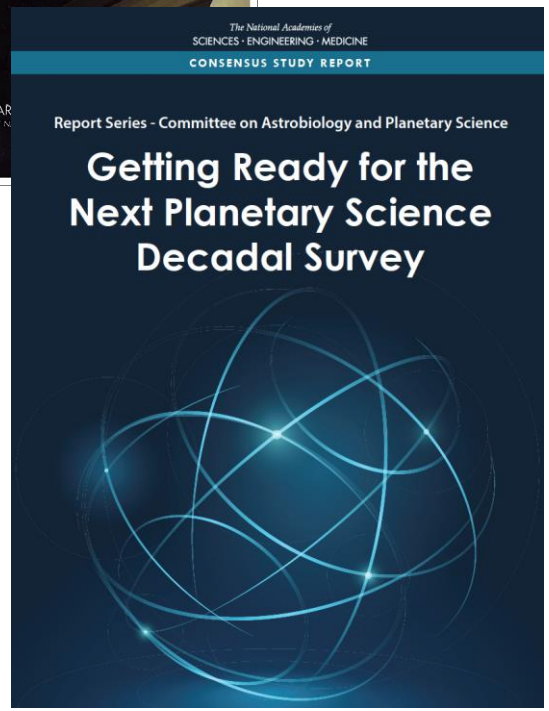
Science	
Objective	**Description**
Ice Shell & Ocean	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange
Composition	Understand the habitability of Europa's ocean through composition and chemistry.
Geology	Understand the formation 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

NASA Planetary Science Studies

Timeline of Studies

- 1st Planetary decadal: 2002-2012
- 2nd Planetary decadal: 2013-2022
- CubeSat Review: Completed June 2016
- Extended Missions Review: Completed Sept 2016
- R&A Restructuring Review: Completed June 2017
- Searching For Life : Completed Sept 2017
- Large Strategic Science Missions: Completed Aug 2017
- Midterm evaluation:
  - Tasked August 26, 2016
  - Above NAS studies will be input
  - Expect report to NASA due ~June 2018
- Sample Analysis Investment Strategy
  - Started November 2017
- 3rd Planetary Decadal: 2023-2032
  - To be tasked *before* October 2019
  - Expect report to NASA due 1st quarter 2022
- CAPS reviewed completed studies and recommended several more to be completed



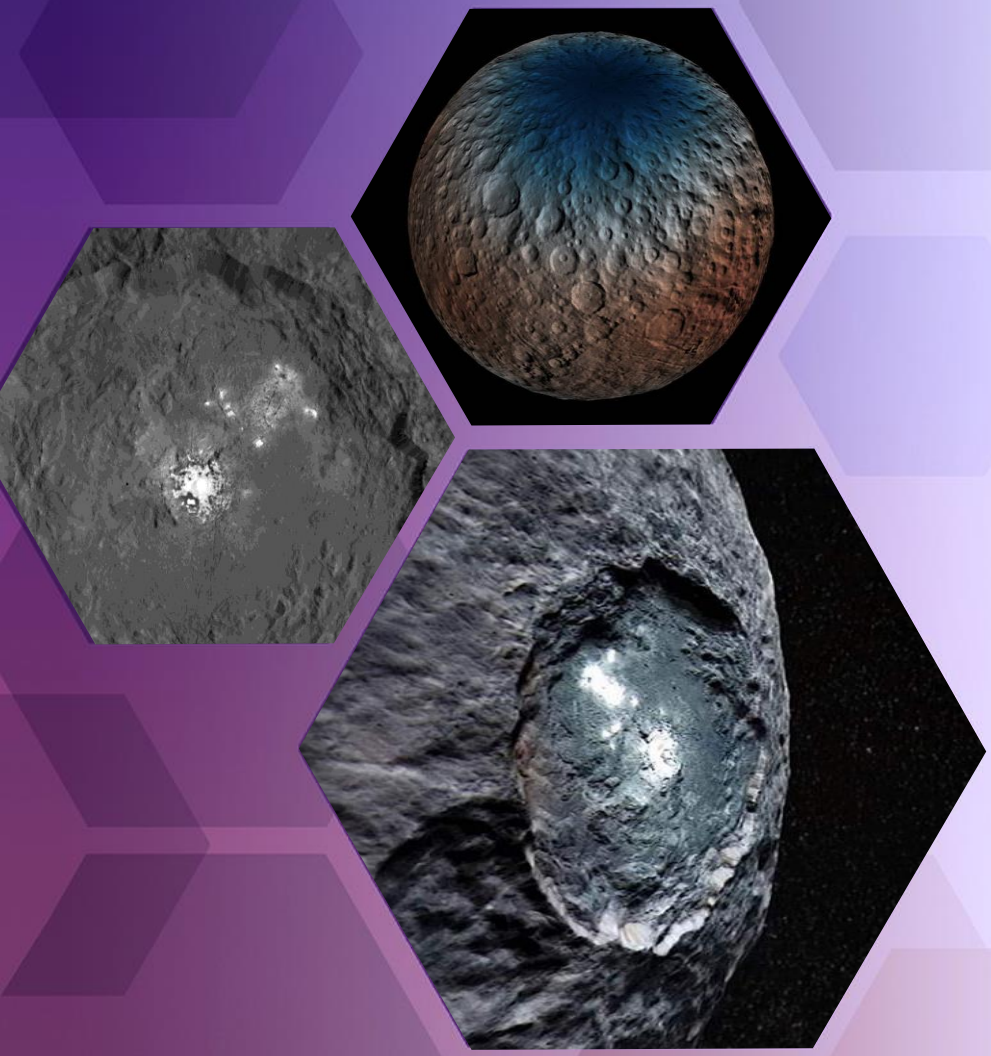


Mission Studies Completed Thus Far

- Mars orbiter
  - 2015 MEPAG's Next Orbiter Science Analysis Group
- Uranus and Neptune (Ice Giants) system missions
  - 2017 NASA science definition team report
- Europa lander
  - 2017 NASA science definition team report
- Venus orbiter and lander (Venera-D)
  - 2017 joint U.S.-Russian science definition team report
- NEO Search and Characterization
  - 2017 NEO science definition team updated report

CAPS Priority Areas Candidates for Large or Medium Class Mission Studies (Unprioritized)

Venus exploration missions	Additional concepts beyond the Venera-D orbiter and lander
Lunar science missions	Understanding interior processes and polar volatiles (Volatiles SAT Team-2)
Mars sample-return next-step missions	Mission elements beyond Mars 2020 necessary for second and third phases of a Mars sample-return campaign
Mars medium-class missions	Multiple mobile explorers, polar explorers, & life-detection. Investigations responsive to new discoveries
Dwarf planet missions	Large- & medium-class mission concepts to Ceres, Pluto, Triton
Io science (NEW FRONTIERS FIVE)	Reexamine mission to Io
Saturn system missions	Affordable, large strategic missions that visit multiple targets
Dedicated space telescope for solar system science	Dynamic phenomena on planetary bodies



Ceres Pre-Decadal Study

- CAPS highlighted Ceres for pre-decadal study
- Dawn revealed Ceres to be an active dwarf planet; It is a solid body, but is it a relic ocean world?
- JPL to lead the Ceres study; Michael Kelley is the PSD POC
- Goals are to assess science priorities and examine trade space of mission concepts
  - Spectrum of alternatives, including New Frontiers and Large Strategic missions
  - Orbiting, landing, roving, sample return?
  - Launch dates between 2024 – 2037
  - PP to be noted, uncover technologies to be addressed
- Key dates:
  - SDT call for applications issued – team is being selected
  - Design study February – Late FY18
  - Engagement with AGs and workshops/conferences

Questions?

Acronym List

AO	Announcement of Opportunity
CDR	Critical Design Review
CH4	Methane
CO	Carbon Monoxide
CO2	Carbon Dioxide
CGS	Common Ground System
CJ	Congressional Justification
CME	Coronal Mass Ejection
CNES	French Space Agency
CSA	Canadian Space Agency
DAMIEN IWG	Detecting And Mitigating the Impacts of Earthbound Near-Earth Objects Interagency Working Group
DLR	German Space Agency
DOE	Department of Energy
EDL	Entry, Descent, Landing
ESA	European Space Agency
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FY	Fiscal Year
GPS	Global Positioning System
HEOMD	Human Exploration and Operations Mission Directorate
IAWN	International Asteroid Warning Network
I&T	Integration and Testing
IRTF	NASA Infrared Telescope Facility
ISS	International Space Station
JAXA	Japanese Space Agency
KDP	Key Decision Point
LDEP	Lunar Discovery and Exploration Program
LRD	Launch Readiness Date
MCR	Mission Concept Review
MOO	Mission of Opportunity
NRA	NASA Research Announcement
NSF	National Science Foundation
PDCO	Planetary Defense Coordination Office
PDR	Preliminary Design Review
PI	Principal Investigator
PIERWG	Planetary Impact Emergency Response Working Group
PSD	Planetary Science Division
R&A	Research and Analysis
R&D	Research and Development
R&T	Research and Technology
RFI	Request for Information
RFP	Request for Proposals
ROSES	Research Opportunities in Space and Earth Science
SALMON	Stand Alone Mission of Opportunity
SAR	Synthetic Aperture Radar
SLS	Space Launch System
SMD	Science Mission Directorate
SMPAG	Space Missions Planning Advisory Group
SR&T	Supporting Research and Technology
STEM	Science, Technology, Engineering, and Math
STDT	Science and Technology Definition Team
STMD	Science and Technology Mission Directorate
TRL	Technology Readiness Level
USGS	U.S. Geological Survey