
National Aeronautics and
Space Administration
NASA
EXPLORE SCIENCE
LORI S. GLAZE, Ph.D.
Planetary Science Division Director
PAC Meeting
March 9, 2020

FY21 Budget Agency Highlights

- One of the strongest budgets in NASA's history, investing more than $25 billion dollars for America's future in space; funding proposed represents an increase of about 12% over last year's request
- Keeps the agency on track to land the first woman and the next man on the Moon by 2024, and with the support of the Gateway, helps prepare for human exploration of Mars
- Budget supports decadal priorities such a Mars Sample Return mission, Europa Clipper, and development of new Earth observation missions

FY21 Budget Strategy

Support Artemis

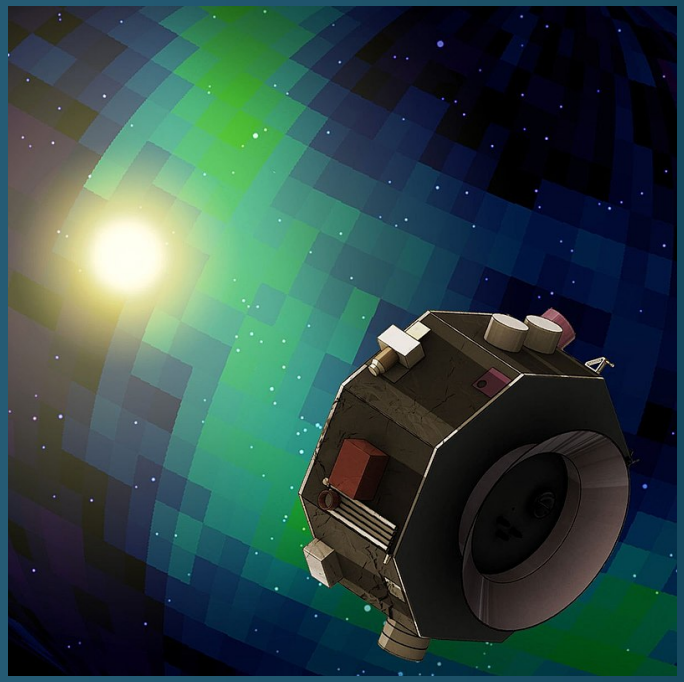
Implement a Balanced and Integrated Science Program

Advance Compelling Science Program with Highest National Priorities

Execute Innovative Partnerships

Support Artemis

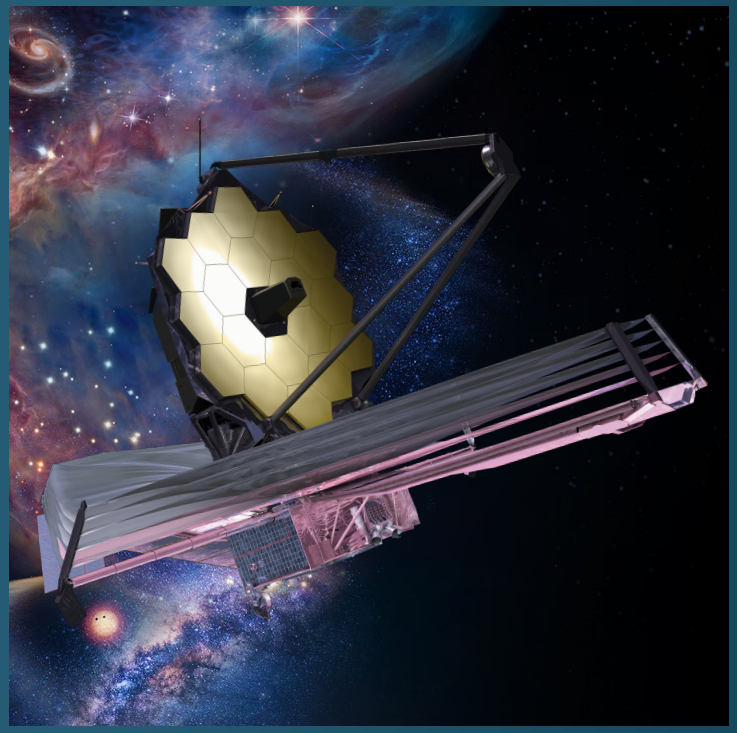
- Support the Artemis program with enhanced lunar science and technology demos, and a strengthened collaboration between science and human exploration
- Enable development of more than 15 missions (including lunar, Mars, and Heliophysics) that inform Artemis work
- Bolster crucial lunar science with Commercial Lunar Payload Services initiative, leveraging commercial partnerships to deliver science and tech payloads beginning in 2021 to virtually anywhere on the Moon, including the poles and far side
- Begin the search for polar ice in as early as December 2022 with Volatiles Investigating Polar Exploration Rover (VIPER)
- Provide valuable precursor experience for human exploration of Mars with bold new missions such as Mars Sample Return, and Mars Ice Mapper



Implement a Balanced and Integrated Science Program

- Over 40 missions in formulation and development in FY 2021, including over 25 small missions
- Planetary portfolio includes development of Europa Clipper, Mars Sample Return, Discovery, New Frontiers, and Planetary Defense missions
- Earth Science implements first Designated Observables mission, fully funds Earth Venture portfolio, advances technology innovation, and furthers SWOT, NISAR partnerships
- Heliophysics supports IMAP, Explorers, and begins work on GDC for launch as early as 2026

FY21 Budget Highlights



Advance Compelling Science with Highest National Priorities

- Execute program informed by Decadal Surveys
- Continue activities for Planetary Defense, to both prevent Near Earth Object (NEO) impacts on Earth and identify NEOs of potential threat to Earth. Enhance NEO identification capability through the continued development of the NEO Surveillance Mission
- Prioritize astrophysics funding for competed small missions and research; fully fund Webb for launch in 2021
- Revitalize Heliophysics fleet with historic number of missions on orbit and in development making critical observations of the near-Sun environment to improve the capability to study and predict space weather to protect our astronauts, our satellites, and power grids on Earth

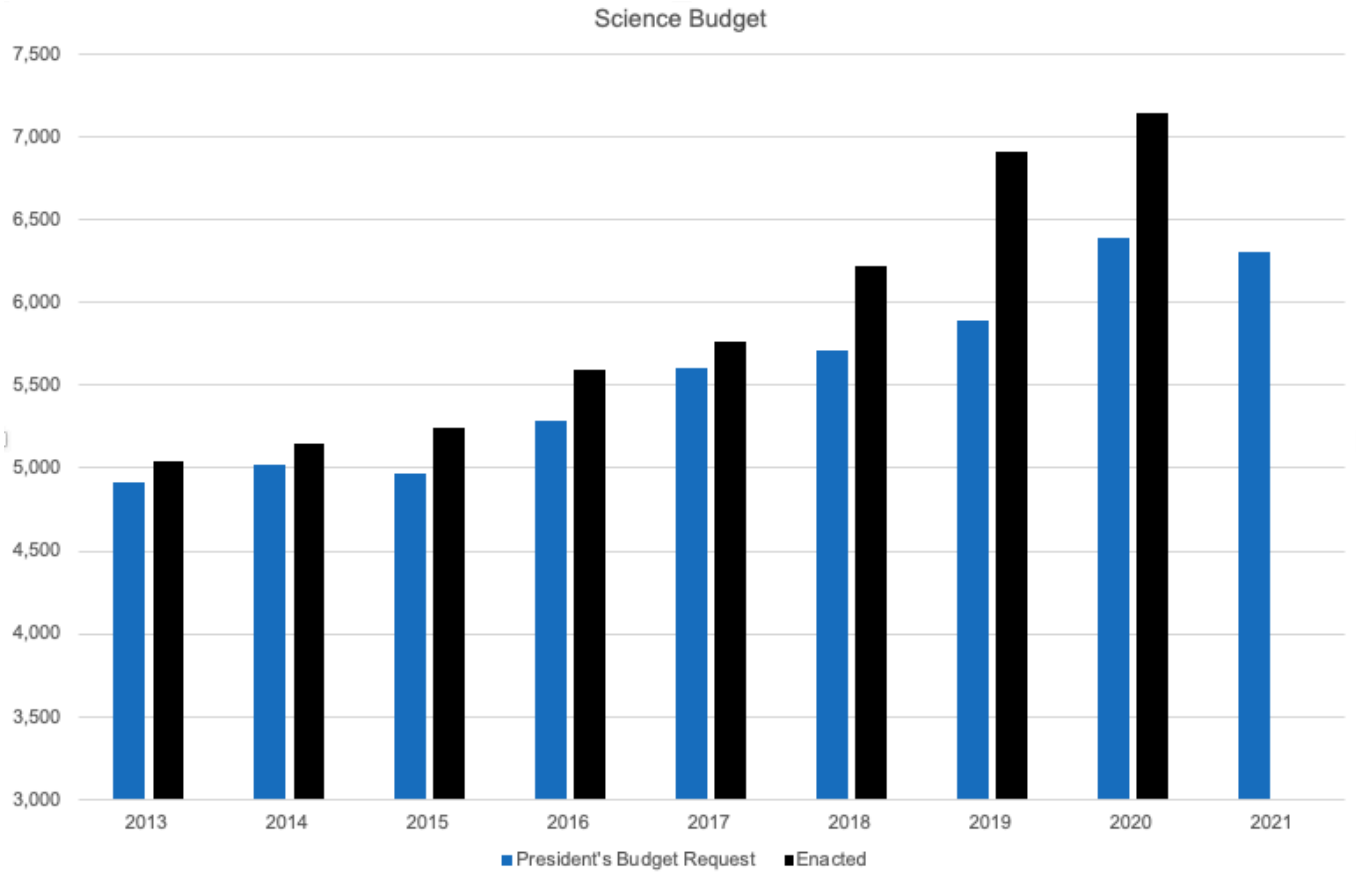
Execute Innovative Partnerships

- Pursue science on future commercial and international lunar and Mars missions
- Purchase Earth Science observation data from commercial sector small satellite constellations to provide a cost-effective means to augment and/or complement observations acquired by NASA
- Leverage data and expertise through interagency partnerships to achieve missions; provide data and products to support operational agencies
- Remain the preferred partner across the globe in all levels of NASA science experience, ~400 SMD agreements, comprising nearly 60% of NASA international agreements
- Enable science learners across the U.S. through over 200 community-based organizations

Science Budget Request Summary ($M)

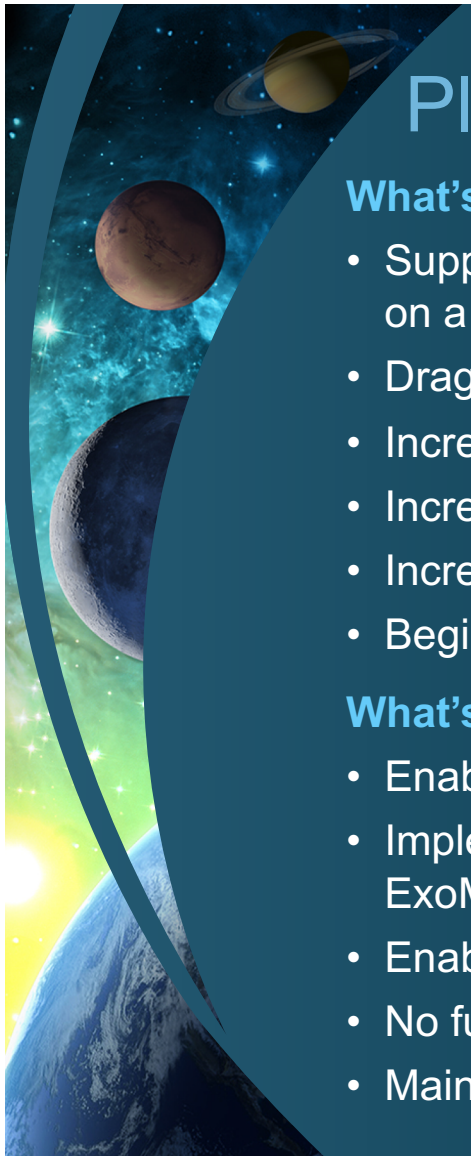
	Actual FY 19	Request FY 20	Enacted FY 20	Request FY 21	Out-years FY 22	FY 23	FY 24	FY 25
Science	**6,886.6**	**6,393.7**	**7,138.9**	**6,306.5**	**6,553.5**	**6,575.7**	**6,705.2**	**6,766.9**
Earth Science	**1,931.0**	**1,779.8**	**1,971.8**	**1,768.1**	**1,878.2**	**1,846.1**	**1,834.5**	**1,984.6**
Earth Science Research	454.1	447.9		447.3	471.9	494.1	528.5	530.3
Earth Systematic Missions	932.7	719.2		608.3	706.1	695.6	640.7	797.3
Earth System Science Pathfinder	223.8	275.4		338.9	301.2	251.6	241.8	234.4
Earth Science Data Systems	202.0	214.4		245.4	259.9	263.2	278.7	277.7
Earth Science Technology	63.4	69.6		74.2	82.8	84.6	86.4	86.4
Applied Sciences	55.1	53.3		53.9	56.3	57.0	58.5	58.5
Planetary Science	**2,746.7**	**2,712.1**	**2,713.4**	**2,659.6**	**2,800.9**	**2,714.9**	**2,904.8**	**2,830.7**
Planetary Science Research	276.6	266.2		305.4	288.6	285.1	295.2	286.7
Planetary Defense	150.0	150.0	160.0	150.0	147.2	97.6	98.0	98.0
Lunar Discovery and Exploration	188.0	300.0	300.0	451.5	517.3	491.3	458.3	458.3
Discovery	409.5	502.7		484.3	424.4	434.8	570.1	505.8
New Frontiers	93.0	190.4		179.0	314.3	332.8	326.9	285.0
Mars Exploration	712.7	546.5	570.0	528.5	588.4	671.2	798.7	855.3
Outer Planets and Ocean Worlds	793.6	608.4		414.4	370.7	239.4	192.3	171.7
Radioisotope Power	123.3	147.9	147.9	146.3	150.1	162.8	165.4	169.8
Astrophysics	**1,191.1**	**844.8**	**1,306.2**	**831.0**	**891.2**	**1,000.9**	**959.7**	**975.5**
Astrophysics Research	222.8	250.7		269.7	279.1	327.2	314.9	331.1
Cosmic Origins	222.8	185.3		124.0	123.2	120.0	122.4	122.4
Physics of the Cosmos	151.2	148.4		143.9	160.8	155.3	169.8	154.1
Exoplanet Exploration	367.9	46.4		47.2	50.4	47.6	51.6	52.2
Astrophysics Explorer	226.5	214.1		246.2	277.7	350.8	301.0	315.6
James Webb Space Telescope	**305.1**	**352.6**	**423.0**	**414.7**	**175.4**	**172.0**	**172.0**	**172.0**
Heliophysics	**712.7**	**704.5**	**724.5**	**633.1**	**807.8**	**841.8**	**834.1**	**804.1**
Heliophysics Research	248.9	237.0		230.5	218.7	225.2	224.0	224.5
Living with a Star	135.3	107.6		127.9	134.5	246.4	225.5	233.3
Solar Terrestrial Probes	180.5	177.9	183.2	126.3	262.2	202.6	195.6	115.5
Heliophysics Explorer Program	147.9	182.0	182.0	148.4	192.4	167.6	189.0	230.8

Science President's Budget Request and Enacted



Science Mission Directorate

Planetary Science



Planetary Science FY21 Budget Features

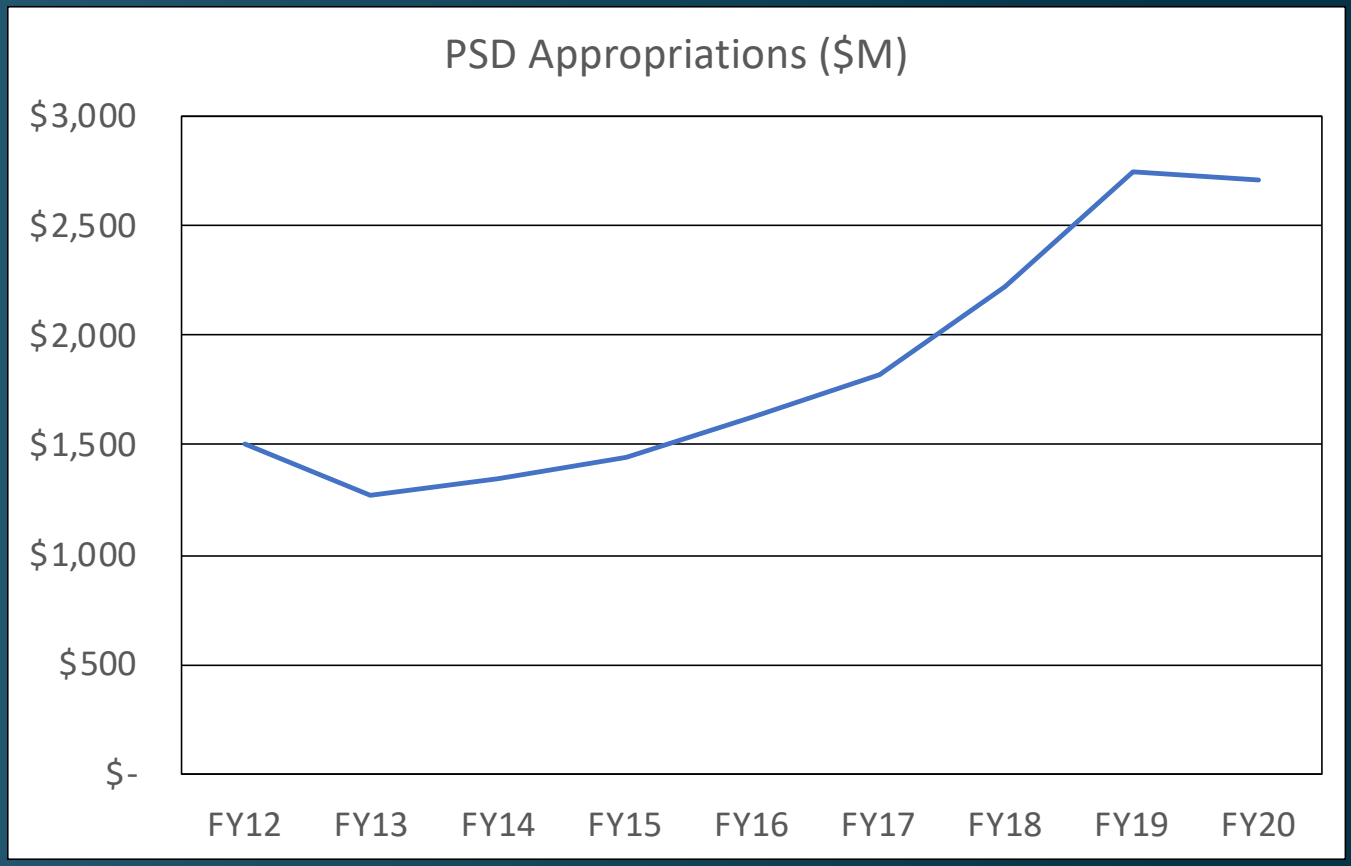
What's Changed

- Supports launch of Europa Clipper on SLS in 2025; proposes Clipper launch in 2024 on a commercial vehicle, which saves ~$1.5 billion
- Dragonfly selected as next New Frontiers mission with launch readiness date in 2026
- Increases Commercial Lunar Payload Services based on awards to date
- Increases SmallSat future opportunities within the Discovery Program
- Increases R&A to maintain adherence to Decadal recommendation
- Begin Mars Ice Mapper planning with international and commercial partners

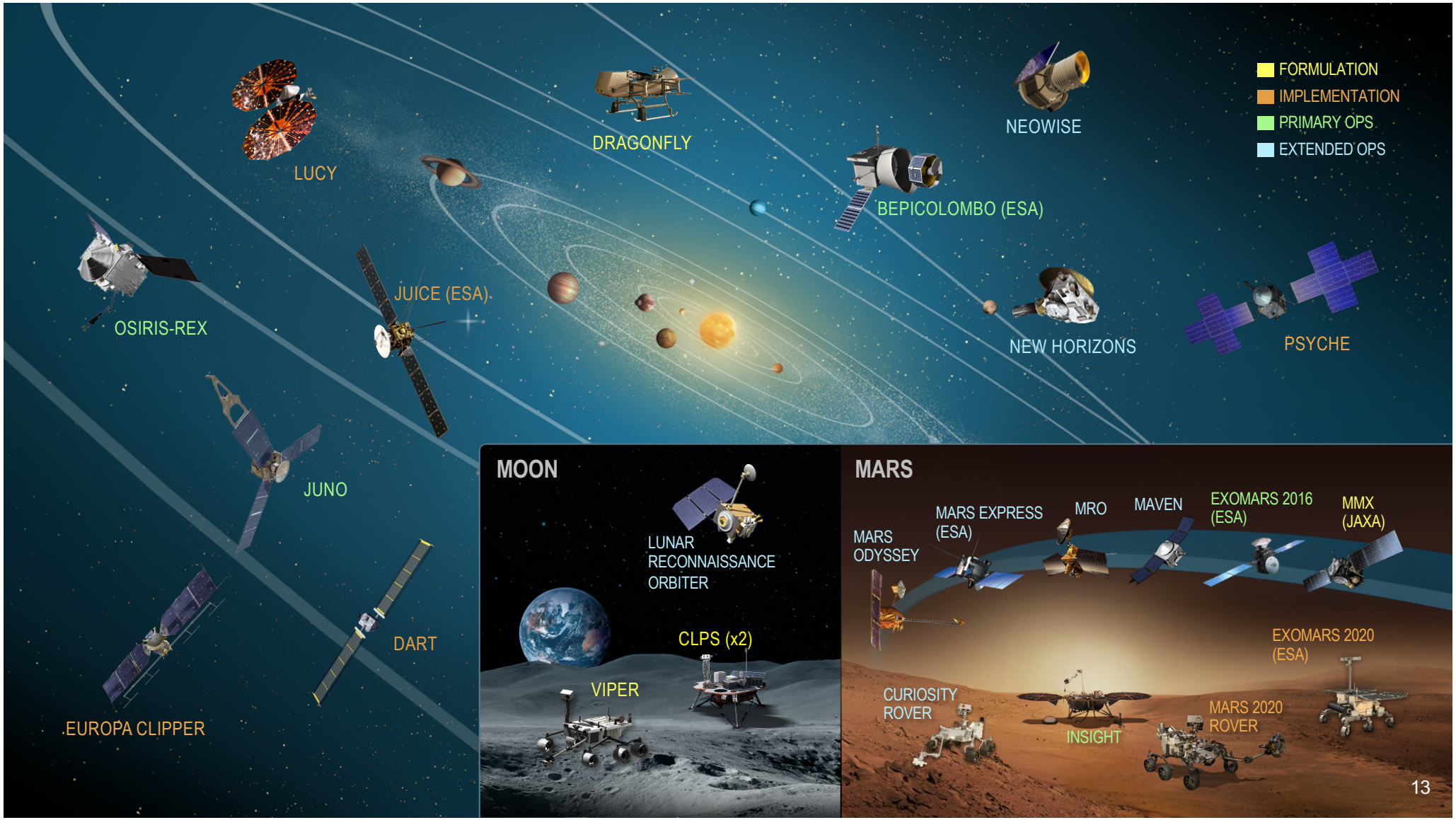
What's the Same

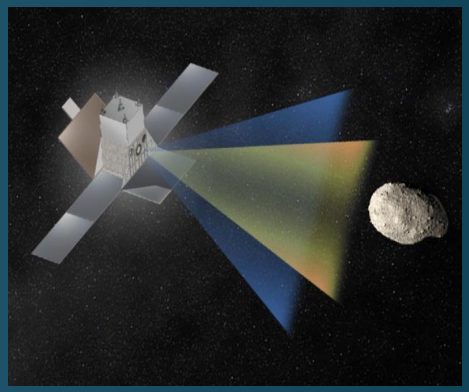
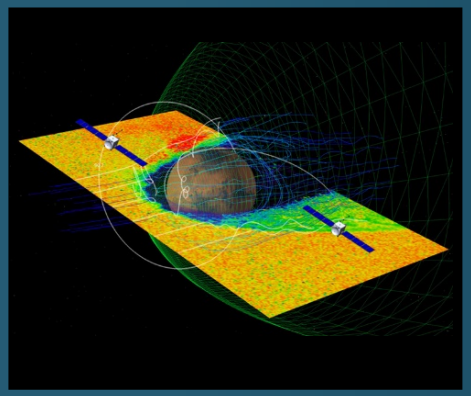
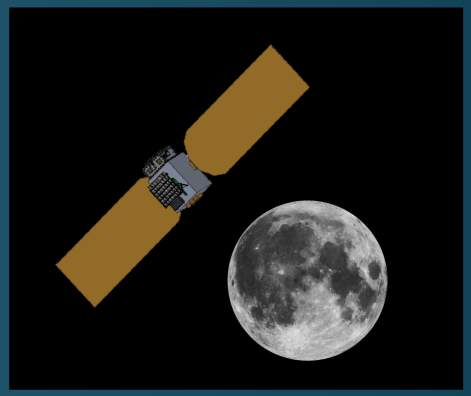
- Enables a Mars Sample Return launch in 2026
- Implements Mars 2020, DART, Dragonfly, Psyche and Lucy as well as instruments on ExoMars 2020, JUICE and MMX
- Enables Discovery selection(s) in 2021 and New Frontiers 5 AO release in 2022
- No funding for Europa Lander
- Maintains Nation's radioisotope power system capability

PSD Appropriations (FY12 – 20)



FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
$1,501	$1,272	$1,343	$1,447	$1,628	$1,828	$2,218	$2,747	$2,713


FORMULATION
IMPLEMENTATION
PRIMARY OPS
EXTENDED OPS
LUCY
DRAGONFLY
NEOWISE
BEPICOLOMBO (ESA)
OSIRIS-REX
JUICE (ESA)
NEW HORIZONS
PSYCHE
JUNO
DART
EUROPA CLIPPER
MOON
LUNAR RECONNAISSANCE ORBITER
CLPS (x2)
VIPER
MARS
MARS ODYSSEY
MARS EXPRESS (ESA)
MRO
MAVEN
EXOMARS 2016 (ESA)
MMX (JAXA)
EXOMARS 2020 (ESA)
CURIOSITY ROVER
INSIGHT
MARS 2020 ROVER

Announcements of Opportunity

Small Innovative Missions for Planetary Exploration (SIMPLEx)

- Three missions selected for Phase A/B development
- Currently capturing lessons learned through PDR for consideration during next cycle
- Release of next opportunity planned for NET June 2020

New Frontiers #4

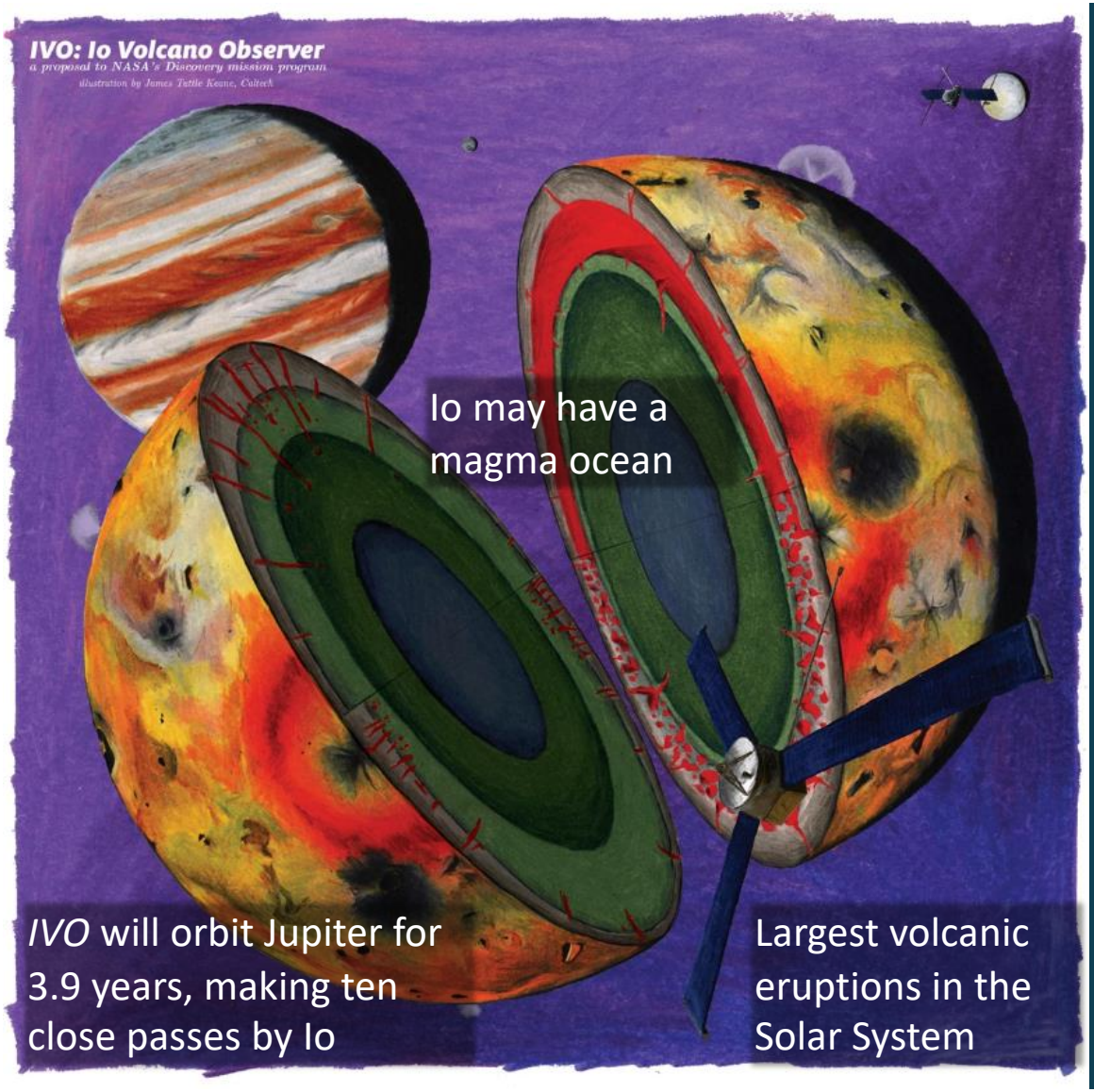
- Dragonfly selection announced June 27, 2019

New Frontiers #5

- To be released Fall 2022 (current schedule)

Discovery 2019

- Step-1 proposals were due July 1, 2019, with selections announced February 13, 2020
- Step-2 selections planned for NET April 2021



Io Volcano Observer (IVO): Follow the Heat!

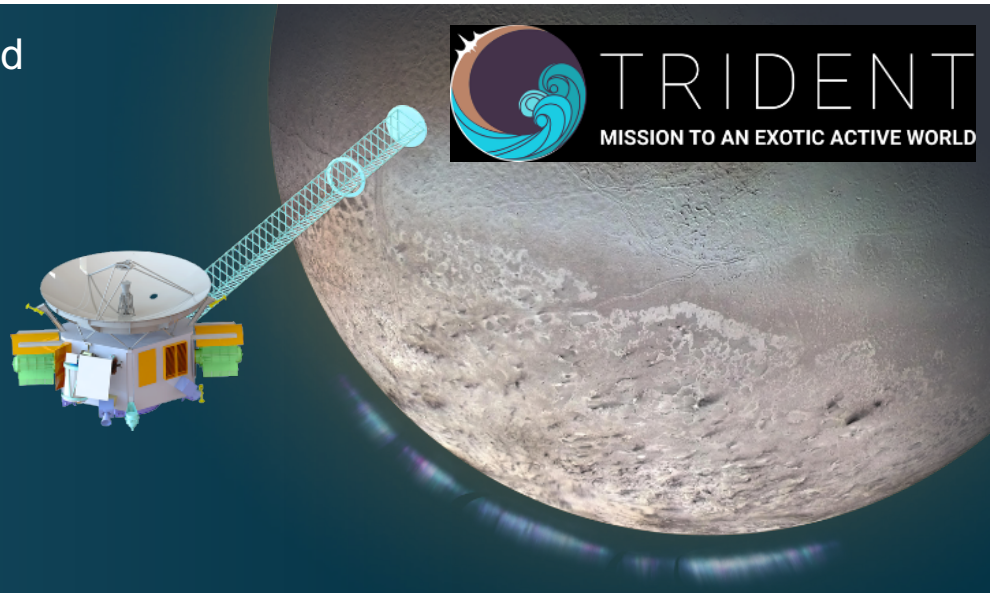
IVO's primary goal is to "Follow the Heat" to understand how tidal heat (A) is generated, (B) is lost, and (C) drives the evolution of Io:

	SCIENCE OBJECTIVES:	KEY MEASUREMENTS:
A1	Determine the degree and distribution of melt within Io's interior	gravity, libration, magnetic induction, lava temperature + composition
B1	Determine Io's lithospheric structure	gravity, libration, magnetic induction, topography
B2	Determine where and how Io is losing heat	visible and thermal imaging
C1	Determine Io's orbit evolution	precision ranging from Earth
C2	Determine Io's volatile loss processes and rates	mass spectrometer, plasma measurements, imaging

University of Arizona: Principal Investigator Alfred McEwen, science operations, student collaborations
Johns Hopkins Applied Physics Lab: Mission and spacecraft design, build, and management; Narrow-Angle Camera; Plasma Instrument for Magnetic Sounding
University of California Los Angeles: Dual Fluxgate Magnetometers
Jet Propulsion Lab: Radio science, navigation
German Aerospace Center: Thermal Mapper
University of Bern: Ion and Neutral Mass Spectrometer
U.S. Geological Survey: Deputy PI, cartography

Triton, the Solar System's weirdest moon, is a captured Kuiper Belt Object and possible ocean world. Trident will encounter Triton to:

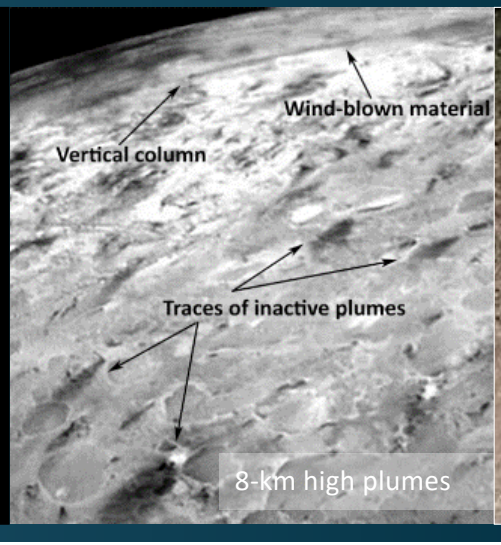
- Explore how worlds become habitable
  - *Is Triton an ocean world?*
- Explore what drives processes on active worlds
  - *What processes resurface Triton?*
  - *What processes drive Triton's plumes?*
  - *Why is Triton's ionosphere so intense?*
- Explore vast, unseen lands
  - *View Triton's unseen hemisphere!*

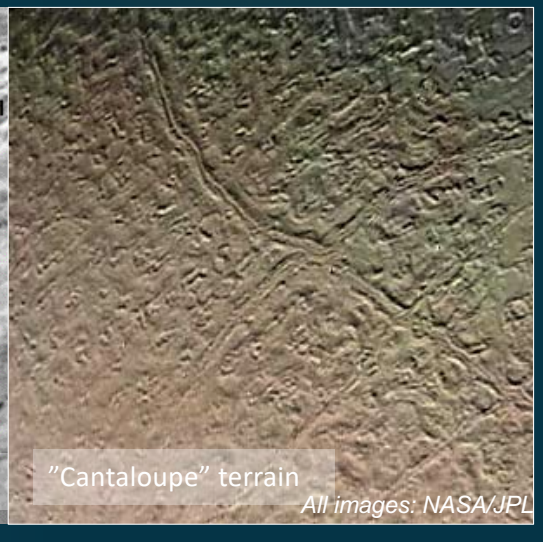


Lunar and Planetary Institute:
Louise Prockter (PI)

INSTRUMENTS

- MAG — Enables detection of subsurface ocean (UCLA)
- IR SPEC-NAC — Spectral and optical imaging of surface features (Ball)
- WAC — Wide-angle eclipse imager (JPL)
- PS — Plasma analyzer and spectrometer (IRF)
- RS — Gravity and atmospheric occultation radio science (ASI)





All images: NASA/JPL

Dr. James B. Garvin, NASA GSFC, Principal Investigator
Drs. Stephanie Getty and **Giada Arney**
NASA GSFC, Deputy Principal Investigators

DAVINCI+

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

Atmospheric Origin & Evolution

- What is the origin of the Venus atmosphere and how has it evolved?
- How and why is Venus different or similar to Earth, Mars, and analog exoplanets?

Atmospheric Composition & Surface Interaction

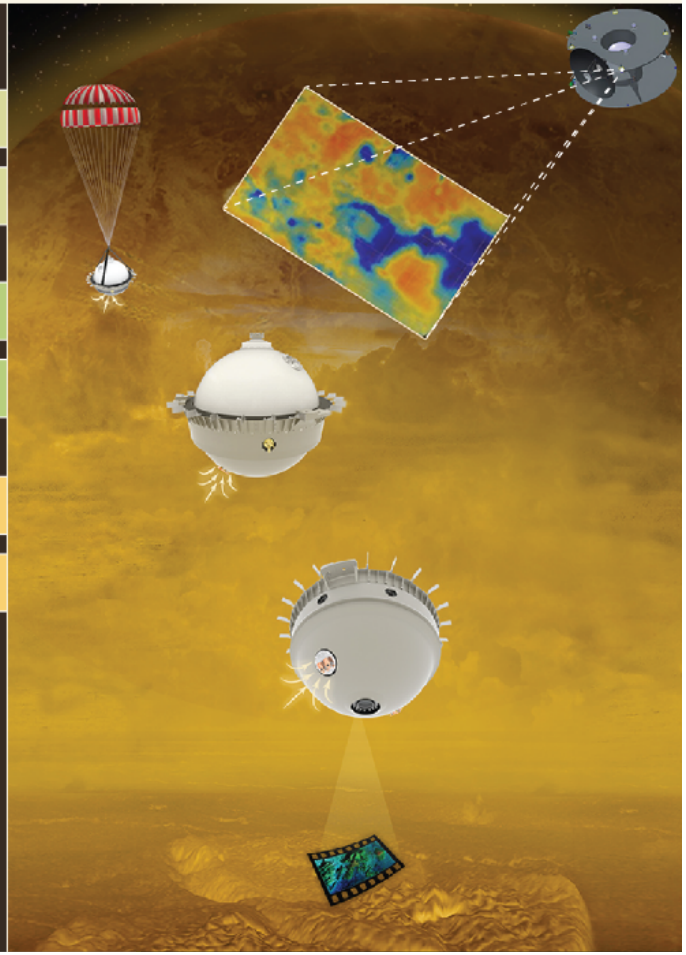
- Was there an early ocean on Venus? If so, when and where did it go?
- What is the rate of volcanic activity on Venus?

Surface Properties

- What exactly are the tesserae highlands, including origin and history?
- How do they compare with major highlands, such as Ishtar Terra?

2027	2028	2029...
Flyby Phase	Probe Descent	Orbital Phase

Major partners: Lockheed-Martin • JPL • MSSS • LaRC • ARC • APL • KinetX • University of Michigan



VERITAS

What makes a rocky planet habitable?

Like Earth, Venus started with all the building blocks of a habitable world. How was habitability lost?

PI: Sue Smrekar, JPL
Managed by JPL

Key Science Questions include:

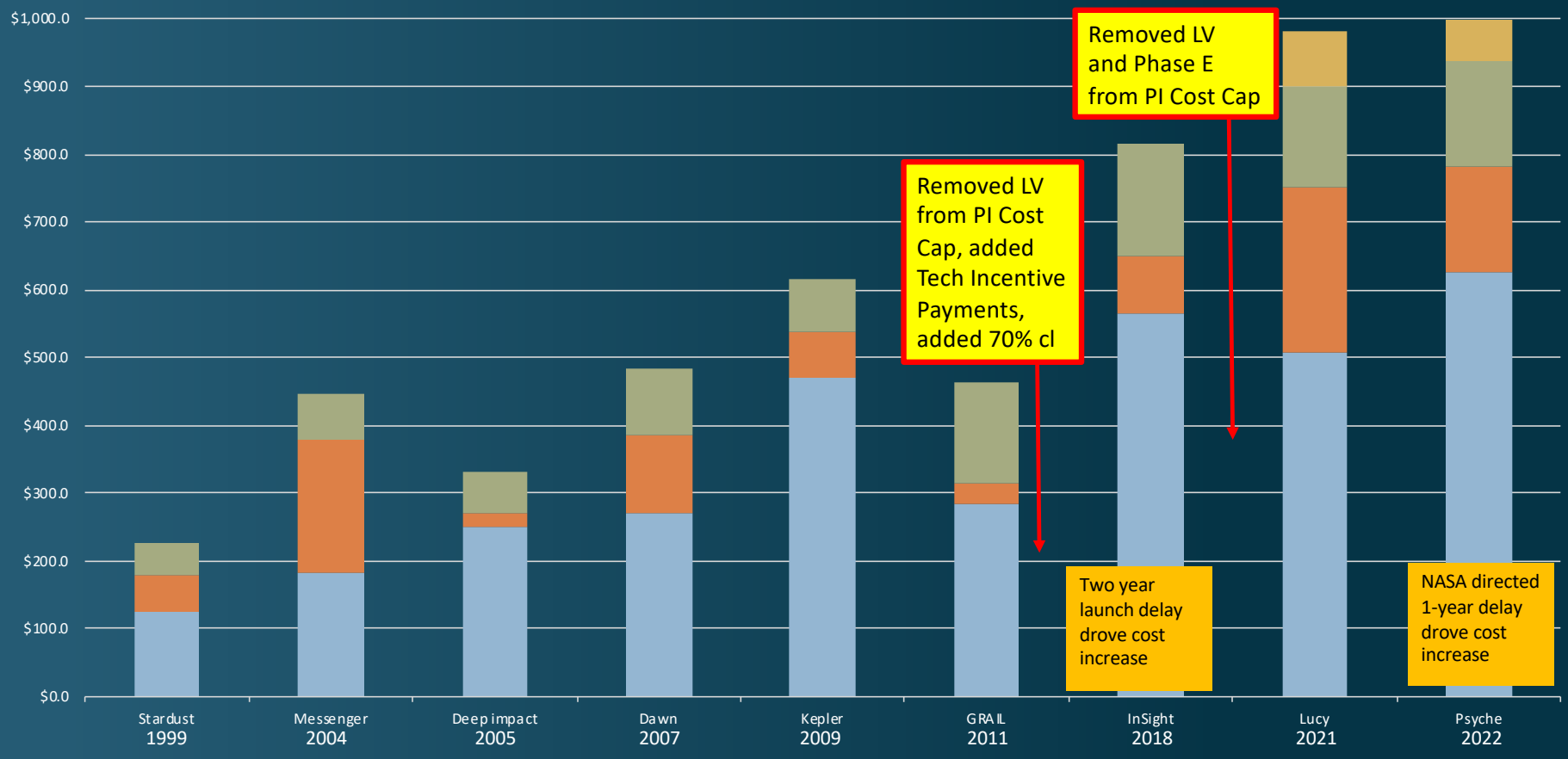
- Are the mysterious "Tessera" plateaus the remains of ancient Earth-like continents?
- Did Venus' young surface form all at once or slowly?
- Is there active volcanism and tectonism today?
- Are volcanoes still spewing water vapor today?
- Is Venus taking the first step towards plate tectonics – the process that formed Earth's surface and shapes its habitability?

Venus Emissivity, Radio Science, InSAR, Topography, & Spectroscopy

VERITAS answers these questions, by producing:

- High resolution global topography and radar image maps
- Venus' first global map of igneous rock type
- A search for active/recent volcanism and faulting
- A high resolution gravity field.

Discovery Cost Growth* Resulting From Strategic Decisions (RY $)



*Cost data from CADRE

Notional Timeline for 2023 Decadal Survey

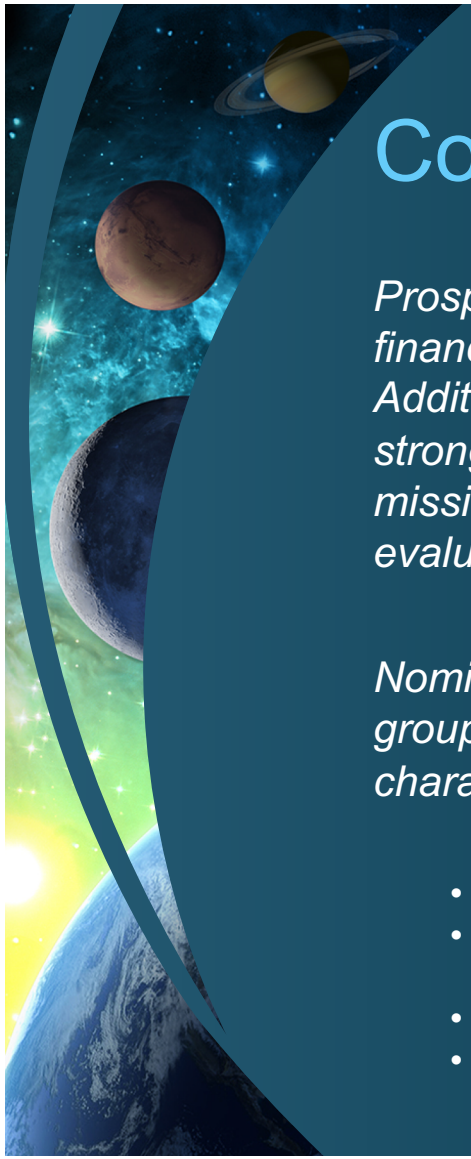
Jan. 2020	Statement of Task finalized
~Mar. 2020	White paper submission website opens
~Mar. 2020	Chair selected and announced at LPSC
~May 2020	Deadline for submission of white papers
~June 2020	Survey committee and panel meetings begin
~Oct. 2021	First complete draft of survey report assembled
~Mar. 2022	Survey report released at LPSC

White Paper Process

- Led by the NAS Space Studies Board (SSB)
- Format similar to last planetary decadal (NAS website)
- LPI website for community collaborations is OPEN

https://www.lpi.usra.edu/decadal_whitepaper_proposals/index.cfm

- Upcoming Activities
  - Early Career Workshop (March 15 @ 10am-12pm, Montgomery A)
  - PMCS status workshop (March 15 @ 8am-6pm, Waterway 1)
  - LPSC Town Hall led by NAS/SSB (March 16 @ 12:00pm, Waterway 1-3)



Conflict of Interest Statement

Prospective members of all National Academies' committees and panels have their financial relationships reviewed to prevent actual or perceived conflicts of interest. Additionally, the National Academies evaluates whether each prospective member is a strong, publicly known advocate for a specific project—broadly defined as a plan, mission, initiative, architecture, or the equivalent—that the committee or panel may evaluate. Such evaluation is necessary to avoid possible bias or a perception thereof.

Nominations and self-nominations to the decadal survey committee—i.e., the steering group and supporting panels—are welcome. Nominees with the following characteristics are encouraged:

- *Scientific and technical expertise, and objectivity;*
- *Experience in the management of a project, organization, or equivalent enterprise is desirable;*
- *Must be broad thinkers, open-minded, and not active proponents of a specific project; and*
- *Be able to participate in-person in survey committee activities.*

Conflict of Interest Statement – Continued

Additional considerations include the following:

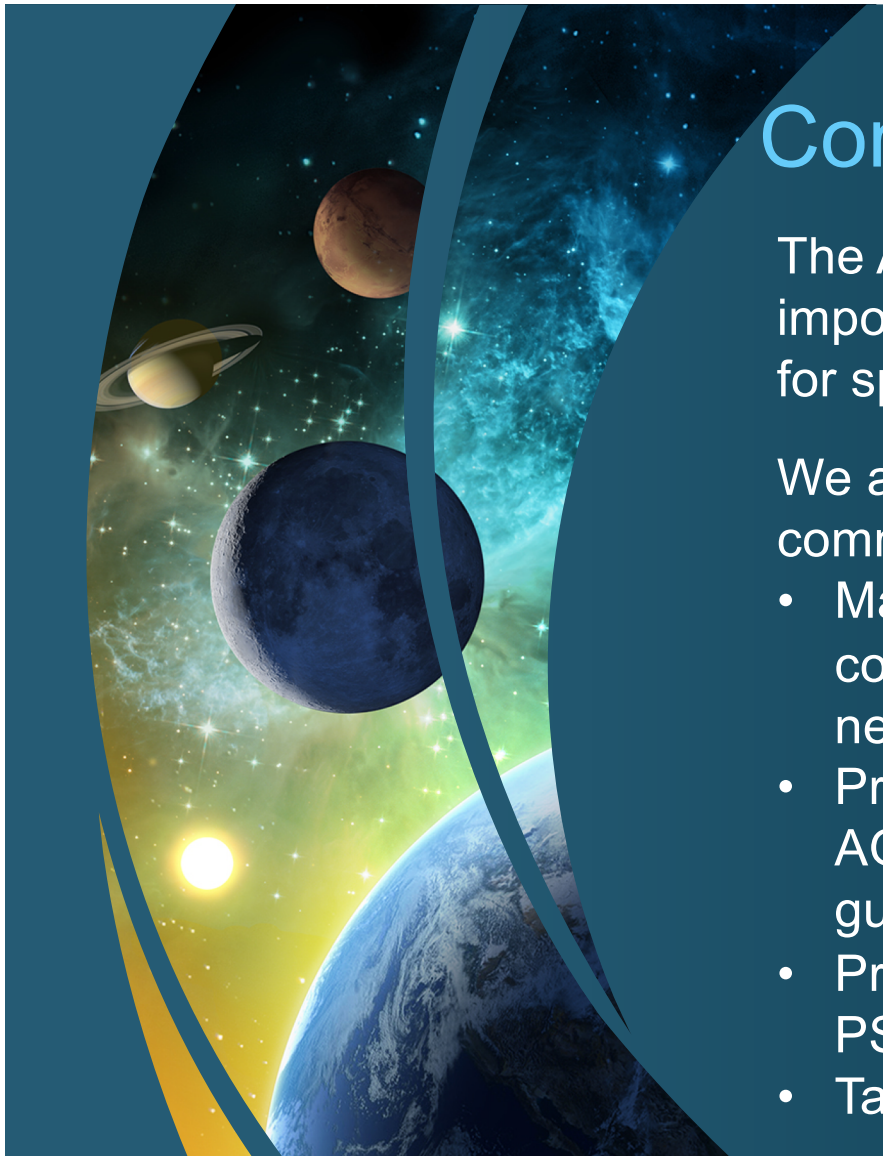
- *All authors of science-focused whitepapers prepared for the survey are eligible to be considered as members of the steering group and its supporting panels;*

- *First authors of mission-focused whitepapers prepared for the survey cannot serve on the steering group or on any panel considering that mission; and*

- *Principal investigators of the NASA-funded, pre-decadal mission-concept studies to be evaluated by the survey cannot serve on the steering committee or on any panel considering that mission.*

First “PI Launchpad”

- Aimed at researchers and engineers who would like to submit a NASA space mission proposal in the next few years but don’t know where to start.
- Two-and-a-half day, interactive workshop held in Tucson, AZ on Nov. 18-20, 2019.
- Very competitive application process. Selected ~40 participants. All costs paid for thanks to a grant from the Heising-Simons Foundation to our partner, the University of Arizona.
- Goals:
  - Lead participants from science question to draft requirements, STM, *etc.*
  - Provide first exposure to how to choose partners, assemble teams, *etc.*
  - Provide networking opportunities with mission managing organizations, spacecraft providers and each other.
- Targeting Later Summer 2020 at the University of Michigan for the next Launchpad.



Community Groups (the AGs)

The AGs are community-based groups that serve an important role in providing analyses and feedback for specific topic areas.

We are exploring how to better work with the community through these groups by:

- Making Terms of Reference for all of the groups consistent, with specific differences to reflect the needs of individual communities.
- Provide more consistent funding support to the AG Chairs, with transparency and clear guidelines on acceptable use.
- Provide a clear path for feedback both to NASA to PSD directly and through the PAC.
- Target date for this by June 2020.

Response to December 2019 Findings

NASA Response to PAC December 2019 Findings

Finding 1 – Recommendation on Dual Anonymous Peer Review (DAPR):

The PAC recommends that NASA engage social science experts in the design of the pilot study to implement dual-anonymous peer review (DAPR) using four program elements in its 2020 Research Opportunities in Space and Earth Sciences (ROSES). The PAC also recommends that NASA compile and analyze data from past ROSES awards to evaluate possible biases in the current review process (e.g., with respect to gender, stage in career, institution, etc.) in order to provide a basis for future comparison with DAPR.

NASA Response:

In creating its Dual-Anonymous Peer Review (DAPR) process, the Space Telescope Science Institute (STScI) was aided greatly by Dr. Stefanie Johnson (Leeds Business School, U. Colorado, Boulder) and Dr. Jessica Kirk (Fogelman College of Business & Economics at the University of Memphis) — both social scientists. SMD builds its process on this work. Dr. Johnson is consulted on a regular basis by SMD and will be invited to observe upcoming SMD DAPR reviews to advise on best practices.

SMD has performed studies in the past on gender-based discrimination in its R&A programs and found no evidence for such bias. Studies on career stage and institution type bias will be performed. Note, though, that even in the absence of provable biases, social science studies on other decision processes have shown that anonymizing applications leads to less (unconsciously-)biased result.

Dual-Anonymous Peer Review

- SMD is strongly committed to ensuring that the review of proposals is performed in an equitable and fair manner that reduces the impacts of any unconscious biases.
- Motivated by, and modeled upon, a successful study conducted for the Hubble Space Telescope, SMD is conducting a pilot program in ROSES-2020 to evaluate proposals using dual-anonymous peer review (DAPR).
  - The primary intent of dual-anonymous peer review is to eliminate “the team” as a topic during the scientific evaluation of a proposal, not to make it absolutely impossible to guess who might be on that team.
  - This creates a shift in the tenor of discussions, away from the individuals, and towards a discussion of the scientific merit of a proposal.
- In PSD: Habitable Worlds (E.4, Step-1 due 11/17/20)
- Additional discussion at R&A Town Hall
- Also find information at: https://science.nasa.gov/researchers/dual-anonymous-peer-review

NASA Response to PAC December 2019 Findings

Finding 2 – Recommendation on Satellite Constellations and Their Potential Impact on NASA's Ground-Based Observing Programs:

The PAC recommends that NASA conduct a quantitative analysis of the impact of mega-constellations of broadband communications satellites on all of NASA's ground-based observations, including observations of Near-Earth Objects (NEOs) and Potentially Hazardous Objects (PHOs) and support observations for NASA flight missions.

NASA Response:

"PSD thanks the PAC for this finding and acknowledges that proposed mega constellations may impact ground-based observations. We are currently working with SMD to identify an appropriate approach for assessing this potential impact."

NASA Response to PAC December 2019 Findings

Finding 3 – Finding on Planetary Major Equipment/Facilities 2018 Selection Delay and Cancellation for 2019:

The PAC finds the cancellation of the ROSES 2019 Planetary Major Equipment/Facilities (PMEF) solicitation and the ongoing delay in selection of awards from the ROSES 2018 PMEF solicitation inconsistent with the Planetary Science Division's (PSD's) stated commitment to addressing the recommendations of the National Academies of Sciences, Engineering, and Medicine (NASEM) 2019 report on *Strategic Investments in Instrumentation and Facilities for Extraterrestrial Sample Curation and Analysis*. Delays in these investments have the potential to adversely affect the readiness of the scientific and curation communities for NASA's first asteroid sample returned from the OSIRIS-REx mission, expected to arrive in 2023, for Mars sample return, and for new lunar samples from the upcoming Artemis mission.

NASA Response:

NASA has been working on a strategic plan that properly responds to the National Academies of Sciences, Engineering, and Medicine (NASEM) 2019 report on *Strategic Investments in Instrumentation and Facilities for Extraterrestrial Sample Curation and Analysis and* fulfils the needs PSD's missions, teams, and their perspective communities. To that effect:

— Intend to make selections from PMEF-18 shortly after we have an Op Plan and know our budget

— Standing up a new Facilities call as part of ROSES20 at a higher planned funding level (contingent on budget)

— Additional details on this plan in the R&A talk


EXPLORE
with us