
National Aeronautics and
Space Administration
NASA
EXPLORE
SCIENCE
Lori S. Glaze, Ph.D., NASA Planetary Science Division Director
Joan Salute, Associate Director, Flight Programs
Planetary Science Advisory Committee (PAC) Meeting
June 21, 2022

PSD Staff Updates

Thank you and farewell to Carl Adams (Program Executive) upon his recent retirement!

Welcoming three new Program Executives and a new IPA Program Scientist (R&A)

Barbara Bendowski Hilton (Program Executive)

Karen Gelmis (Program Executive)

Melissa Morris (Program Executive)

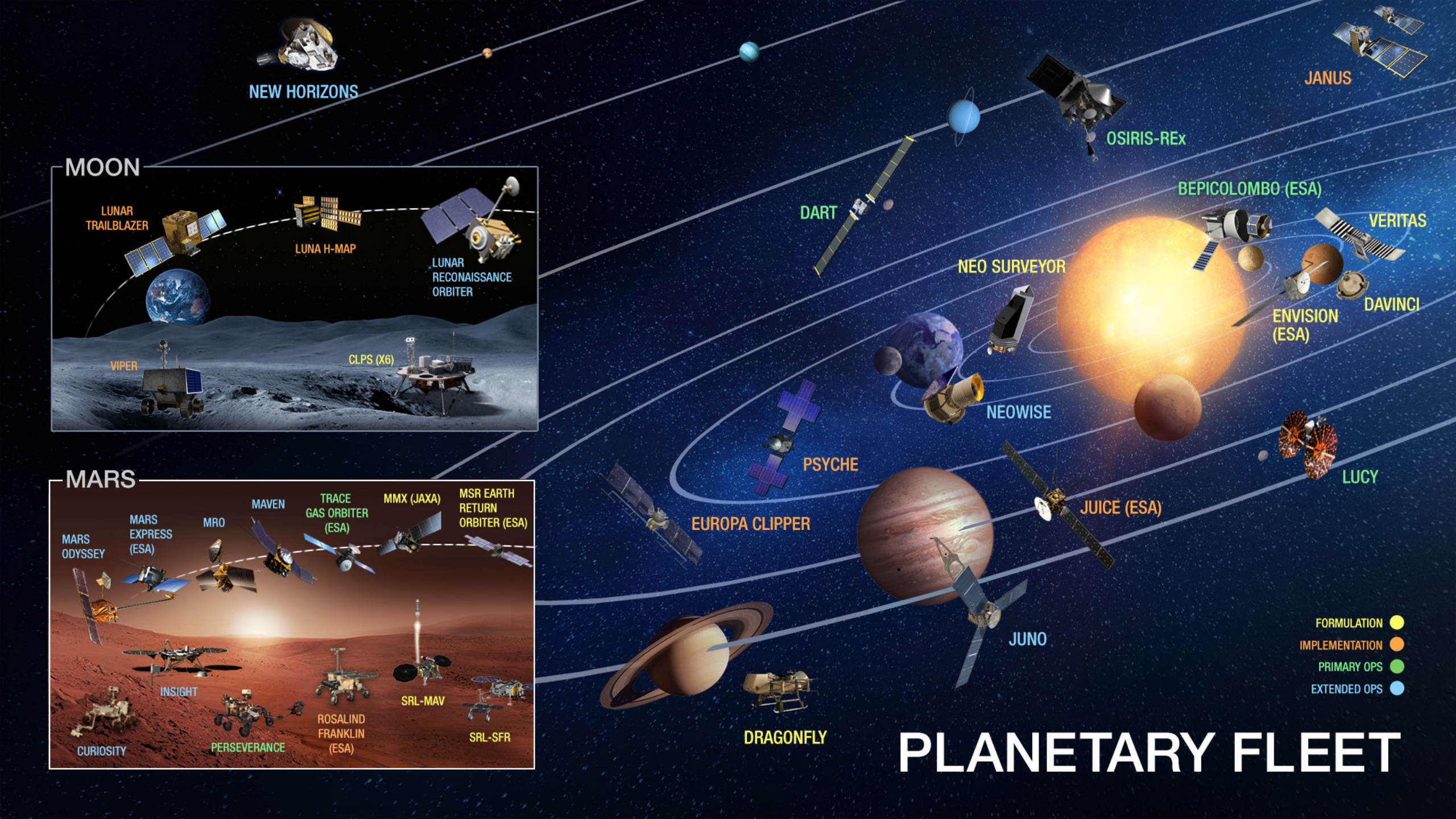
Nicholas Lang (Program Scientist, IPA from Mercyhurst University)

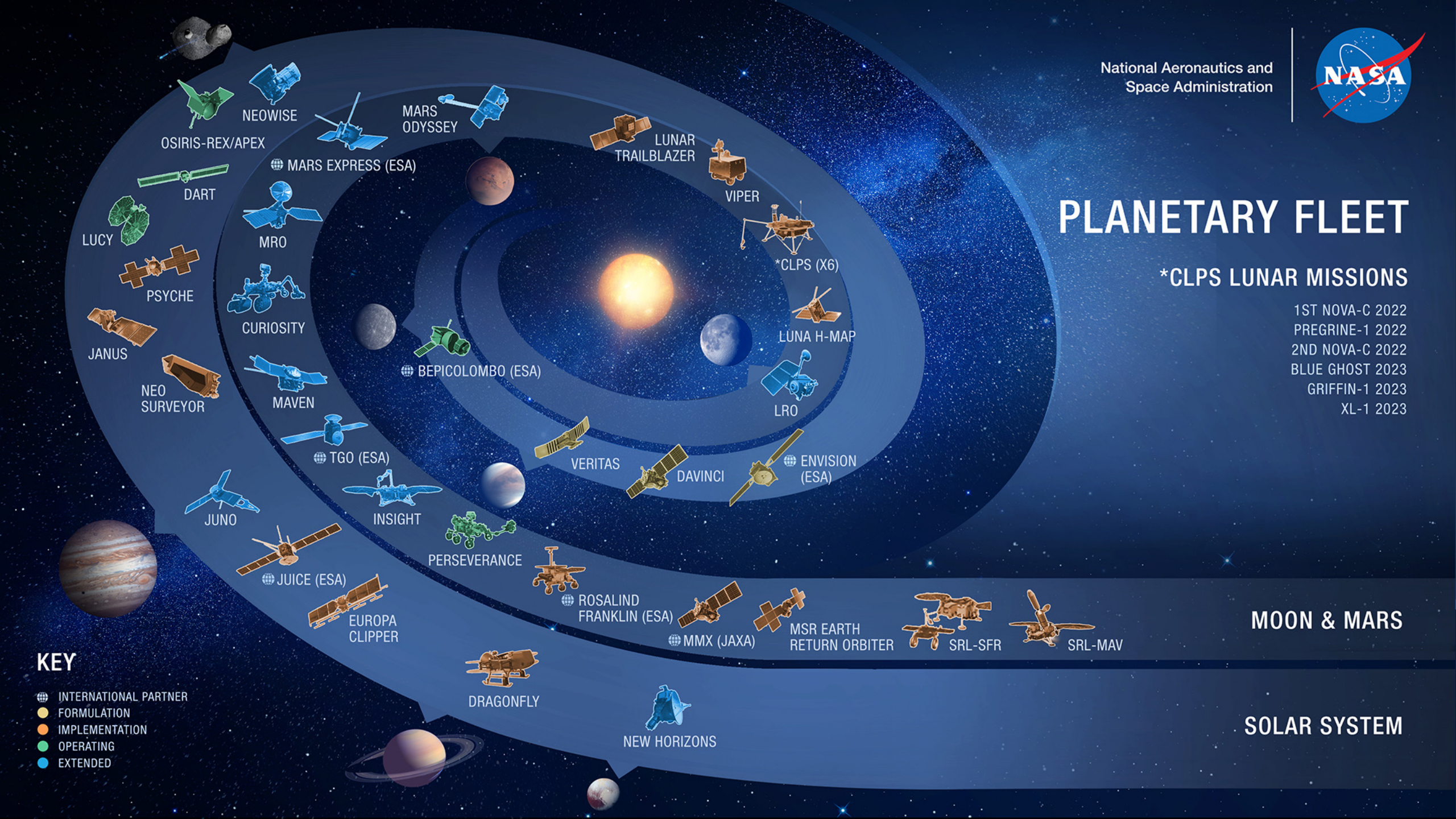
Budget

FY 2022 Enacted Budget

- NASA's FY 2022 appropriation shows strong support for Science (>$7.6B)
  - 4% growth over FY21 budget
  - Support for high-priority activities/missions, including Mars Sample Return, Europa Clipper, and the Lunar Exploration and Discovery Program
- FY 2022 PSD Appropriation is $427.2M above FY 2021
  - Challenge: $79.6M less than the President's Budget Request
- Awaiting approval of initial operating plan

($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
PSD	1,342.3	1,446.7	1,628.0	1,827.5	2,217.9	2,746.7	2,712.6	2,693.2	3,120.4


NEW HORIZONS
MOON
LUNAR TRAILBLAZER
LUNA H-MAP
LUNAR RECONAISSANCE ORBITER
VIPER
CLPS (X6)
MARS
MARS ODYSSEY
MARS EXPRESS (ESA)
MRO
MAVEN
TRACE GAS ORBITER (ESA)
MMX (JAXA)
MSR EARTH RETURN ORBITER (ESA)
INSIGHT
CURIOSITY
PERSEVERANCE
ROSALIND FRANKLIN (ESA)
SRL-MAV
SRL-SFR
JANUS
OSIRIS-REx
DART
BEPICOLOMBO (ESA)
VERITAS
NEO SURVEYOR
ENVISION (ESA)
DAVINCI
NEOWISE
PSYCHE
LUCY
EUROPA CLIPPER
JUICE (ESA)
JUNO
DRAGONFLY
FORMULATION
IMPLEMENTATION
PRIMARY OPS
EXTENDED OPS
PLANETARY FLEET


National Aeronautics and Space Administration
NASA
PLANETARY FLEET
*CLPS LUNAR MISSIONS
1ST NOVA-C 2022
PREGRINE-1 2022
2ND NOVA-C 2022
BLUE GHOST 2023
GRIFFIN-1 2023
XL-1 2023
OSIRIS-REX/APEX
NEOWISE
MARS ODYSSEY
MARS EXPRESS (ESA)
DART
LUCY
MRO
PSYCHE
CURIOSITY
JANUS
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BEPICOLOMBO (ESA)
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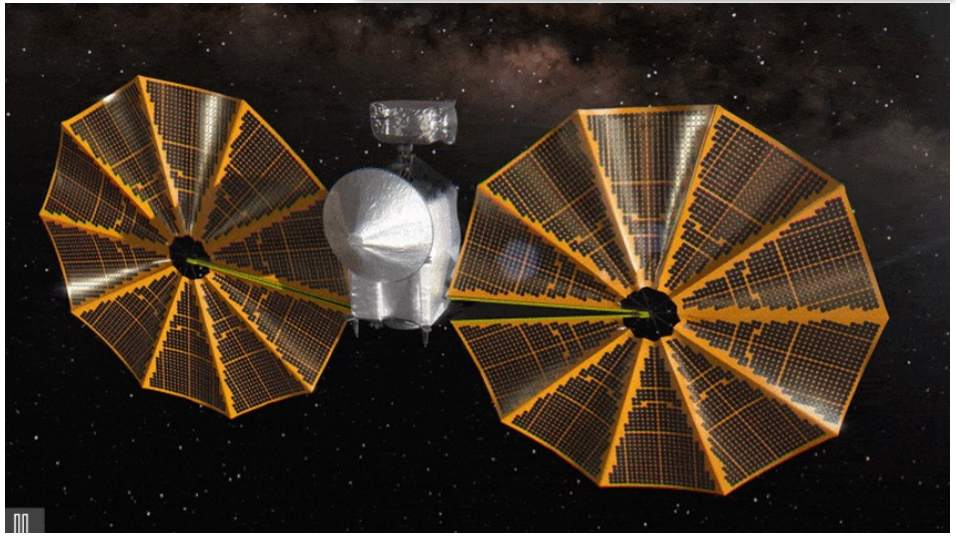
DRAGONFLY
NEW HORIZONS
MOON & MARS
SOLAR SYSTEM
KEY
INTERNATIONAL PARTNER
FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED

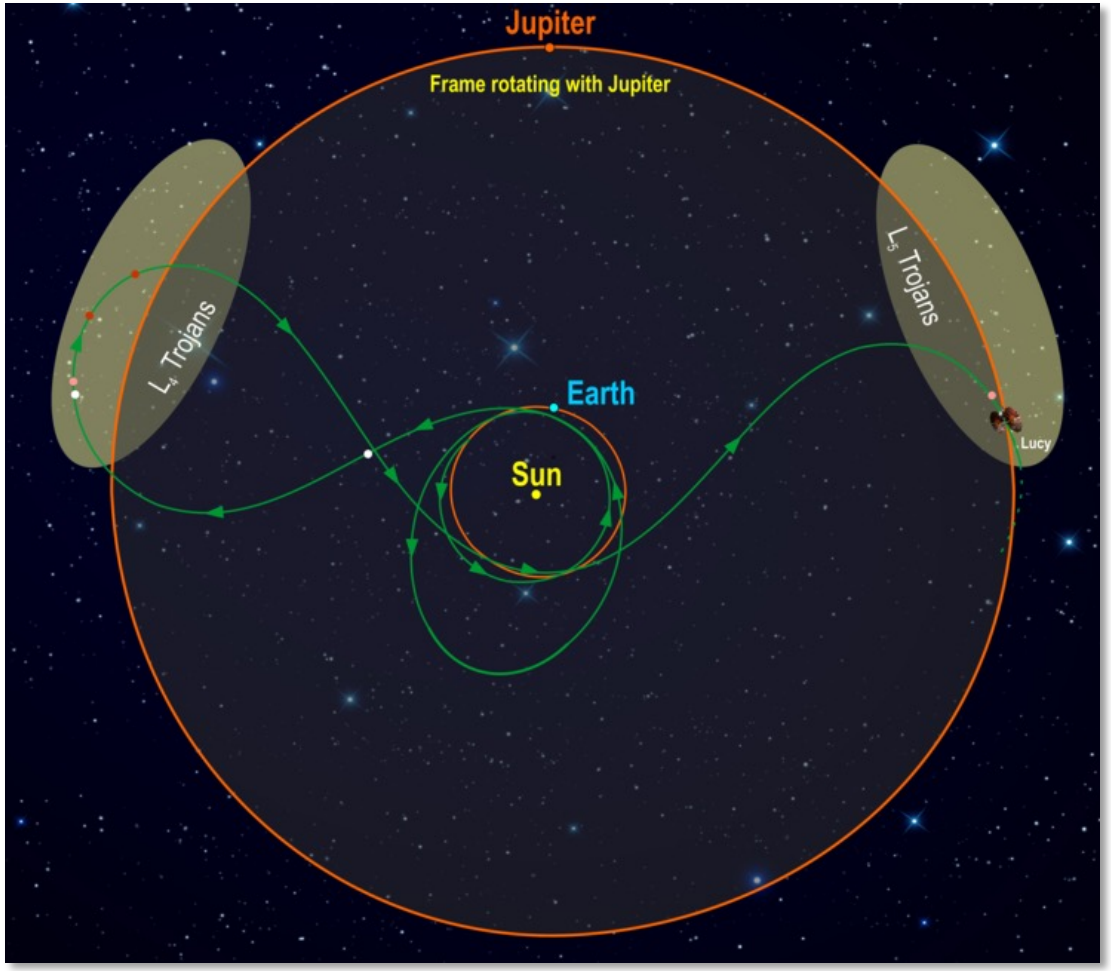
Mission Updates

Lucy

Lucy launch, Cape Canaveral, Oct 16, 2021

Solar Array Anomaly resolution in progress



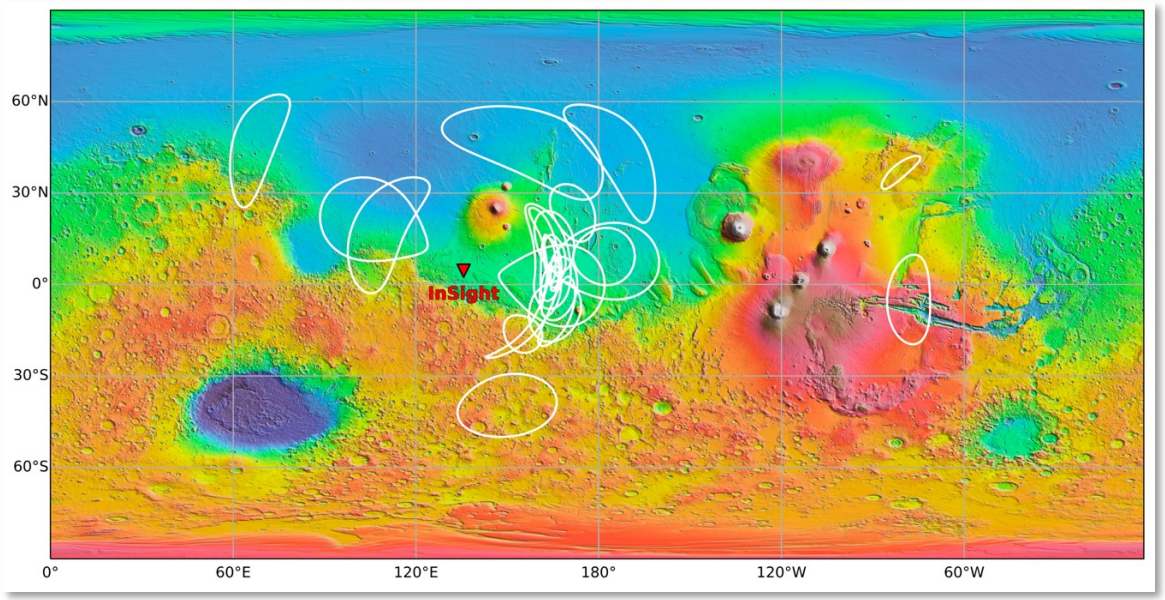


First Earth Gravity Assist: October 2022

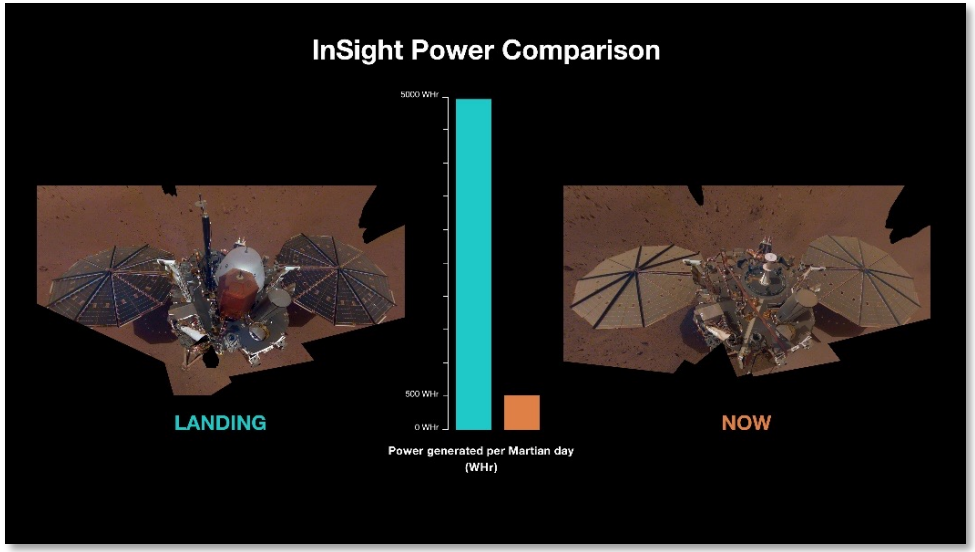
Lunar eclipse observed by L'LORRI

InSight

- Continuing to map Mars seismic activity
  - Seven largest quakes of the mission have taken place since aphelion last summer!
- Seasonal atmospheric conditions are currently generating relatively high seismic noise levels, but larger events are still being seen (e.g., recent magnitude ~5 event on May 4, 2022)
- Available power continues to drop as Mars enters the dusty season
  - Still able to keep SEIS instrument on >50% of the time
- Science operations are expected to cease, because of insufficient energy, sometime late this summer or fall
  - Expect conclusion of all operations by end of 2022



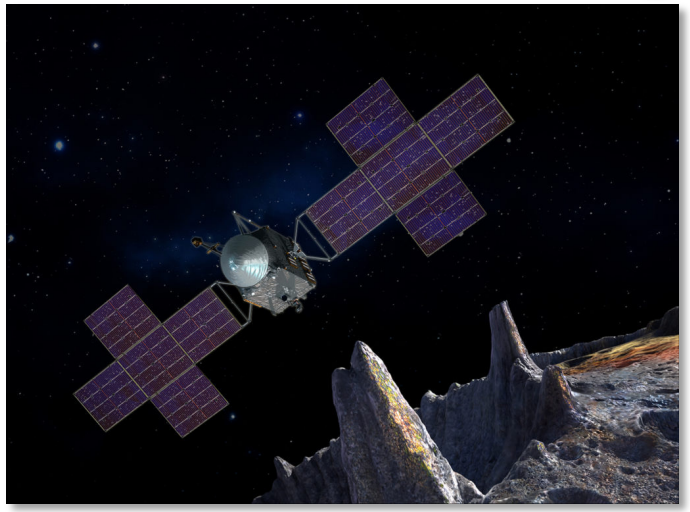
Locations (with uncertainties) of the 25 largest low-frequency seismic events detected by InSight



Solar panel production in November 2018 versus spring 2022. Credit: NASA/JPL-Caltech

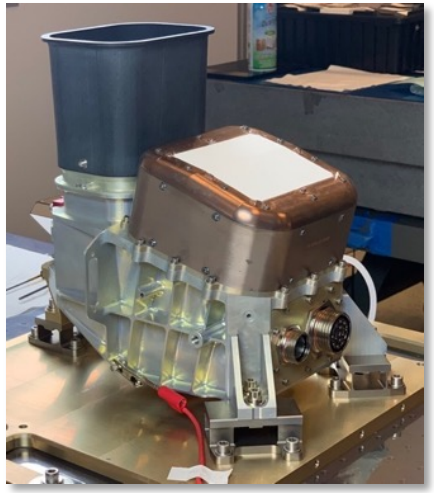
Psyche/Janus

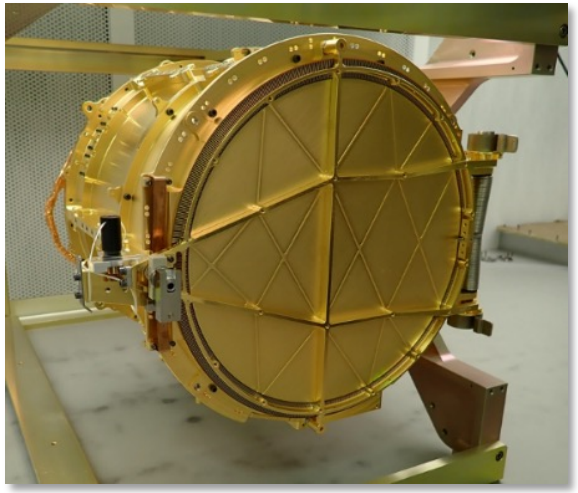
- Psyche spacecraft has arrived at the Cape in preparation for launch
  - Crews performing a range of work including re-installing solar arrays, testing the telecommunications system, loading propellants, before encapsulation and integration on the launch vehicle.
- Launch period is now no earlier than September 20, 2022, pending range availability
  - Launch window extends until October 11, 2022
- Psyche rideshare **Janus** (SIMPLEx-2): team is evaluating the impact of new launch period on their mission plans and is working to accommodate the change



Europa Clipper

- Instruments delivered:
  - E-UVS (Europa Ultraviolet Spectrograph), PI: Kurt Retherford (SwRI)
  - E-THEMIS (Europa Thermal Imaging System), PI Philip Christensen (ASU)
- PIMS (Plasma Instrument for Magnetic Sounding) and EIS WAC (Europa Imaging System Wide Angle Camera) will be delivered to JPL ATLO this week
- KDP-D completed and ATLO started March 2022
- Spacecraft core (RF/prop module) arrived at JPL early June 2022





Above: *E-UVS delivered.* ***Top left:*** *E-THEMIS FM integrated sensor assembly.* ***Top right:*** *Surface Dust Analyzer (SUDA) FM sensor assembly.* ***Bottom right:*** *Spacecraft main body inspection at JPL.*

Dragonfly

Mission Plan

- Launch June 2027; arrive at Titan by 2034
- More than 3 years of exploration, traversing up to ~180 km with 20+ unique landing sites

Status

- Preparing for Mission PDR in October 2022; subsystem and instrument-level reviews have begun
- Focus on preliminary design, technology maturation, and hardware testing
- Receipt and preparation of Titan chamber
- Production of PICA-D heat shield material has begun
- Flight tests of Dragonfly Integrated Platform drone successfully conducted using autonomous takeoff, hop, and autonomous landing
- International agreement with CNES and DLR signed; JAXA agreement in progress

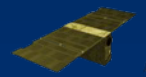
Dragonfly testbed flights. Credit: JHUAPL (Video)

Titan chamber arriving at APL

DART
Double Asteroid Redirection Test

Vandenberg Space Force Base
Nov 24, 2021

IMPACT: Sep 26, 2022

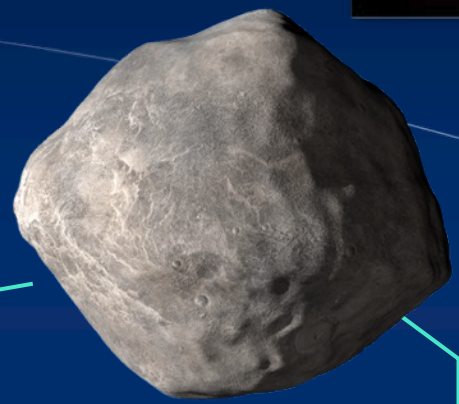


LICIACube
(Light Italian Cubesat for Imaging of Asteroids)
Italian Space Agency contribution

DART Spacecraft
14,000 miles per hour

Dimorphos
160 meters
11.92-hour orbital period

1,180-meter separation between centers

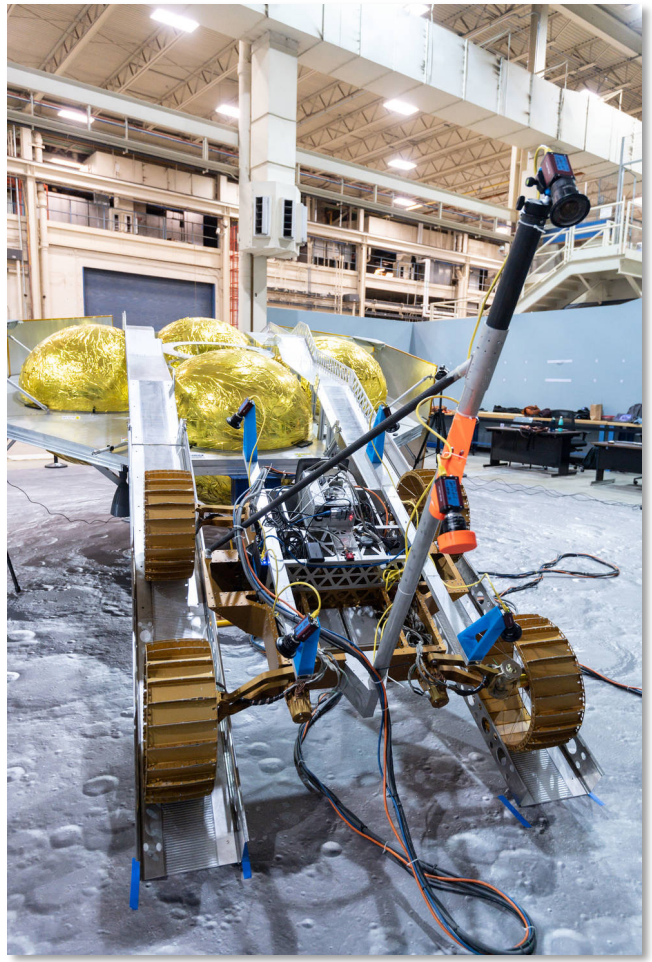


Didymos
780 meters

Earth-Based Observations
6.7 million miles (0.07 AU) from Earth at DART impact

Lunar Strategy and News

- The Moon plays a critical role in Solar System science: many of our highest priority goals can be achieved at the Moon
- Working closely with ESSIO to develop an integrated lunar strategy
- Recent lunar updates:
  - LunaH-Map integrated on Artemis I, awaiting launch
  - Lunar Trailblazer:
    - Removed from IMAP manifest
    - Will fly on IM-2 (PRIME-1), launching about a year from now
  - Eight new VIPER Co-Is selected
  - VIPER team is preparing for System Integration Review
- Full Lunar Science Update (PAC Day 3, Sarah Noble)



Senior Review

- Eight PSD missions have been approved for extended operations through the 2022 Senior Review process:

MRO	Mars Odyssey
InSight	MSL
MAVEN	New Horizons (Details TBD)
LRO	OSIRIS-APEx (APophis EXplorer)

- Most will be extended for three years except:
  - OSIRIS-APEX: for nine years, for Apophis encounter
  - InSight: until end of 2022, unless spacecraft power allows for longer operations
  - New Horizons:
    - Mission has not identified any feasible close flyby targets
    - Two-year extension for a suite of science, jointly funded by Planetary Science / Astrophysics / Heliophysics Divisions
- Two new PIs:
  - OSIRIS-APEX: Daniella DellaGiustina, University of Arizona
  - MAVEN: Shannon Curry, University of California, Berkeley
- *Final Report* and *NASA Response* available online

Venus Science Updates

Venus Science Coordination Group (VeSCoor)

- Being established by NASA and ESA to benefit science return from VERITAS, DAVINCI, and EnVISION (and other potential Venus missions)
  - A forum for dialogue within the broader Venus scientific community
- **Primary goals:** identify new, unanticipated scientific approaches and outcomes based on synergies among the missions to Venus and suggest studies to enhance overall scientific return
- Will meet twice per year, with alternate hosting by NASA and ESA
- Membership:
  - Led by two appointed co-chairs from both Agencies, selected from the community, for two-year terms
  - One member per Venus-mission science team
  - Additional 10 members representing the Venus science community
- Dear Colleague Letter for community involvement will be released by late July 2022

EnVision VenSAR Science Team

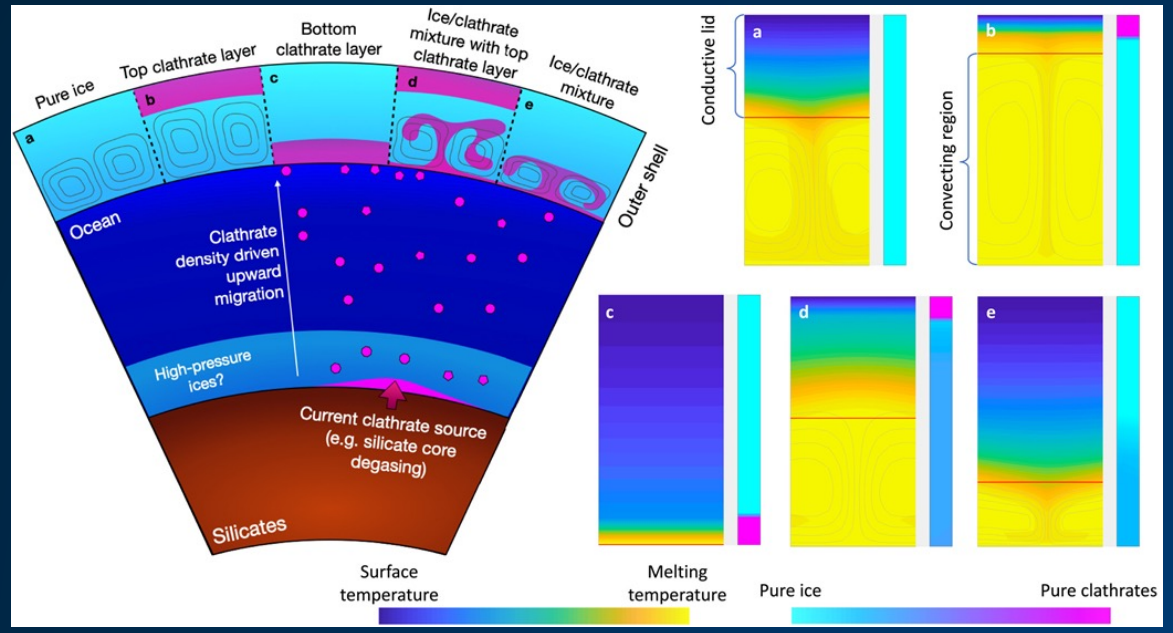
- 14 Scientists competitively selected to join the EnVision Science Team

Science Highlight: Dynamics of Clathrates in Ocean Worlds

Icy ocean worlds have outer shells predominantly composed of ice that insulates internal oceans and are prime targets for where extraterrestrial life may exist

Recent study (**Carnahan et al., 2022**; Geophysical Research Letters):

- Explored dynamics that determine the location of clathrates (gases trapped in water ice) within ice shells
  - Used computer models and physical data for ices and clathrates, based on constraints from Cassini and New Horizons
- Results show clathrates accumulating at the base of the ice shell entrain throughout the shell, which slows convection and thickens the conductive lid
- The pronounced effect of clathrates on heat transport has the potential to preserve sub-ice ocean habitats, and simultaneously limiting avenues for habitability-promoting material transport through the ice shell



Schematic of modeled icy ocean worlds with mixed clathrate-ice outer shells and their corresponding thermal structures


Community

PSD Early Career Award (ECA) 2021 Winners!

Timothy Goudge

(University of Texas, Austin)

Uncrewed aerial vehicles for planetary surface exploration research, outreach, and teaching

Juan Lora

(Yale University)

Disseminating the science of planetary atmospheres and climates

Marisa Palucis

(Dartmouth College)

Using flume studies to quantitatively assess planetary surface processes and paleoclimate

Laura Kerber

(JPL)

Improving science/engineering communication

Richard Remsing

(Rutgers University)

Uncovering the molecular mechanisms of protocell membrane formation and stability

ROSES-22 ECA Call (C.18) proposal deadline: December 8, 2022

Future Announcements of Opportunity

Current release plans:

- **New Frontiers 5:**
  - Pulled forward to 2023 (changed from no later than 2024)
  - Schedule for draft AO and AO to be released soon

- **Discovery:**
  - Now occurring after New Frontiers (timing TBD)

Updated information will be added to the Science Office for Mission Assessments (SOMA) website:
https://soma.larc.nasa.gov/index.html

Inclusion, Diversity, Equity and Accessibility (IDEA)

NASA Equity Action Plan launched April 2022

- Comprehensive effort to assess and examine potential barriers and challenges for historically underrepresented/underserved communities in aerospace and STEM fields
- NASA is assessing its programs, procurement processes, and grant policies to identify systemic barriers that limit representation and participation of a diverse community of students and professionals
- NASA has a responsibility to model inclusivity by implementing initiatives and programs that create opportunities for those who want to contribute to our work in space

SMD is developing and launching a Bridge Program for new researchers

- Will seek to address the lack of clear pathways for career/research experiences, specifically for MSI students
- Will ensure collaborative efforts between MSI, PUIs, very-high-research activity universities and NASA Centers

In PSD

- New internal PSD IDEA team is collecting, tracking, and communicating the many IDEA initiatives in PSD
  - Collaborating with SMD IDEA Working Group on the SMD IDEA strategic plan
- Recent//Upcoming PSD IDEA presentations:
  - Advancing IDEA in Planetary Science conference (April 2022); AbSciCon (May 2022)
  - Day 2 of this PAC meeting

Decadal Survey

Planetary Science and Astrobiology Decadal Survey 2023–2032

- ***Origins, Worlds, and Life*** released April 19, 2022
- NASA is reviewing the recommendations in detail and appreciates the Steering Committee and panels for their dedicated work
- Official timeline for a response is being set by SMD and PSD:
  - Preliminary PSD response will be provided to the National Academies by mid-July
  - Public townhall for the community being planned for August (details TBA)

Response to February 2022 PAC Findings

Finding 1: SPD-41

Finding: A number of AGs highlight that, while there is value in sharing software, the current draft of SPD-41 leaves a number of critical issues unclear. Discussed issues include the full scope of work required for compliance and complexities of software that is not fully funded by NASA. There are concerns that the policy could disadvantage new proposers and those without institutional resources to aid in compliance. The PAC commends NASA for putting the draft policy out for public review, and encourages NASA to fully address the concerns raised by the AGs and by the community through the public comment process.

Response: The community responses to the draft SPD-41 are currently being given full consideration. An update on the progress of implementing the responses will be given by Steven Crawford during this PAC meeting (Day 3).

Finding 2: Inclusion, Diversity, Equity, and Accessibility (IDEA)

Finding: The PAC commends NASA for supporting inclusion, diversity, equity, and accessibility (IDEA) efforts in planetary science and working towards inclusive NASA-supported conferences and meetings. Examples of key areas of support include the cross-AG IDEA working group and the NASA HQ IDEA group as well as the requirement that all NASA-supported workshops include a code of conduct. However, there still remain community-voiced concerns regarding how to improve inclusivity and safety for under-represented minorities at NASA-supported conferences/meetings.

Recommendation: To continue advancing IDEA principles in the community, the PAC recommends that NASA should leverage existing IDEA efforts, such as the IDEA Inter-AG working group, the NASA HQ IDEA group, or social scientists who focus on IDEA, to ensure that all NASA-supported conferences are as inclusive and safe as possible along multiple axes of representation, and in particular for historically excluded communities.

Response: NASA thanks the PAC for these suggestions and plans to continue to engage with these types of groups to help improve inclusion, diversity, equity, and accessibility within the planetary science community. Further updates on the IDEA landscape in PSD and in the wider community will be the focus of several talks on Day 2 of this PAC meeting.

Finding 3: Community Service

Finding: The PAC appreciates the initial efforts to identify avenues of community service within the planetary science community and estimated costs and issues associated with potential direct payment for such work. These efforts present an important starting point for a needed discussion and effort.

Recommendation: In response to the request for PAC feedback with respect to prioritization for potential initial PSD efforts, the PAC recommends a first focus on funding surveys/studies of the workforce to assess the state and concerns of the planetary science community, as these seem less complicated to initiate with funding and may help fill important information gaps.

Response: NASA acknowledges this recommendation and would value such studies for determining how to best approach IDEA issues. As noted under Finding 4, commissioning such a study has significant challenges and would take time to implement.

Finding 4: COVID Impacts & Workforce

Finding: The PAC notes that the impacts of COVID have been numerous and are likely to be felt for years to come, by both individuals and larger efforts such as mission teams. Impacts may result in lower productivity in professional tasks and/or ability to participate in community service work, and may be unevenly distributed within the community. Identification and measurement of impacts are needed to guide mitigation efforts. Surveys of the workforce can provide critical sources of relevant information, either directly about impact or indirectly by looking at who is participating and in what capacities. The most recent workforce survey for the planetary science community was prompted by the ongoing Decadal Survey and was collected prior to COVID.

Recommendation: The PAC recommends that NASA consider commissioning a new survey, with a primary aim of assessing COVID impacts and institutional support for community service. Input on the construction of the survey should be solicited from social scientists, community groups containing relevant expertise (such as the cross-AG IDEA working group or the AAS/DPS Professional Climate and Culture Subcommittee (PCCS)), and/or those involved in constructing and analyzing the last workforce survey.

Response: NASA acknowledges the idea that a robust survey of the Planetary Science workforce would help understand the community, particularly impacts from COVID and the level of current support for community service activities. However, any survey commissioned by NASA must be approved by the OMB—a process that involves a public notice in the Federal Register and an open 60-day comment period, can take at least six months, and may require OMB-requested changes. Even if NASA commissioned a third-party to create, distribute, and analyze such a survey, the OMB may still need to be involved. Professional societies (e.g., AGU or AAS) may be better placed to conduct such a survey.


EXPLORE
With Us

FY2023 Science Budget Request Summary ($M)

	Actual FY21	Enacted FY22	Request FY23	Out-Years FY24	FY25	FY26	FY27
Science	**$7,290.7**	**$7,614.4**	**$7,988.3**	**$8,148.1**	**$8,311.1**	**$8,477.3**	**$8,646.8**
Earth Science	**$1,996.5**	**$2,064.7**	**$2,411.5**	**$2,460.3**	**$2,589.0**	**$2,722.3**	**$2,782.0**
Earth Science Research	$484.3		$534.9	$575.6	$597.5	$609.6	$622.1
Earth Systematic Missions	$773.1		$998.1	$979.3	$1,061.3	$1,119.6	$1,034.5
Earth System Explorers	$0.0		$23.4	$36.3	$92.0	$150.2	$251.3
Earth System Science Pathfinder	$286.8		$308.4	$274.8	$237.5	$219.3	$230.4
Earth Science Data Systems	$299.6		$366.1	$406.7	$383.9	$399.1	$414.8
Earth Science Technology	$83.7		$102.3	$105.9	$114.1	$117.7	$119.0
Applied Sciences	$69.0		$78.2	$81.8	$102.8	$106.7	$109.9
Planetary Science	**$2,693.2**	**$3,120.4**	**$3,160.2**	**$3,186.1**	**$3,197.4**	**$3,176.4**	**$3,299.0**
Planetary Science Research	$304.1		$298.6	$299.4	$309.3	$324.9	$342.3
Planetary Defense	$158.1		$87.7	$116.5	$181.5	$242.5	$247.7
Lunar Discovery and Exploration	$443.5		$486.3	$458.3	$458.3	$458.3	$468.3
Mars Sample Return	$241.6		$822.3	$800.0	$700.0	$600.0	$612.1
Discovery	$447.7		$230.0	$369.6	$540.5	$594.7	$686.4
New Frontiers	$150.9		$478.4	$415.0	$453.8	$409.6	$401.1
Mars Exploration	$339.5		$233.9	$223.8	$211.7	$226.8	$242.1
Outer Planets and Ocean Worlds	$461.5		$356.8	$313.8	$130.3	$120.5	$127.9
Radioisotope Power	$146.3		$166.3	$189.7	$212.1	$199.2	$171.0

FY2023 Science Budget Request Summary ($M)

	Actual	Enacted	Request	Out-Years			
	FY21	FY22	FY23	FY24	FY25	FY26	FY27
Science	**$7,290.7**	**$7,614.4**	**$7,988.3**	**$8,148.1**	**$8,311.1**	**$8,477.3**	**$8,646.8**
Astrophysics	**$1,770.9**	**$1,568.9**	**$1,556.0**	**$1,597.0**	**$1,578.5**	**$1,620.5**	**$1,625.6**
Astrophysics Research	$249.3		$329.8	$350.8	$345.5	$348.4	$350.1
Cosmic Origins	$618.5		$298.5	$316.5	$316.3	$316.6	$316.6
JWST (non-add)	$414.7		$172.5	$187.0	$187.0	$187.0	$187.0
Physics of the Cosmos	$146.4		$159.9	$188.1	$182.4	$182.2	$177.6
Exoplanet Exploration	$552.4		$522.2	$450.2	$423.0	$388.4	$258.0
Astrophysics Explorer	$204.4		$245.6	$291.4	$311.3	$385.0	$523.2
Heliophysics	**$751.0**	**$777.9**	**$760.2**	**$802.6**	**$842.0**	**$851.9**	**$831.9**
Heliophysics Research	$280.8		$225.4	$224.7	$226.2	$226.0	$226.0
Living with a Star	$110.8		$137.3	$133.1	$224.1	$241.3	$200.4
Solar Terrestrial Probes	$133.3		$188.8	$199.1	$117.5	$77.2	$61.4
Heliophysics Explorer Program	$162.7		$157.9	$190.9	$222.6	$270.2	$307.5
Heliophysics Technology	$19.2		$28.4	$23.0	$17.3	$13.0	$14.0
Space Weather	$44.3		$22.3	$31.9	$34.5	$24.2	$22.7
Biological and Physical Sciences	**$79.1**	**$82.5**	**$100.4**	**$102.1**	**$104.1**	**$106.2**	**$108.4**