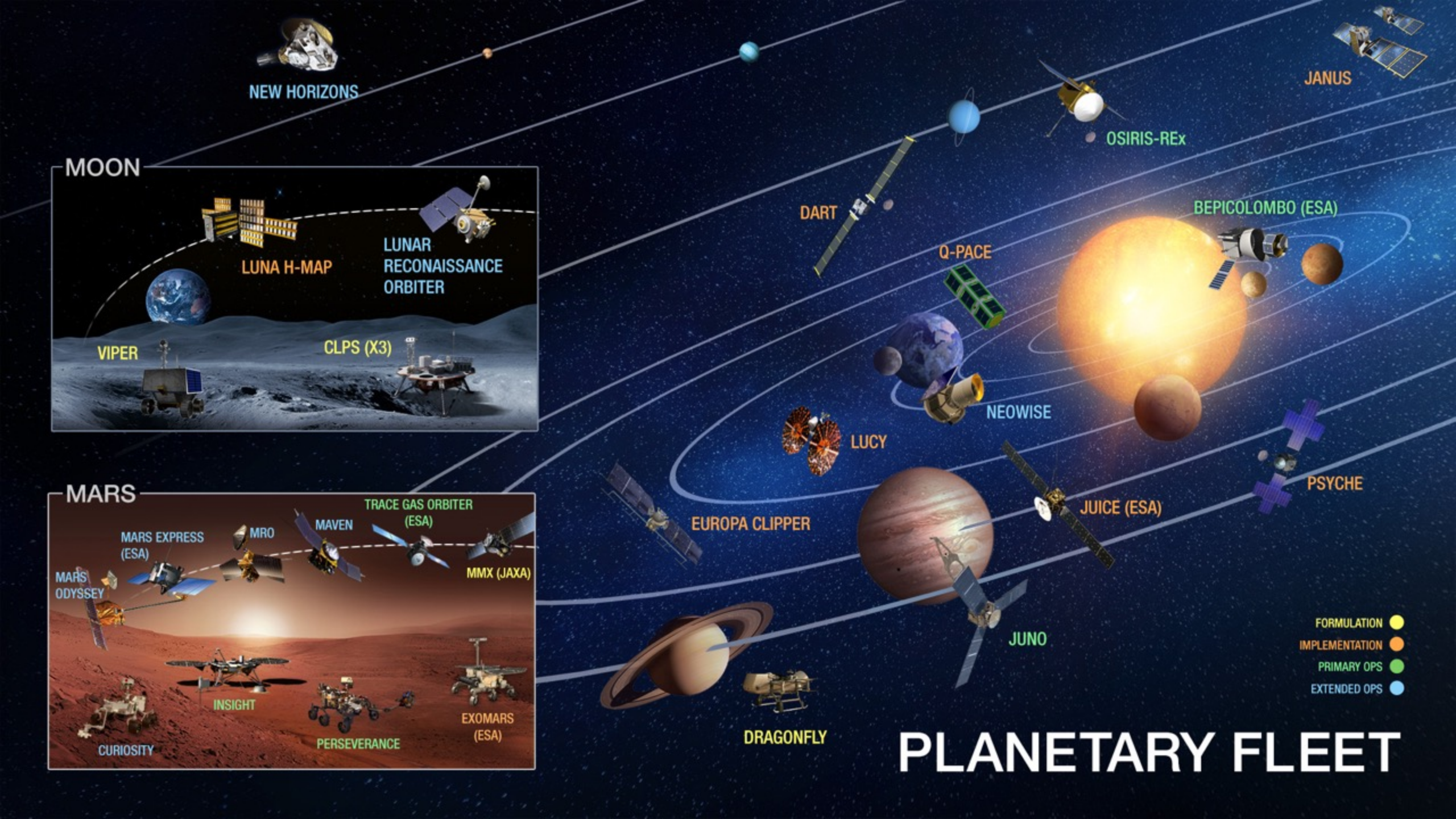
Lori S. Glaze, Ph.D.
NASA Planetary Science Division Director

2023–2032 Planetary Science and Astrobiology Decadal Survey
Small Bodies Panel
November 13, 2020


NEW HORIZONS
JANUS
OSIRIS-REx
MOON
LUNA H-MAP
LUNAR RECONAISSANCE ORBITER
VIPER
CLPS (X3)
DART
Q-PACE
BEPICOLOMBO (ESA)
NEOWISE
LUCY
EUROPA CLIPPER
JUICE (ESA)
PSYCHE
MARS
TRACE GAS ORBITER (ESA)
MAVEN
MRO
MARS EXPRESS (ESA)
MARS ODYSSEY
MMX (JAXA)
INSIGHT
CURIOSITY
PERSEVERANCE
EXOMARS (ESA)
JUNO
DRAGONFLY
FORMULATION
IMPLEMENTATION
PRIMARY OPS
EXTENDED OPS
PLANETARY FLEET

Lunar Discovery and Exploration

Artemis and PSD

- Initial Commercial Lunar Payload Service (CLPS) flights will study the lunar surface and resources at the lunar poles, starting from 2021
- **VIPER**: Golf-cart-sized rover will investigate volatiles in lunar polar soil
  - Astrobotic CLPS delivery by end of 2023
- **Artemis III** (2024): Crew will travel to the Moon and use Human Landing System to touch down on the lunar surface
  - Science Definition Team (chaired by Renee Weber, MSFC, and HLS Science Lead) will define detailed science objectives
- Working with ESSIO on many lunar projects, e.g., ANGSA, instrument and technology development, international collaborations

Mars Program

Mars Sample Return

- New Mars Sample Return (MSR) Program, Director: Jeff Gramling
- Michael Meyer is serving as Lead/Chief Scientist for MEP and MSR
- NASA/ESA MOU signed on October 5th
- Findings of SMD-commissioned Independent Review for MSR released November 10
- Working towards two launches in 2026 (NASA lander and ESA orbiter) – on track to enter Phase A this fall
- NASA/ESA MSR Sample Planning Group – Phase 2 will address science and curation planning questions
- Perseverance/MSR Caching Strategy Workshop is being planned for January 2021

Outer Planets and Ocean Worlds

Europa Clipper

Above: Upper cylinder of propulsion module
Top right: Thermal radiator flight unit

Project Schedule: Final instrument CDR was in June, Project & Flight System CDR will be December 2020

Launch Date: Team working to launch readiness in 2024

Instrument Cost Control: Steps taken to control cost growth on EIS and MASPEX, including changes to Level 1 requirements

Gravity/Radio Science Team: Competitively selected a team of seven, led by Erwan Mazarico (GSFC), to join the Clipper science team

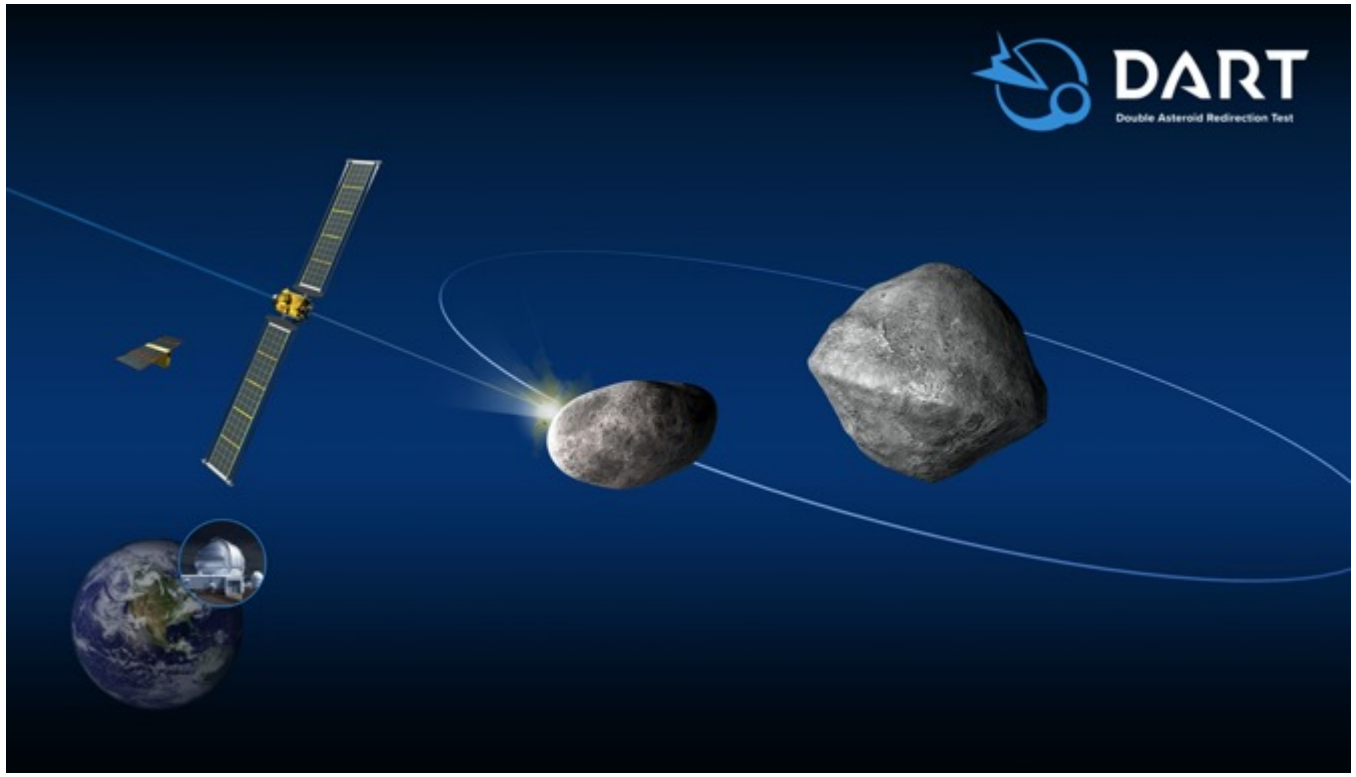
Launch Vehicle: LV uncertainty remains a concern; Congress directs use of SLS, but availability before 2025 is not clear

Instrument & Flight System Hardware: Now being built!

Planetary Defense

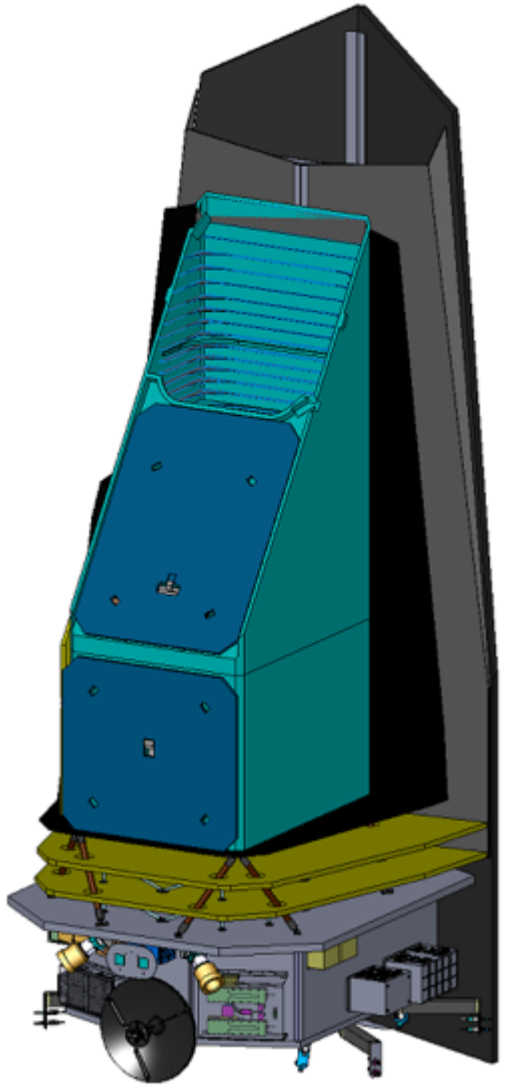
Double Asteroid Redirection Test (DART)

- First mission to demonstrate asteroid deflection technique; first mission from NASA's Planetary Defense Coordination Office
- Kinetic impact will change the motion of asteroid Dimorphos (moon of 65803 Didymos)
- Binary target allows measurement of deflection by ground-based observations
- Dimorphos, will be only 0.07 AU from Earth at impact in October 2022
- ATLO has started; spacecraft core structure is at APL after COVID-19-related shipping delay
- LICIACube manufacturing, integration, and test has started; on track for delivery March 2021
- Mission is on track for July 2021 launch aboard a SpaceX Falcon 9



NEO Surveyor

- Designed to meet George E Brown NEO Survey Goal
- Objectives:
  - Find 65% of undiscovered Potentially Hazardous Asteroids (PHAs) >140 m in 5 years (goal: 90% in 10 years)
  - Estimate sizes directly from infrared (IR) signatures
  - Compute cumulative chance of impact over next century for PHAs >50 m and comets
  - Deliver new tracklet data daily to the Minor Planet Center
- KDP-B targeted in Fall 2020



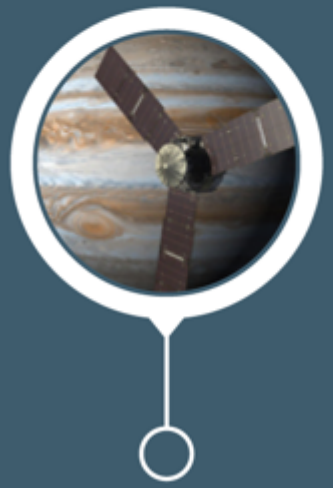
New Frontiers

NEW FRONTIERS MISSIONS

2006–Present

NEW HORIZONS

Pluto-Kuiper Belt



2011–Present

JUNO

Jupiter polar orbiter

2016–Present

OSIRIS-REx

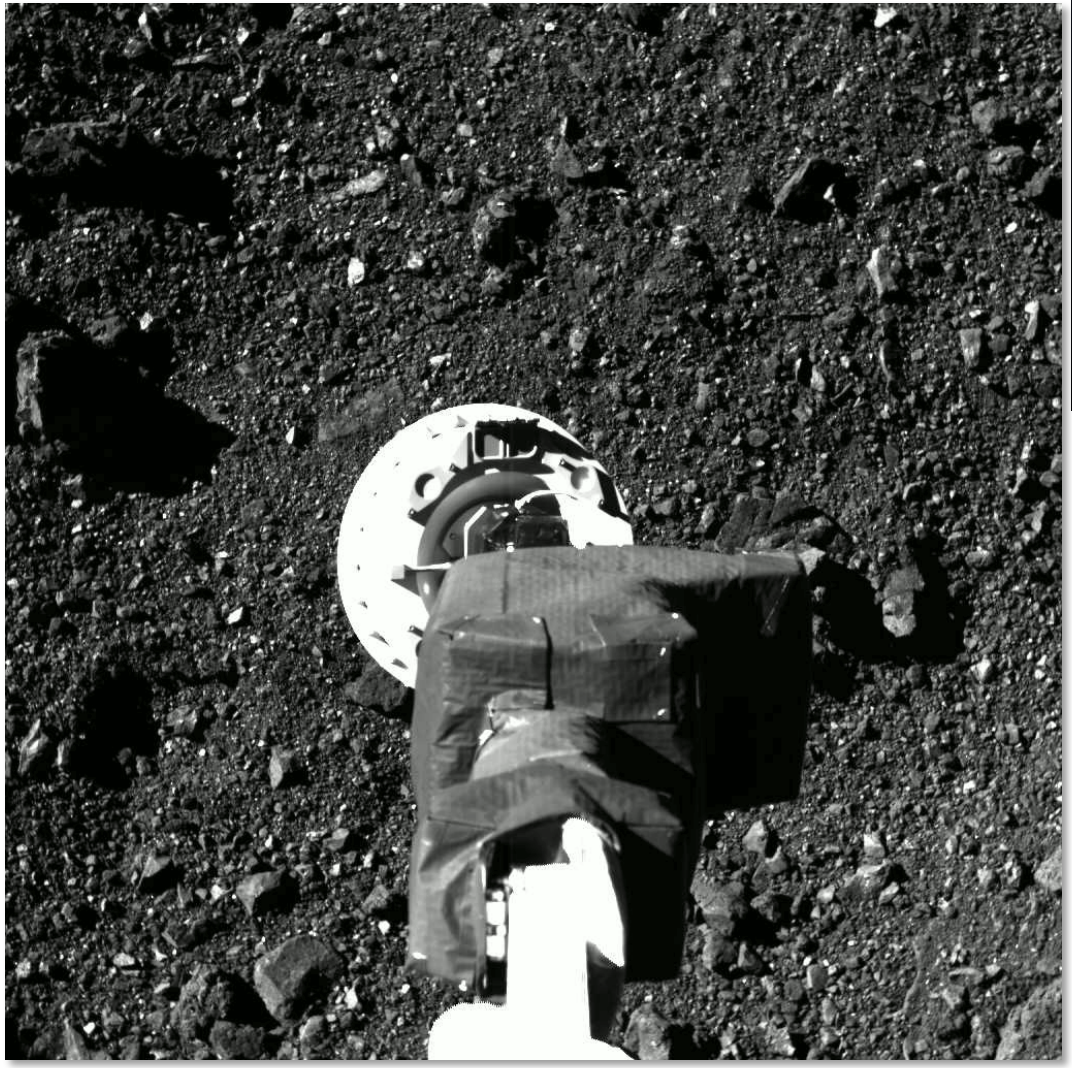
Asteroid
sample return

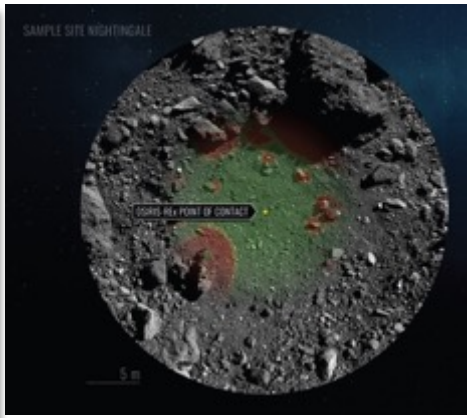
2027–

DRAGONFLY

Titan drone

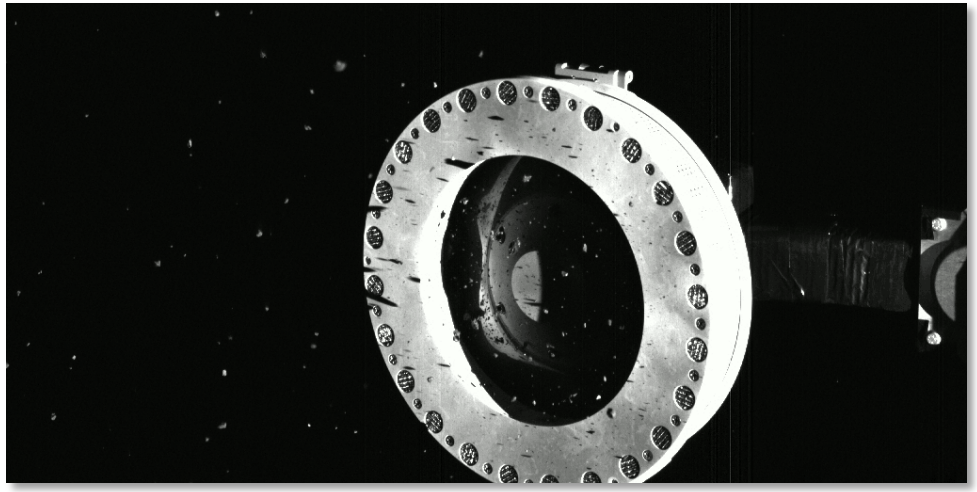
OSIRIS-REx

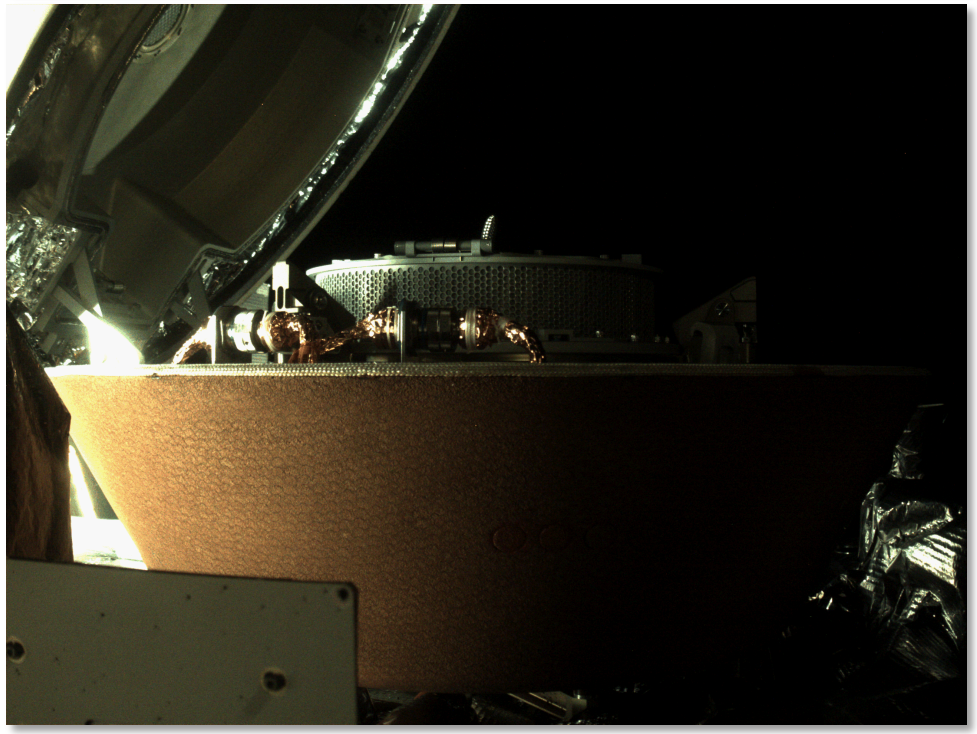




Touch-and-Go ('TAG') at Nightingale Crater Oct 20

Touch-and-Go Sample Acquisition Mechanism (TAGSAM) Oct 22





Sample stowed in Sample Return Capsule Oct 28

New Frontiers Target List Evolution

Recommended Target	Report	NF2	NF3	NF4	NF5 ?	Selected mission
Kuiper Belt-Pluto Explorer	NF					**New Horizons** (NF1)
Jupiter Polar Orbiter	NF	X				**Juno** (NF2)
Lunar South Pole-Aitken Basin Sample Return	NF, NOSSE, V&V	X	X	X	X*	
Venus In Situ Explorer	NF, NOSSE, V&V	X	X	X	X	
Comet Surface Sample Return	NF, NOSSE, V&V	X	X	X	X	
Network Science	NOSSE		X			
Trojan/Centaur Reconnaissance	NOSSE, V&V		X	X		**Lucy** (Discovery)
Asteroid Rover/Sample Return	NOSSE		X			**OSIRIS-REx** (NF3)
Io Observer	NOSSE, V&V		X		X**	
Ganymede Observer	NOSSE		X			
Ocean Worlds (Titan/Enceladus)				X	X***	**Dragonfly** (NF4)
Saturn Probe	V&V			X	X	
Lunar Geophysical Network	V&V				X	

NF: New Frontiers in the Solar System (Decadal Survey 1)
NOSSE: New Opportunities in Solar System Exploration
V&V: Vision and Voyages (Decadal Survey 2)

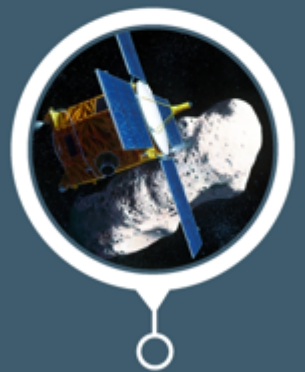
*Pending Artemis landing site selections and science objectives

**Pending Discovery selections

***Only Enceladus

Discovery

DISCOVERY MISSIONS



1996–1999

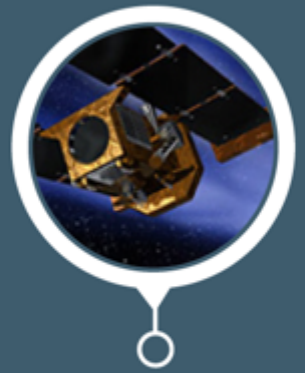
NEAR SHOEMAKER
Near Earth asteroid rendezvous

1996–1997

MARS PATHFINDER
Mars rover

1998–1999

LUNAR PROSPECTOR
Moon orbiter

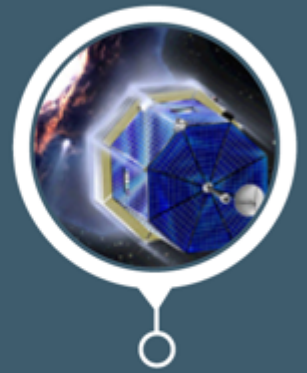


1999–2011

STARDUST
Cosmic dust collector

2001–2004

GENESIS
Solar wind collector



Lost 2002

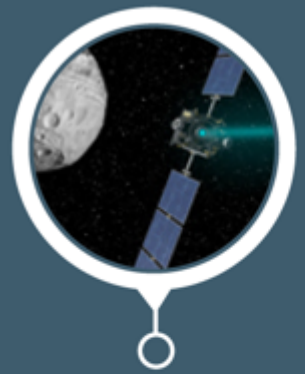
CONTOUR
Comet nucleus tour

2004–2015

MESSENGER
Mercury orbiter

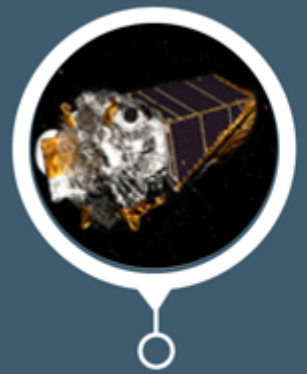
2005–2012

DEEP IMPACT
Comet impactor



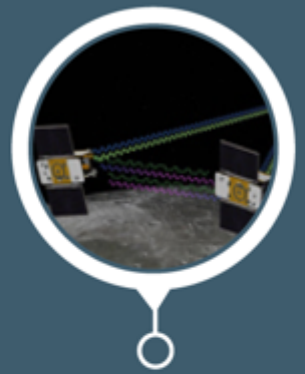
2007–2018

DAWN
Vesta and Ceres orbiter



2009–2018

KEPLER
Exoplanet observatory



2011–2012

GRAIL
Gravitational mapping of the Moon

2018–Present

INSIGHT
Mars interior exploration

2021–

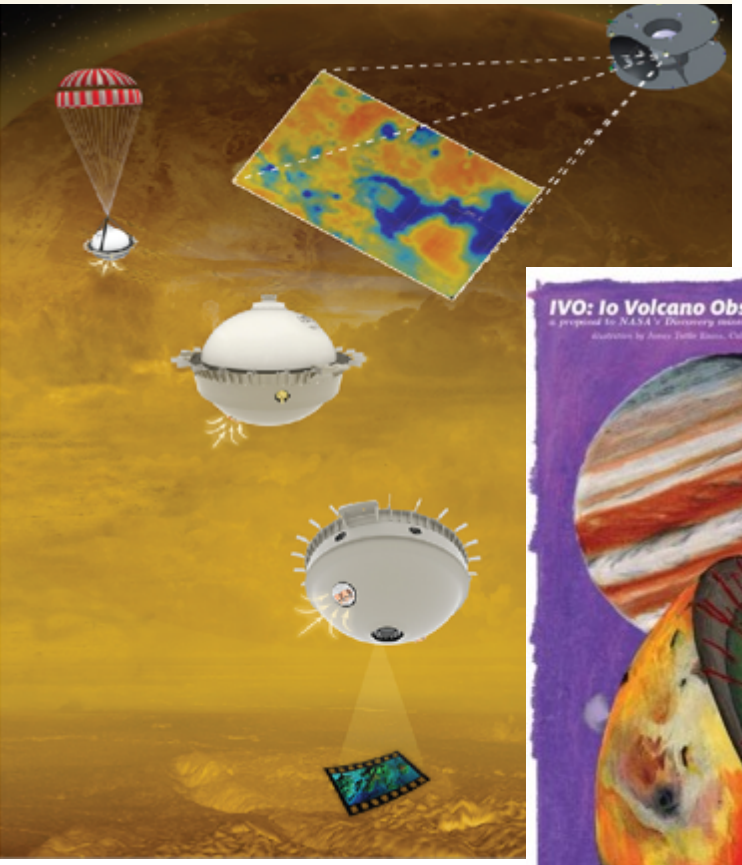
LUCY
Trojan asteroid tour

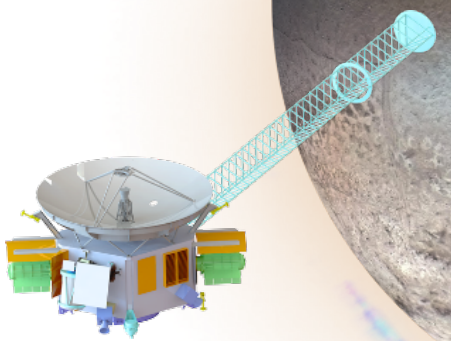
2022–

PSYCHE
Metallic asteroid orbiter

Four Discovery Concepts in Phase A

DAVINCI+
Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging Plus

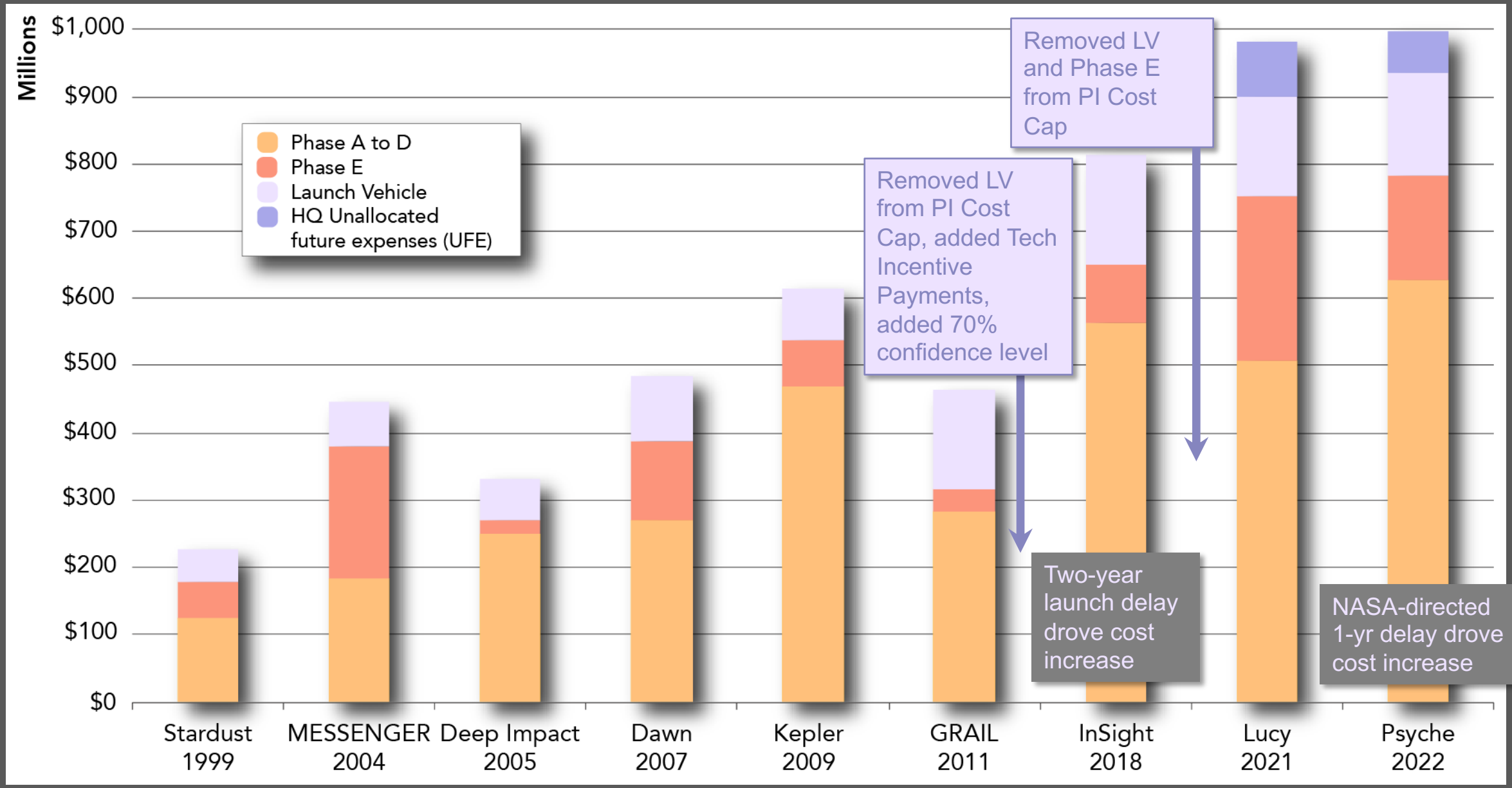




TRIDENT
MISSION TO AN EXOTIC ACTIVE WORLD

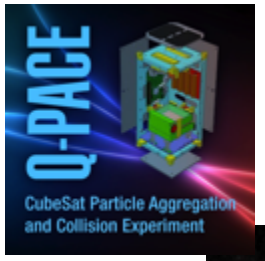
Selections planned NET April 2021

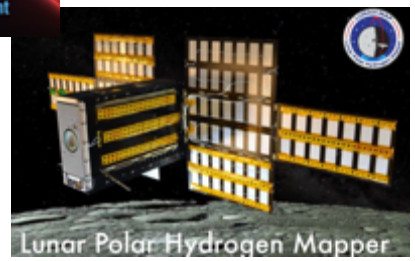
Discovery Cost Growth* from Strategic Decisions (RY$)

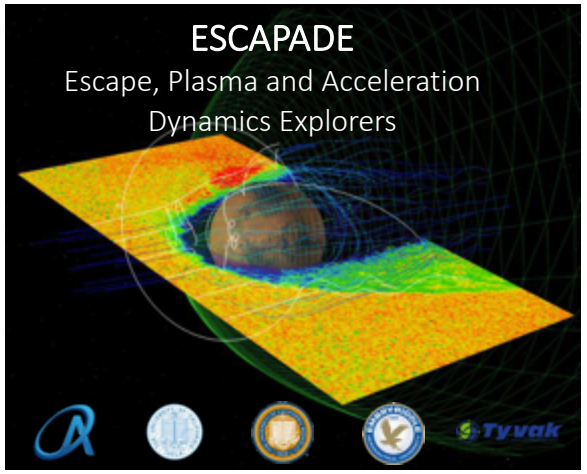


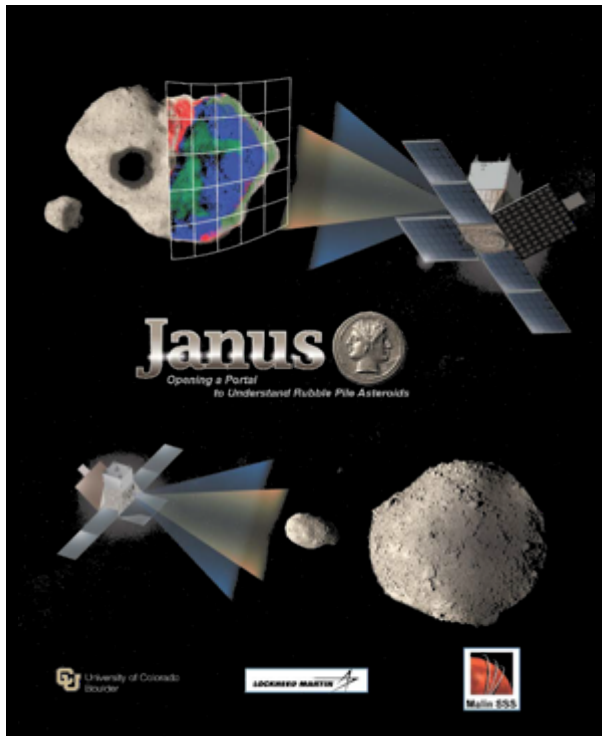
*Cost data from CADRE

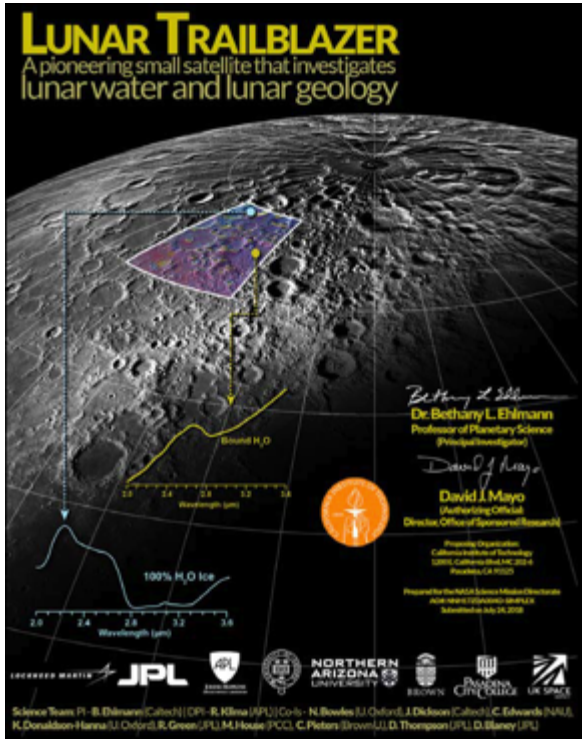
Small Innovative Missions for Planetary Exploration (SIMPLEx)











SIMPLEx

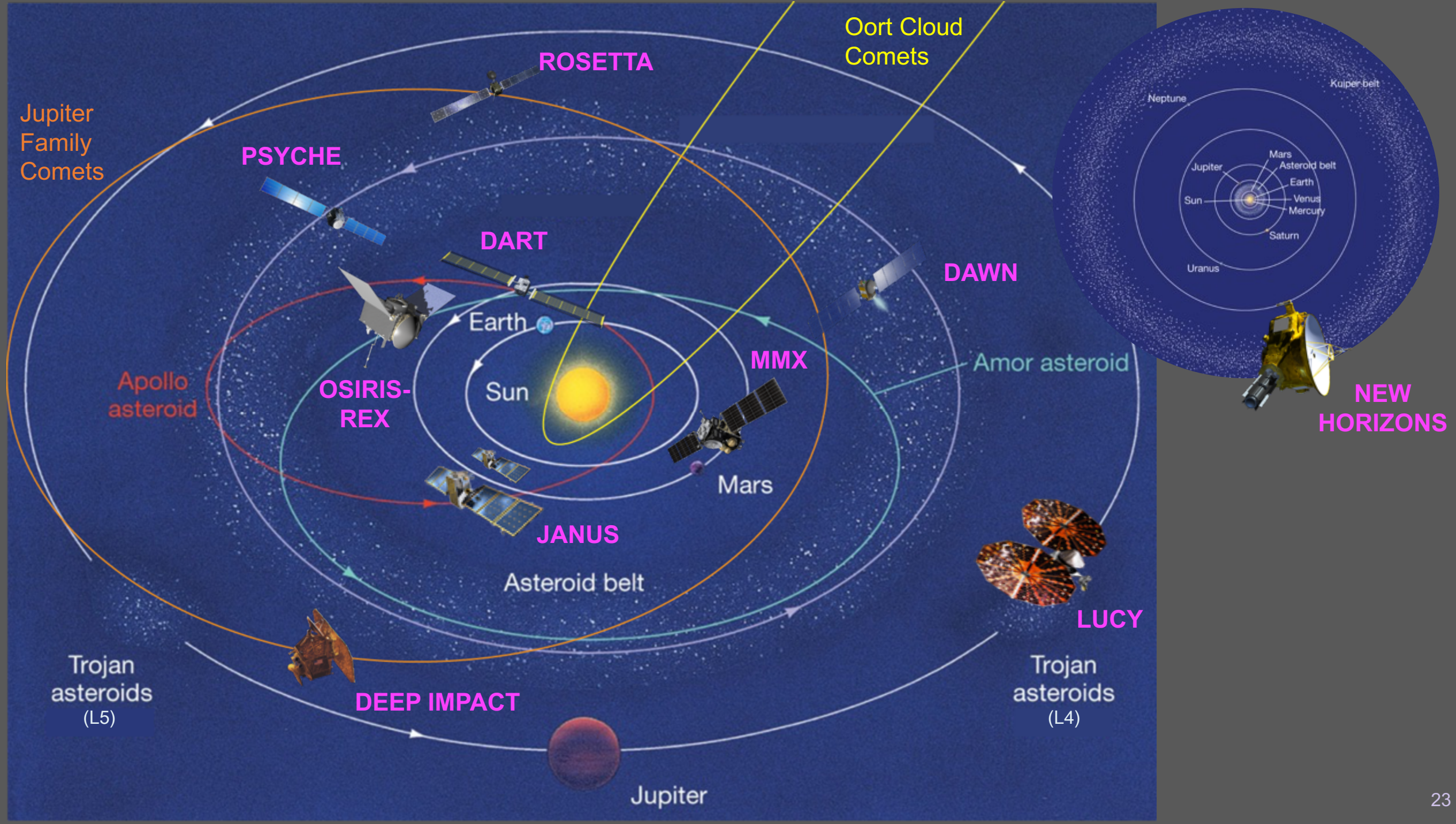
SIMPLEx-1:

- Solicited as an appendix in ROSES-2014
- Low budget/very-low-cost missions
- Two missions selected in 2015: **Q-PACE** (due for November 2020 launch on Virgin Orbit's LauncherOne) and **LunaH-Map** (will launch on Artemis I, NLT November 2021)
- Lessons learned: larger cost cap and need to run as an AO

SIMPLEx-2:

- Solicited as an appendix in SALMON-3 AO
  - Required significant science goals
- PI-managed mission cost cap (all mission phases): $15–55 million
- Three missions selected in 2019:
  - **Janus** (Psyche rideshare)
  - **EscaPADE** (TBD Rideshare)
  - **Lunar Trailblazer** (IMAP rideshare)

Small Body Populations


Oort Cloud
Comets
ROSETTA
Jupiter
Family
Comets
PSYCHE
DART
DAWN
Earth
MMX
Amor asteroid
Apollo
asteroid
OSIRIS-
REX
Sun
Mars
JANUS
Asteroid belt
LUCY
Trojan
asteroids
(L5)
DEEP IMPACT
Trojan
asteroids
(L4)
Jupiter
Kuiper belt
Neptune
Mars
Asterold belt
Jupiter
Earth
Sun
Venus
Mercury
Saturn
Uranus
NEW
HORIZONS

What's next?