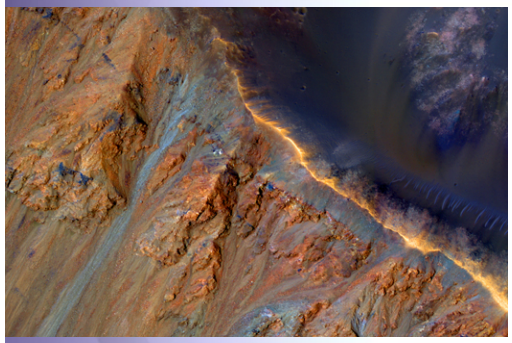
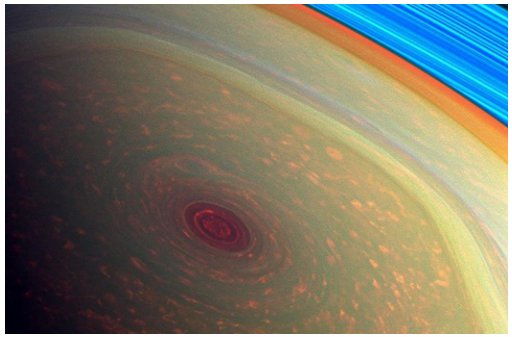
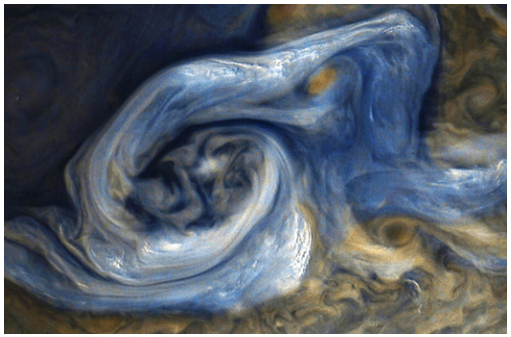
SCIENCE

National Aeronautics and Space Administration


STATUS REPORT

# Planetary Science Division

**Jim Green**
Division Director
Planetary Science Division
Science Mission Directorate, NASA
James.Green@nasa.gov

February 21st, 2018

# Outline

- Planetary Science Mission Events
- Planetary Science Budget
- Discovery Program
- New Frontiers Program
- Ocean Worlds
- NASA Planetary Science Studies
- PSD CubeSats/SmallSats
- SIMPLEx

# Planetary Science Missions Events

## 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

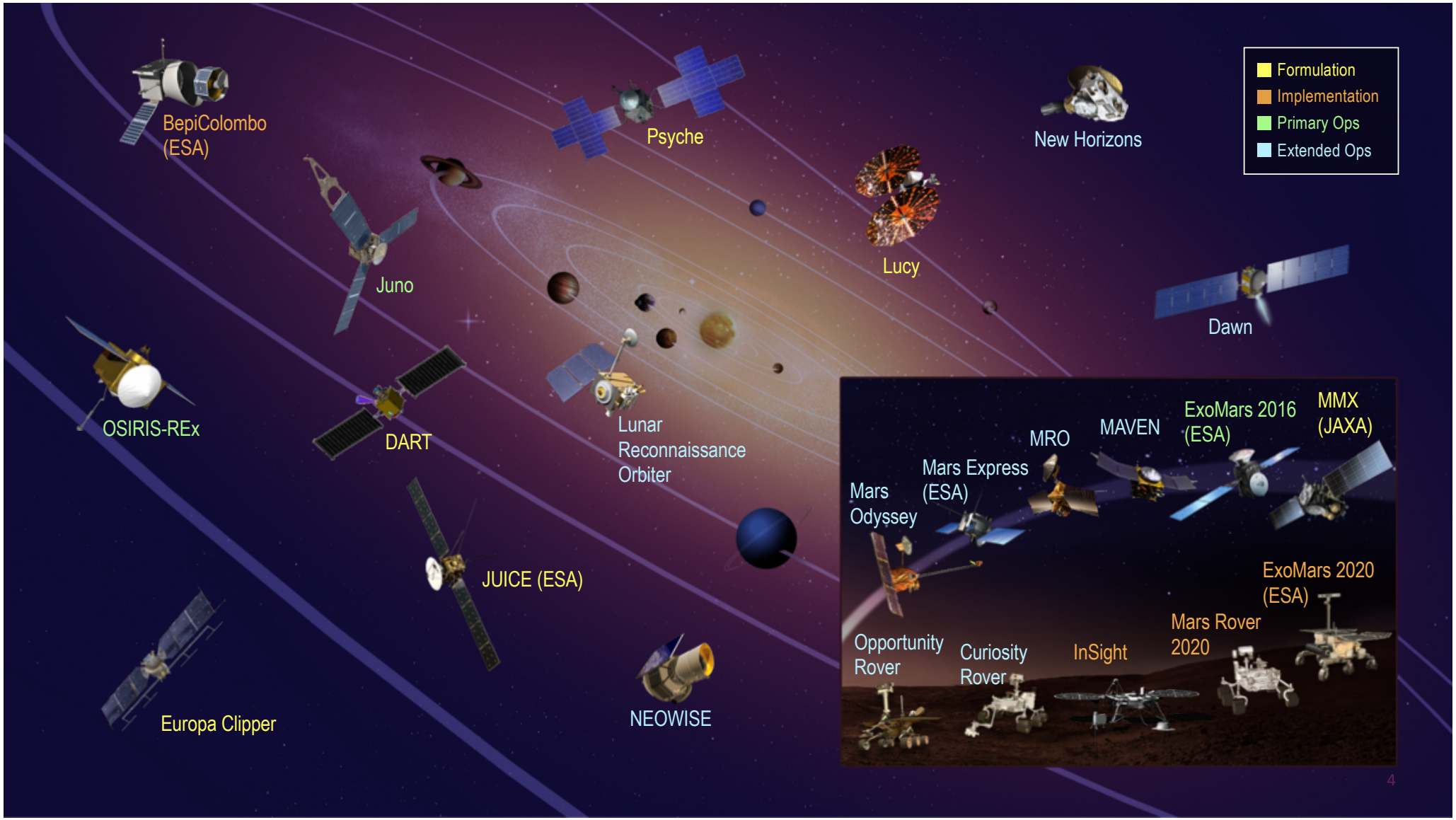
August – *OSIRIS-REx* arrival at Bennu

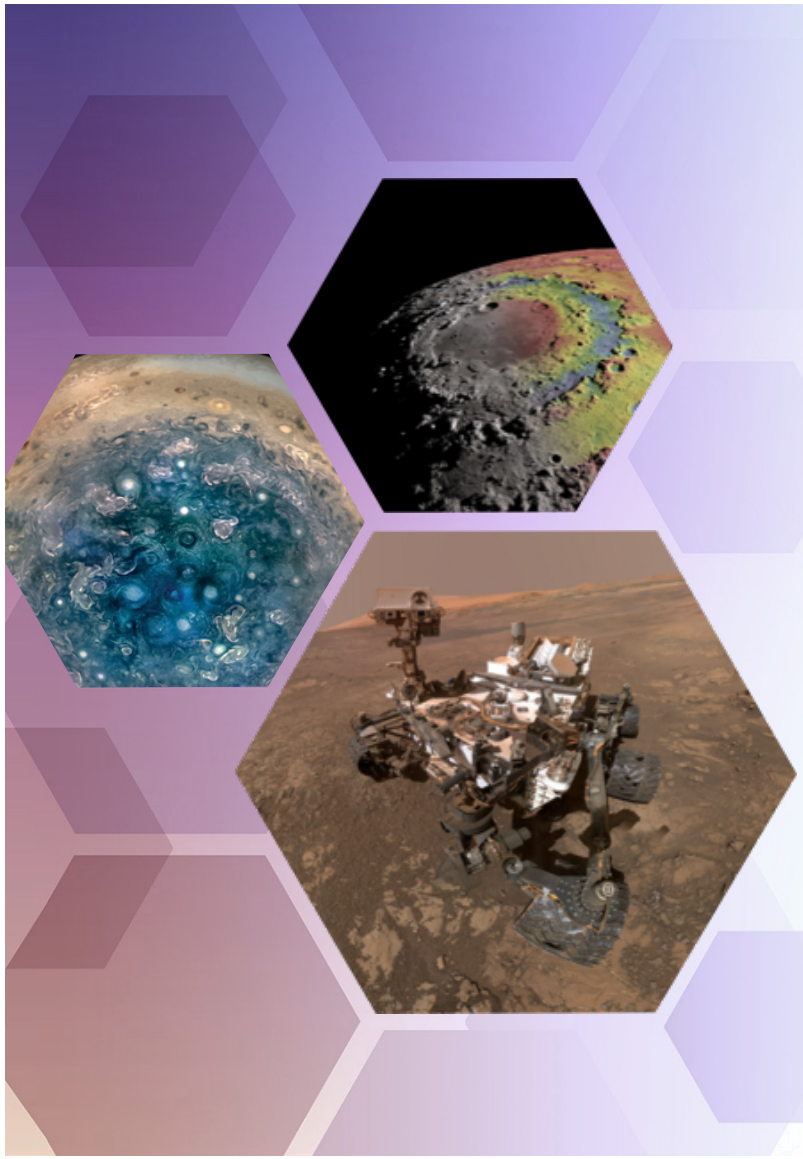
October – Launch of ESA's *Bepi Colombo* to Mercury

November 26 – *InSight* landing on Mars

## 2019

January 1 – *New Horizons* flyby of Kuiper Belt object 2014MU69


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



# Planetary Science Overview

## Strategic Objective

- Ascertain the content, origin, and evolution of the Solar System and the potential for life elsewhere

## Major Activities

- Initiates a new Lunar science and exploration program
- Manage both Principal Investigator-class and strategic missions to numerous objects within our Solar System
- Enhanced efforts to detect, track, and characterize NEOs of all sizes under a new planetary defense program
- Engage international & commercial partners on PSD missions, including development of instruments and support services
- Advance the highest quality Planetary Science Research and Technology Program

# Major Recent Accomplishments FY17-18

- *Cassini* completed 13-year tour of Saturn with dramatic "Grand Finale" – 22 weekly dives between Saturn and rings – before plunging into Saturn's atmosphere
- *Juno* continues to orbit Jupiter, sending back spectacular images and data
  - Early science results showed swirling, continent-sized storms densely clustered and rubbing together at both poles
- Two Discovery missions selected for development
  - *Lucy*: Explores six of Jupiter's Trojan asteroids
  - *Psyche*: Explores a potentially metallic asteroid named Psyche
- Two New Frontier finalists announced
  - *CAESAR*: Probe to collect and return sample of comet Churyumov-Gerasimenko
  - *Dragonfly*: Helicopter-like drone to explore Saturn's largest moon, Titan
- Three potential landing sites identified for *Mars 2020* rover, each with unique environments potentially harboring signs of past microbial life
- *Europa Clipper*, to perform multiple flybys of Jupiter's ocean moon, Europa, entered design phase

# Planetary Science Budget

# Planetary Science Budget Features

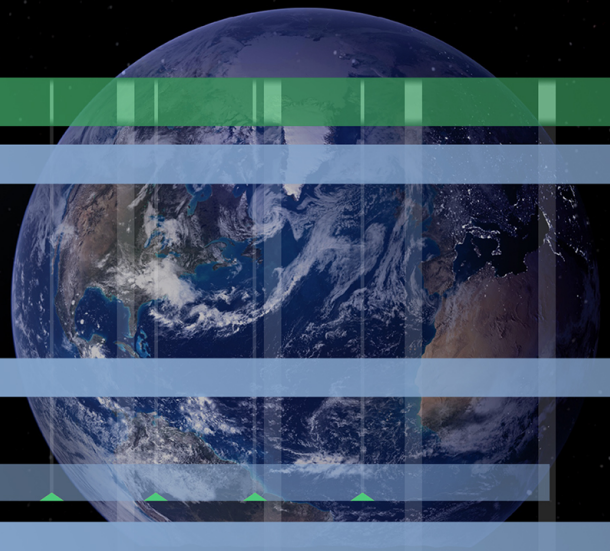
## What's Changed

- 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

# NASA Lunar Exploration Campaign



**NOTIONAL LAUNCHES**

**EARLY SCIENCE & TECHNOLOGY INITIATIVE**

- **SMD**–Pristine Apollo Sample, Virtual Institute
- **HEO/SMD**–Lunar CubeSats
- **SMD**/HEO–Science & Technology Payloads

**SMALL COMMERCIAL LANDER INITIATIVE**

- **HEO**–Lunar Catalyst & Tipping Point
- **SMD**/HEO–Small Commercial Landers/Payloads

**MID TO LARGE COMMERCIAL LANDER INITIATIVE TOWARD HUMAN-RATED LANDER**

- **HEO**/SMD–Mid Commercial Landers (~500kg–1000kg)
- **HEO**/SMD–Human Descent Module Lander (5-6000kg)
- **SMD**/HEO–Payloads & Technology/Mobility & Sample Return

**LUNAR ORBITAL PLATFORM—GATEWAY**

- **HEO**/SMD–Power & Propulsion Element/Communication Relay
- **HEO**/SMD–Crew Support of Lunar Missions
- **HEO**/SMD–Lunar Sample Return Support

2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

Timelines are tentative and will be developed further in FY 2019


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

# Enhanced Planetary Defense

- FY19 budget request executes an enhanced Planetary Defense program for near-Earth object detection and mitigation
- This is a significant ramping up of our NEO-related activities!
- *DART*, w/CubeSat/SmallSat, is an innovative way to test deflection capability
  - Joint study with ASI for CubeSat
- Currently studying low-cost space-based near-Earth object detection mission options for future competition

# Planned Accomplishments FY18-19

- First commercial opportunities as part of the Lunar Discovery and Exploration Program in 2019
- Explore options for an affordable space-based NEO search capability
- *InSight* will launch May 2018 and land on Mars November 2018
  - Will peer beneath surface of Mars, providing insight into processes that shaped rocky planets of inner solar system
- *OSIRIS-REx* will arrive at asteroid Bennu August 2018
  - Investigation of asteroid will provide information about early history of Solar System and help scientists develop future missions to mitigate asteroid impacts at Earth
- *New Horizons* will flyby MU69 on January 1, 2019; first ever flyby of a Kuiper Belt object beyond Pluto system
- Next New Frontiers mission (*CAESAR* or *Dragonfly*) will be announced in 2019

# Planetary Science Program Content

| | Actual FY 17 | Enacted FY 18 | Request FY 19 | Notional FY 20 | Notional FY 21 | Notional FY 22 | Notional 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 | | 2,234.7 | 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 | | 381.2 | 476.6 | 375.0 | 355.6 | 348.5 |
| New Frontiers | 134.0 | | 130.2 | 163.7 | 245.0 | 327.6 | 388.4 |
| Mars Exploration | 647.0 | | 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 |

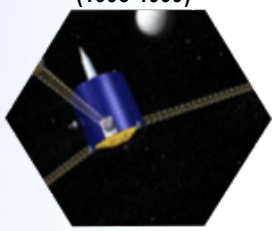
# Discovery Program

# Discovery Program

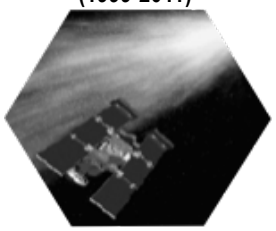
NEO characteristics
NEAR
(1996-1999)

Mars evolution
Mars Pathfinder
(1996-1997)

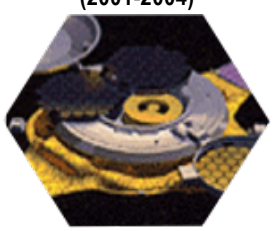
Lunar formation
Lunar Prospector
(1998-1999)



Nature of dust/coma
Stardust
(1999-2011)



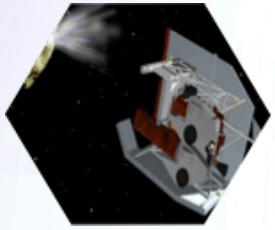
Solar wind sampling
Genesis
(2001-2004)



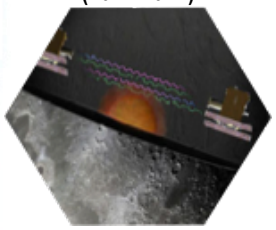
Comet Diversity
CONTOUR
(2002)


Mercury Environment
MESSENGER
(2004-*2015*)

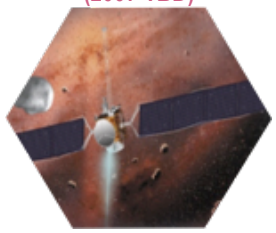
Comet Internal Structure
Deep Impact
(2005-2012)



Lunar Internal Structure
GRAIL
(2011-2012)

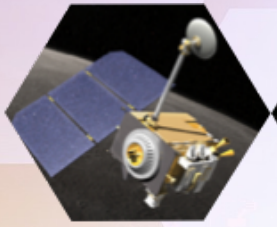


Main-belt Asteroids
Dawn
(2007-*TBD*)

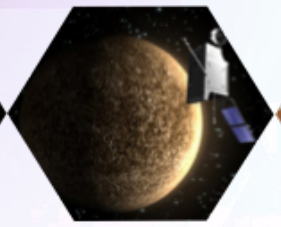


Exoplanets
Kepler
(2009-TBD)

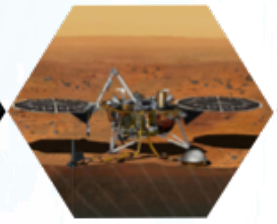
Lunar Surface
LRO
(2009-*TBD*)



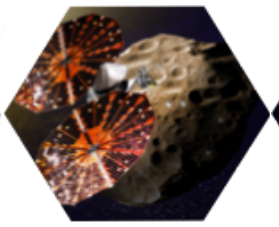
ESA/Mercury Surface
Strofio
(*2017-TBD*)



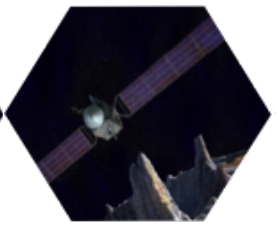
Mars Interior
InSight
(*2018*)



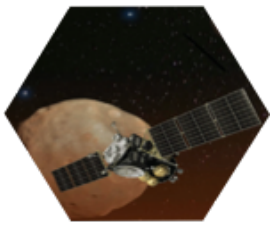
Trojan Asteroids
Lucy
(*2021*)

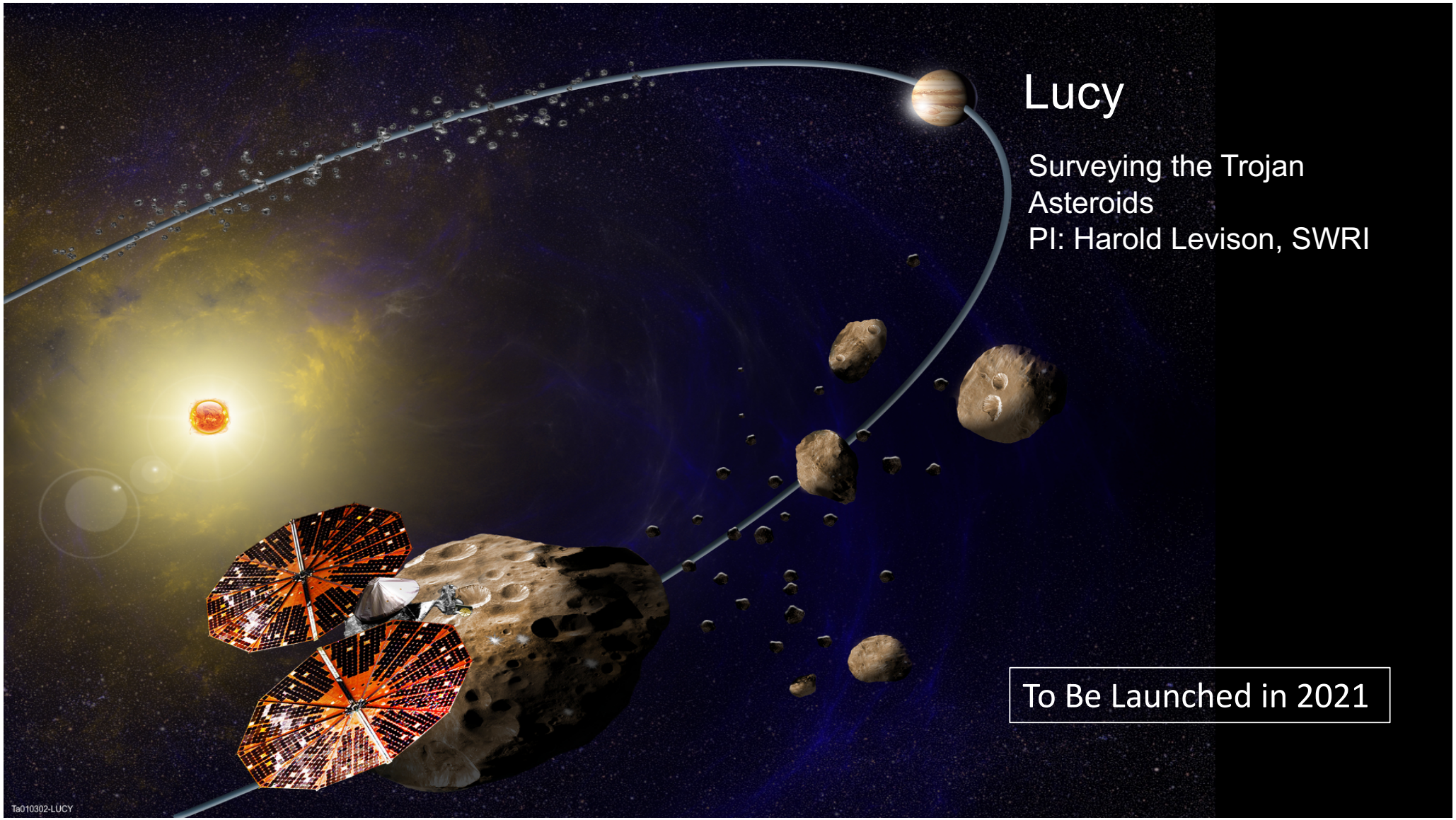


Metal Asteroids
Psyche
(*2022*)



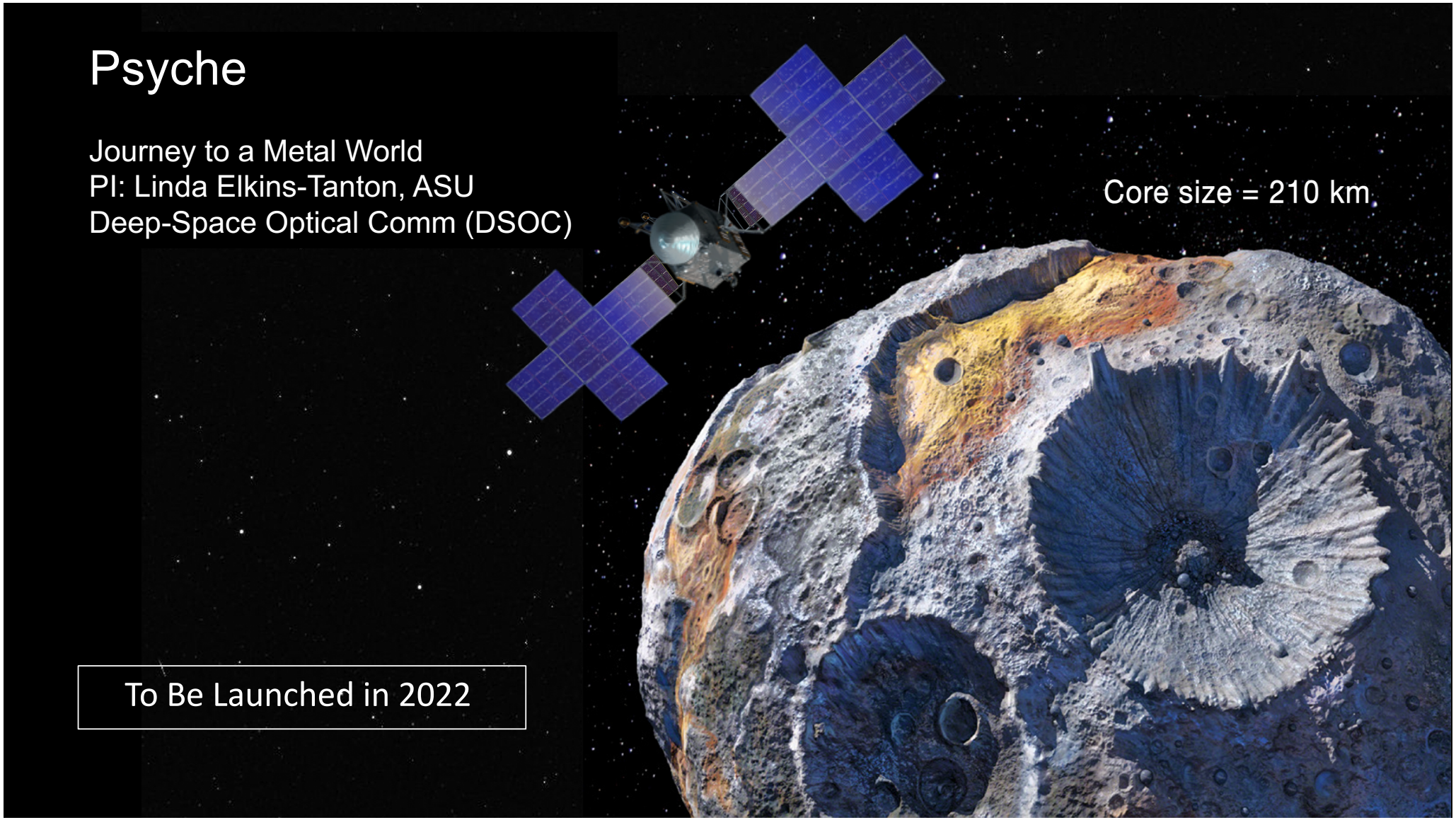
Martian Moons
MMX/MEGANE
(*2024*)




Lucy
Surveying the Trojan Asteroids
PI: Harold Levison, SWRI
To Be Launched in 2021
Ta010302-LUCY

# Psyche

Journey to a Metal World
PI: Linda Elkins-Tanton, ASU
Deep-Space Optical Comm (DSOC)




To Be Launched in 2022

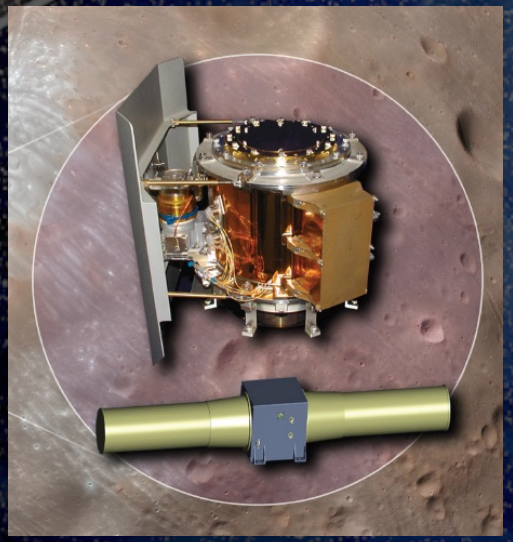
# JAXA Martian Moons eXploration (MMX) Mission

## Neutron & Gamma-Ray Spectrograph

- Solicited by NASA through the SALMON-3 AO
- Selection Announced Nov 16, 2017
  - MEGANE (“eyeglasses”)
  - David Lawrence (JHU APL), PI

To Be Launched in 2024

- Cryocooled high-purity Germanium γ-ray detector (MESSENGER GRS heritage)
- $^{3}$He proportional counter neutron detector (Lunar Prospector heritage)



# Discovery Long-Range Planning

- Cost Cap $495M Phase A-D (FY19) excluding LV
- May not propose the use of radio-isotope power systems (RPS) – *under study*
- 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

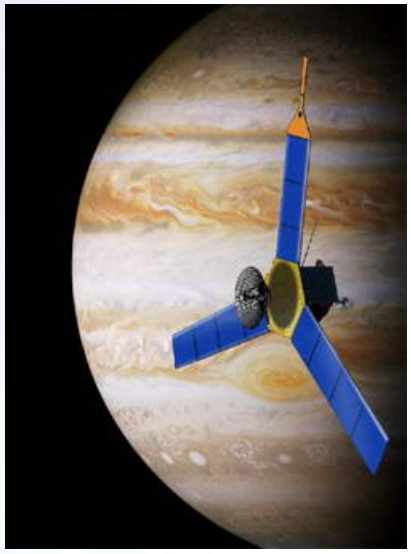
# New Frontiers Program

# New Frontiers Program

1st NF mission
**New Horizons**
Pluto-Kuiper Belt

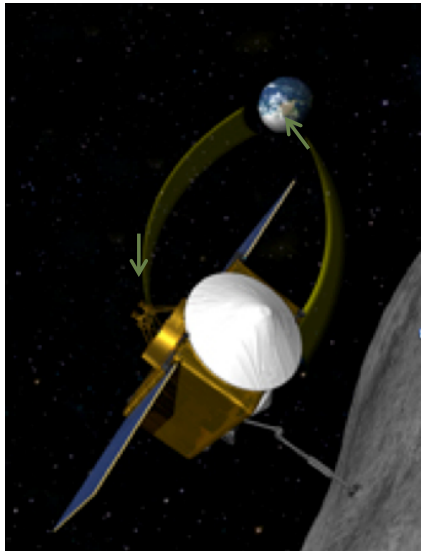
Launched January 2006
Flyby July 14, 2015
PI: Alan Stern (SwRI-CO)

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*

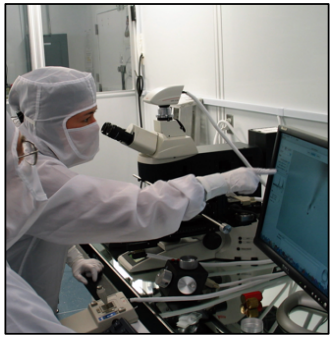
Down selection for Flight (target)..... July 2019

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.



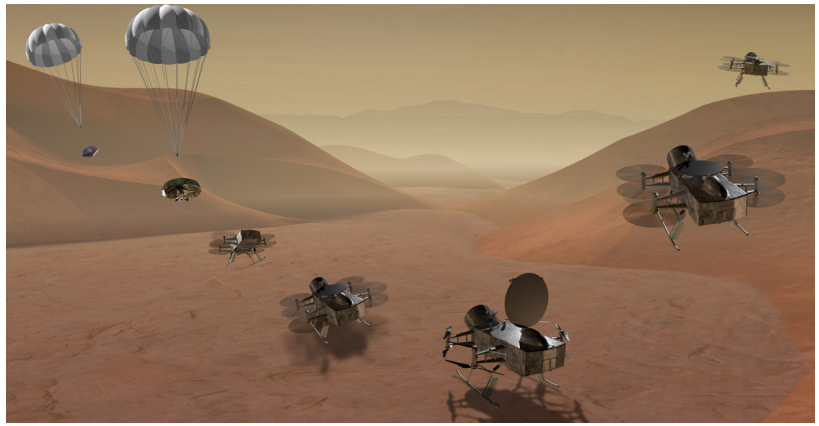
# A rotorcraft to explore prebiotic chemistry and habitability on the ocean world Titan

- 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***

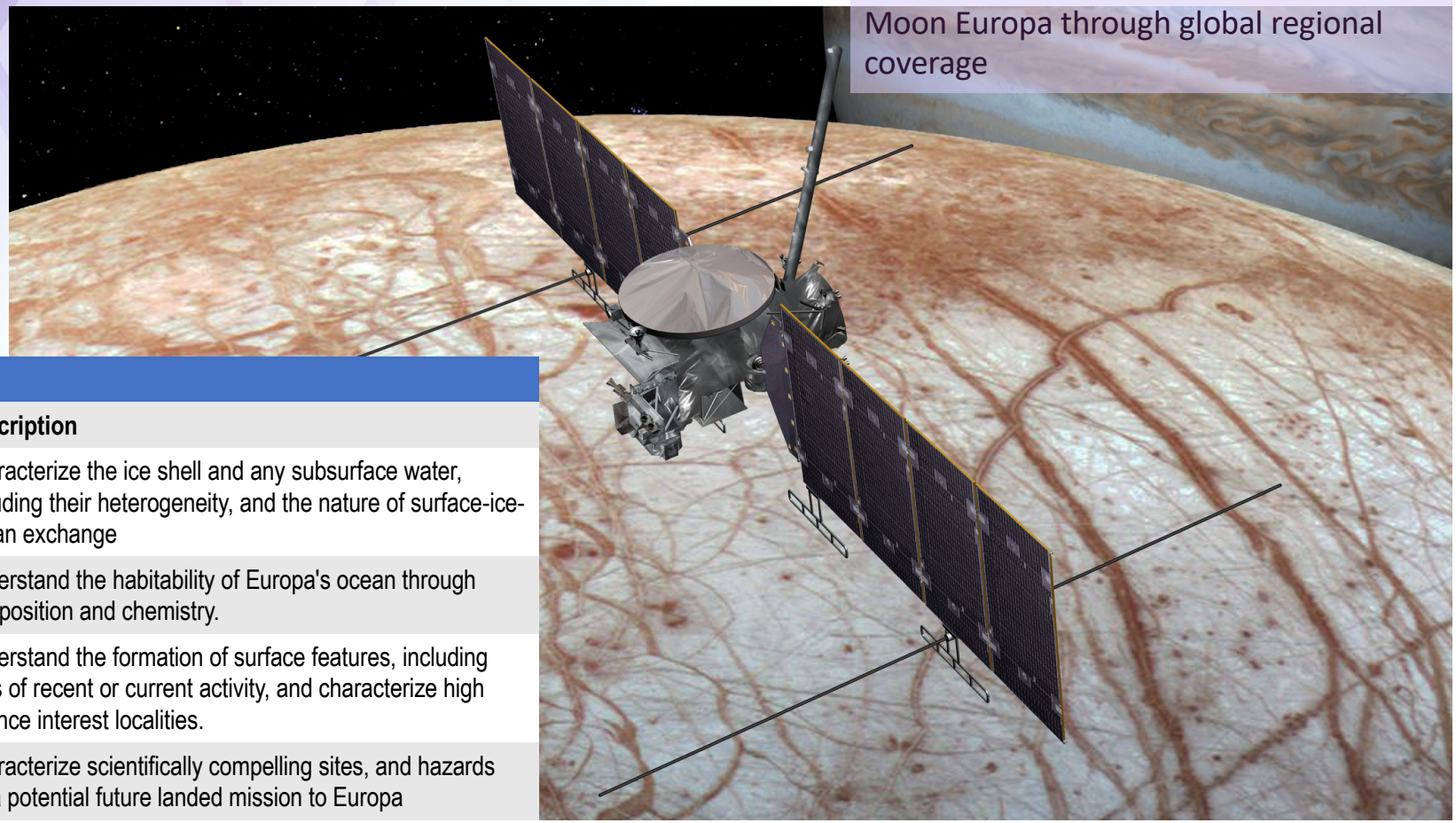


PI: Dr. Elizabeth Turtle at APL
Dragonfly would arrive at Titan in 2034 and explore for over 2 years, performing detailed chemical analyses, measuring the atmosphere and seismic activity, and imaging the surface.

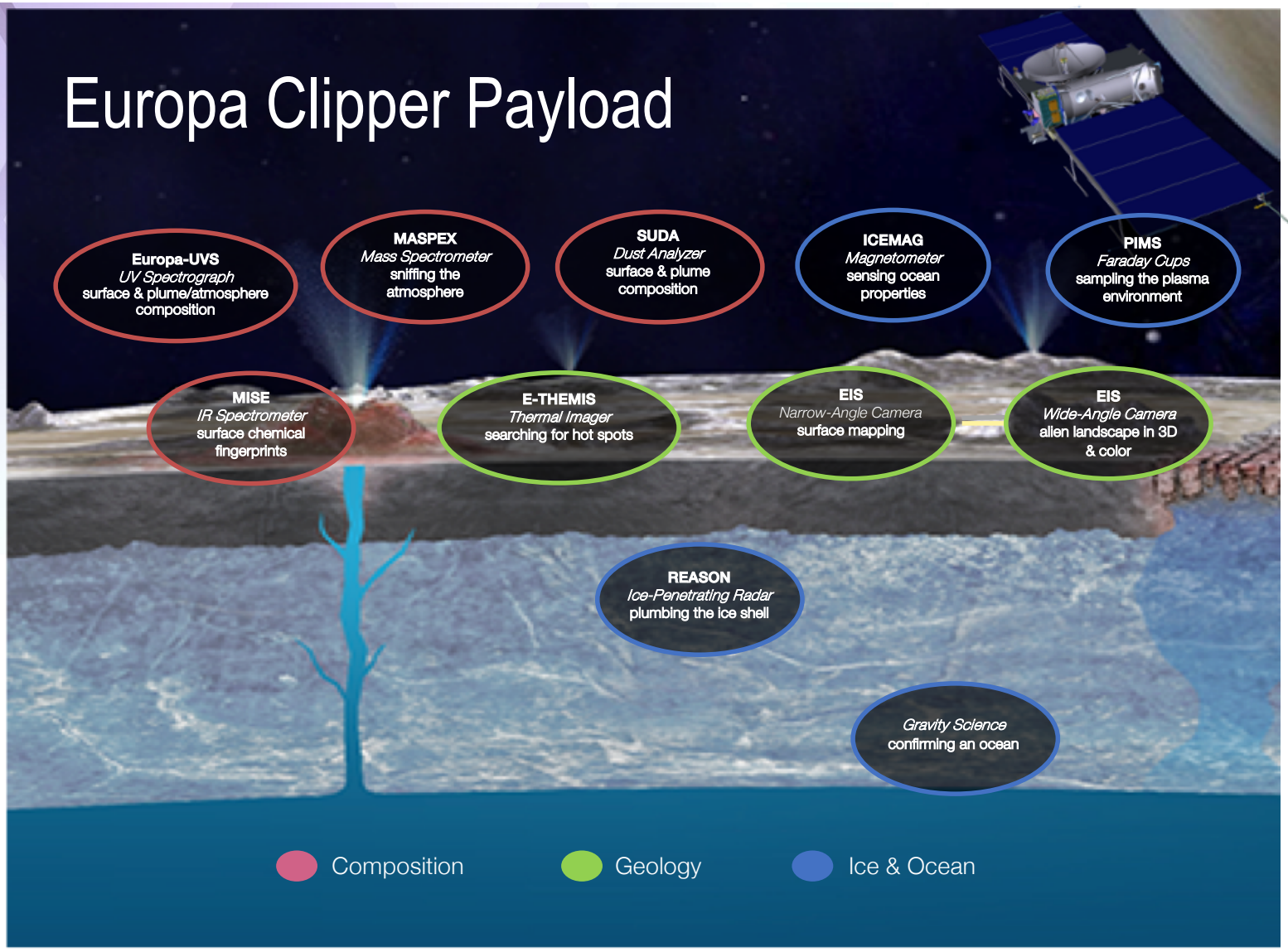
# Oceans Worlds

# 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



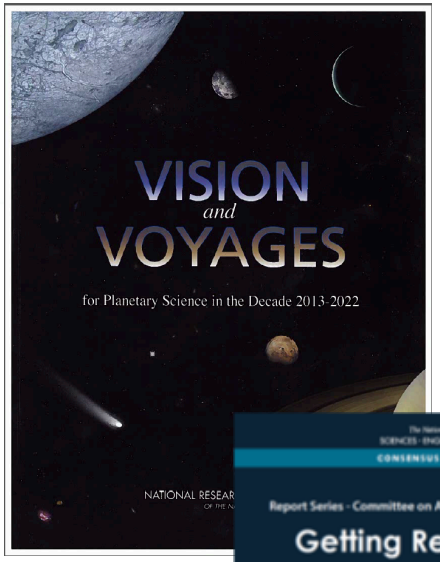
| Science | |
|---|---|
| **Objective** | **Description** |
| Ice Shell & Ocean | Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange |
| Composition | Understand the habitability of Europa's ocean through composition and chemistry.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

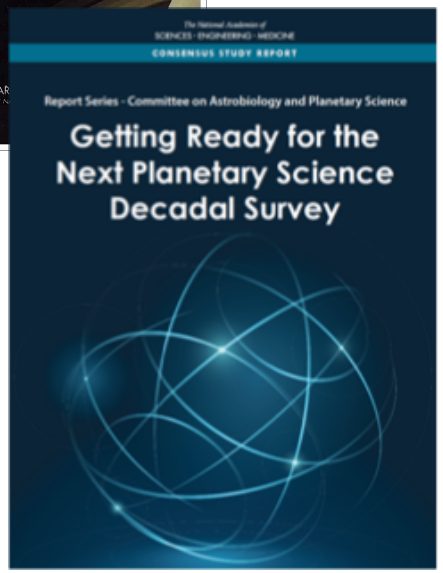

Europa Clipper Payload
Europa-UVS
UV Spectrograph
surface & plume/atmosphere composition
MASPEX
Mass Spectrometer
sniffing the atmosphere
SUDA
Dust Analyzer
surface & plume composition
ICEMAG
Magnetometer
sensing ocean properties
PIMS
Faraday Cups
sampling the plasma environment
MISE
IR Spectrometer
surface chemical fingerprints
E-THEMIS
Thermal Imager
searching for hot spots
EIS
Narrow-Angle Camera
surface mapping
EIS
Wide-Angle Camera
alien landscape in 3D & color
REASON
Ice-Penetrating Radar
plumbing the ice shell
Gravity Science
confirming an ocean
Composition
Geology
Ice & Ocean

# 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 ~March 2018
- NEW: 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



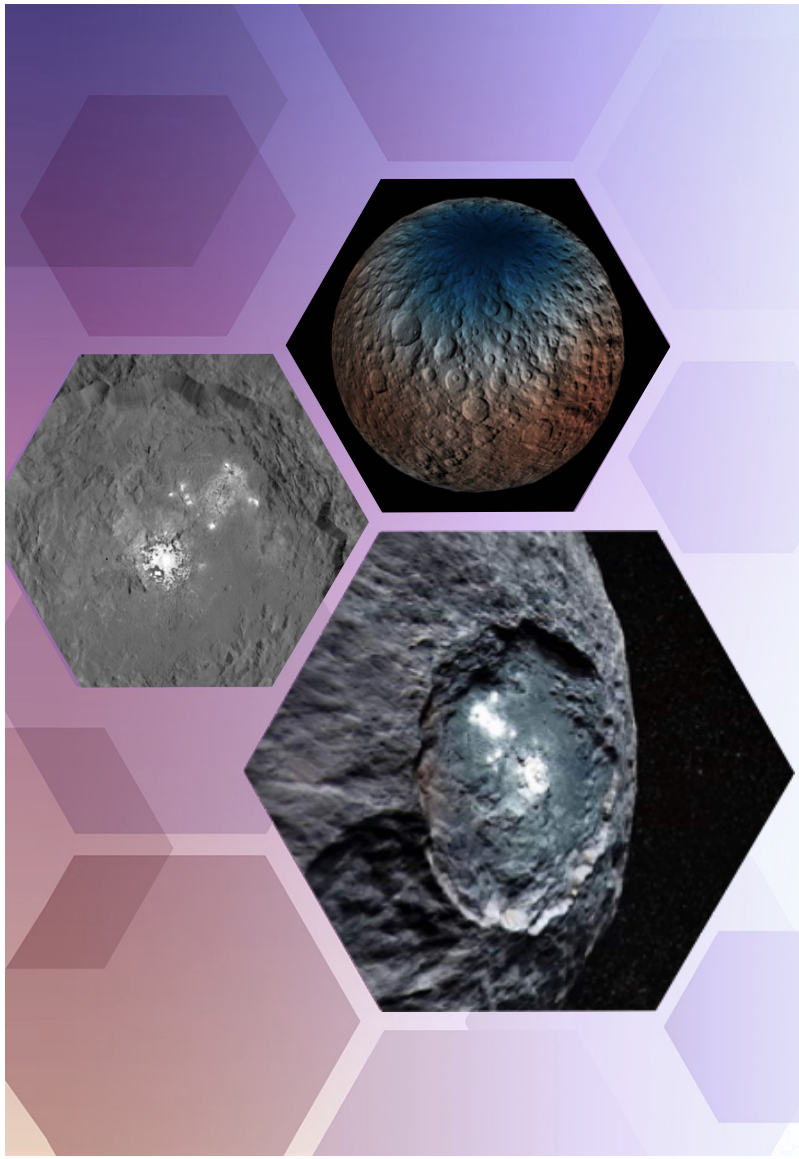



# Mission Studies Completed Thus Far

- 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

# PSD CubeSats/SmallSats

# Planetary Science Deep Space SmallSat Studies: Awards

| | |
|---|---|
| **Venus** | CUVE - CubeSat UV Experiment |
| | Seismicity Investigation on Venus Using Airglow Measurements |
| | Seismic and Atmospheric Exploration of Venus (SAEVe) |
| | Cupid's Arrow |
| **Moon** | Innovative Strategies for Lunar Surface Exploration |
| | Lunar Water Assessment, Transportation, and Resource Mission |
| | Mini Lunar Volatiles (MiLUV) Mission |
| | CubeSat X-ray Telescope (CubeX) (also applicable to NEOs and Phobos/Deimos) |
| | Bi-sat Observations of the Lunar Atmosphere above Swirls (BOLAS) |
| **Small Bodies** | CAESAR: CubeSat Asteroid Encounters for Science & Reconnaissance |
| | Primitive Object Volatile Explorer (PrOVE) |
| | APEX: Asteroid Probe Experiment |
| **Mars** | Aeolus - to study the thermal and wind environment of Mars |
| | PRISM: Phobos Regolith Ion Sample Mission |
| | Mars Ion and Sputtering Escape Network (MISEN) |
| | Chariot to the Moons of Mars |
| | Mars Aerosol Tracker (MAT) |
| **Icy Bodies & Outer Planets** | SNAP: Small Next-generation Atmospheric Probe |
| | JUpiter MagnetosPheric boundary ExploreR (JUMPER) |


#smallsats2018

# Planetary Science Deep Space SmallSat Mission Concepts

**Sunday, March 18, 2018**
**The Woodlands, Texas**
**The Woodlands Waterway Marriott Hotel and Convention Center**

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## Call for poster abstracts is OPEN!

**Abstracts for inclusion in the Planetary Science Deep Space SmallSat Mission Concepts topic at LPSC are now being accepted. Abstracts may be submitted via the LPSC abstract submission process to the topic "SmallSat Mission Studies".**

NASA's Planetary Science Division is considering including small secondary payloads on future launch opportunities. To help identify high-priority science objectives that could be addressed with small satellites, nineteen studies were funded to develop mission concepts. A brief overview of each of these nineteen studies will be presented at the upcoming Planetary Science Deep Space SmallSat Studies meeting on March 18, 2018. In addition, workshop participants are encouraged to submit LPSC abstracts to the poster topic described above.

Additional details are now available on the meeting website.

**https://www.hou.usra.edu/meetings/smallsat2018/**

# Small Innovative Missions for Planetary Exploration (SIMPLEx)

# SIMPLEx-2 : Overview

- Solicits formulation and development of science investigations that require a spaceflight mission that can be accomplished using small spacecraft
  - ESPA-Class or smaller (< 180Kg)
  - Solicitation for secondary payload on specific primary missions, which will determine:
    - Launch readiness date
    - Initial release trajectory
  - Cost-capped missions
  - Funding Available $15-$55 Million
  - Continuously Open call with mission-specific deadlines
  - Foreign Participation will be allowed

# SIMPLEx-2 : AO

- **SALMON3 – PEA:** Third Stand Alone Missions of Opportunity Notice (SALMON-3) Program Element Appendix (PEA)
- **Small Complete Missions (SCM):** Investigation that can be realized within the PEA-specific Cost Cap.
  - The term “complete” encompasses all appropriate mission phases Phase A - E, including data analysis and publication, delivery of the data to an appropriate NASA data archive, and closeout

Draft Open Call for proposals : Released January 30th, 2018

Comments Due by : March 14th, 2018

# SIMPLEx-2 : Schedule

- Launch minus four years (L-4): Cut-off consideration for a specific mission
  - Select and award ~1 year Phase A/B design studies; expected product is PDR-level design
  - Launch Vehicle is unknown
- L-3 years: Down-select secondary mission(s) for specific primary mission
  - May be possible to select multiple secondaries for a given primary mission
  - Selections coordinated with launch vehicle selection
  - Provided for Phase C design/build:
    - More detailed launch vehicle trajectory, environments and interfaces
- L-2 years: Build/test secondary payload
- L-1 years: Build/test/integrate secondary payload
- L-3 months: Integrate secondary payload into the launch vehicle (nominal date)
- L: launch

# Questions?

# SIMPLEx-2 : Flight Opportunities

| Primary Mission | SIMPLEx Proposal Cut-off Date | Payload Integration /Launch Readiness Dates | Launch Site | Primary Payload Destination | Launch Orbit | Spacecraft Orbit at Separation | | | | | | Allowed Elements | | | | | Potential Launch Vehicles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Launch Flight Azimuth [degrees] | Characteristic Energy (C3) [km2/s2] | Hyperbolic Escape Velocity [km/s] | Separation Altitude [km] | Right Ascension of the Launch Asymptote (RLA) | Declination of the Launch Asymptote (DLA) | CubeSat Deployer | ESPA Ring | ESPA Grande | Propulsive ESPA ring | Radioactive elements | |
| **LEO or GTO** | On-going | On-going | Varies | N/A | LEO or GTO | Varies | | | | | | Y | Y | Y | Y | N | |
| **Lucy** | 1 July 2018 | August 2021 / 16 October 2021 | Cape Canaveral Air Force Station | Jupiter L4 and L5 Trojan Swarms | Helio-centric Escape | 86.68 | 45.91 | 5.34 | 1641 | 16.94 | 8.46 | Y | Y | N | N | N | Atlas V, Falcon 9, Antares, … |
| **Psyche** | 1 July 2018 | June 2022 / August 2022 | Cape Canaveral Air Force Station | (16) Psyche | Elliptic Helio-centric | TBD | 14.53 | 3.81 | TBD | 72.96 | 1.78 | Y | Y | N | N | N | Atlas V, Falcon 9, Antares, … |
| **IMAP*** | TBA | TBD | TBD | TBD | TBD | TBD | TBD | TBD | TBD | TBD | TBD | N | Y | N | N | N | |
| **EM-x** | TBA | TBD | Kennedy Space Center | Lunar Orbit | TBD | TBD | TBD | TBD | TBD | TBD | TBD | Y | N | N | N | N | SLS |

# 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 |