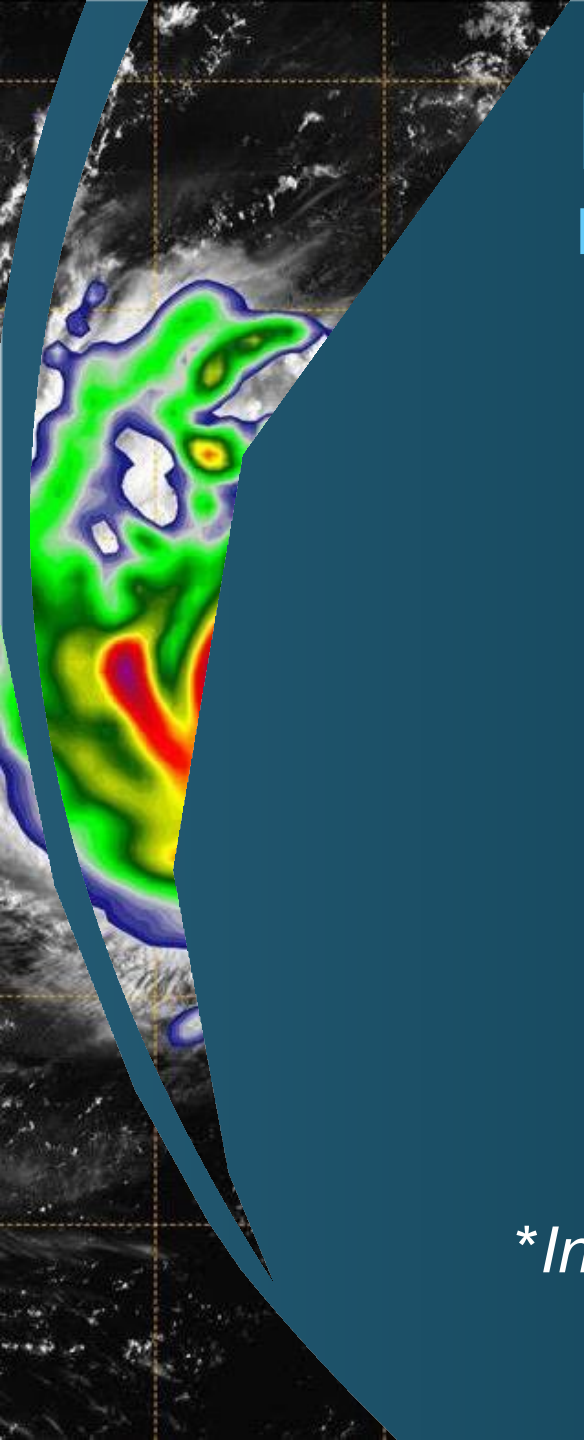
National Aeronautics and Space Administration

EXPLORE EARTH

Ask Me Anything #3

Pamela Millar, Director,
Earth Science
Technology Office,
Earth Science Division
Science Mission Directorate, NASA

August 10, 2022



Earth Science Technology Opportunities

Research Opportunities in Earth and Space Sciences, ROSES

ROSES-22 upcoming solicitations

- **SLIT-22** (Sustainable Land Imaging Technology)

ROSES-23 upcoming solicitations

- **InVEST-23** (In-space Validation of Earth Science Technologies)
- **IIP-23** (Instrument Incubator Program)*

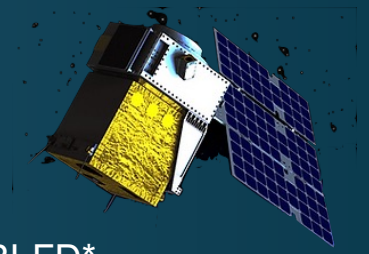
**In some cases an IIP can transition into an InVEST tech demo*

ESTO InVEST-17 CubeSat Launches

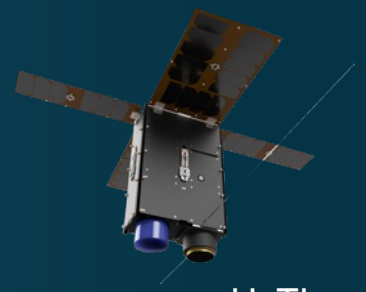
For project details see: https://esto.nasa.gov/invest/

CTIM

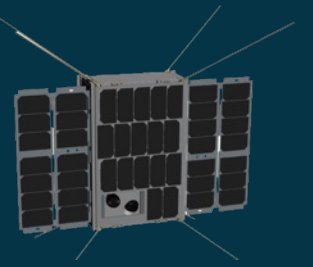
NACHOS-1 & 2



MURI-FD*



HyTI



SNOOPI

2022

June/July

November

February

2023

NASA Earth Science Focus Areas

Atmospheric Composition		Earth Surface and Interior
Carbon Cycle and Ecosystems		Water and Energy Cycle
Climate Variability and Change		Weather and Atmospheric Dynamics

*SLIT, Hosted Payload on YAM5

07.24.22

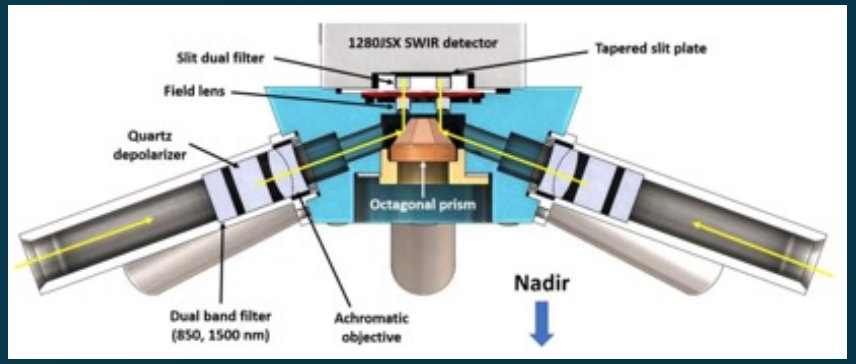
Earth Science Technology Highlight // August 2021

Three New Projects Selected Under InVEST-20

In late June 2021, three new projects were selected, from a total of 13 proposals, under the In-Space Validation of Earth Science Technologies (InVEST) program. The solicitation targeted small instruments and instrument subsystems that can advance technology to enable relevant Earth science measurements. Total funding for these investigations is approximately $16.6 million:

The Aerosol Radiometer for Global Observation of the Stratosphere (ARGOS) Instrument

PI: Matthew DeLand, Science Systems And Applications, Inc., in partnership with GSFC and Loft Orbital



Stratospheric aerosols impact Earth's energy budget through their direct radiative effects. ARGOS instrument will collect limb scattering data of atmospheric aerosols at several wavelengths in multiple viewing directions simultaneously. Such dense sampling could reduce the uncertainty in climate model calculations of post-volcanic eruption global aerosol loading by a factor of 2-3. ARGOS can be considered as a next generation OMPS limb profiler. This is the InVEST program's first hosted payload (via Loft Orbital), the instrument and measurement concept leverages GSFC's IRAD Program and ESTO's Instrument Incubator Program, IIP.

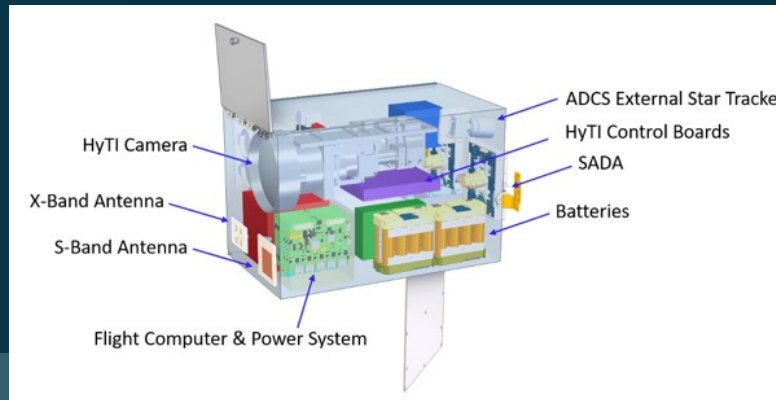
ARCSTONE: Calibration of Lunar Spectral Reflectance from Space

Constantine Lukashin, NASA Langley Research Center

Calibration accuracy and long-term stability are the primary on-orbit performance metrics for all Earth observing sensors. ARCSTONE, a hyperspectral instrument spanning the VSWIR spectral range that was designed to be integrated into a 6U CubeSat in low Earth orbit (LEO), will provide lunar spectral reflectance measurements with a target accuracy < 0.5% (k=1), sufficient to establish an absolute, on-orbit lunar calibration standard for current and future Earth observing sensors. This project is a transition from ESTO's Instrument Incubator Program, IIP and STMD's SBIR Program.

Active Cooling for Multi-spectral Earth Sensors (ACMES)

Charles Swenson, Utah State University



The 6U ACMES CubeSat will demonstrate two technologies: an active architecture for thermal control of instruments on small satellites, which aims to reduce radiator size by 70% for a given application; and a filter incidence narrow-band infrared spectrometer for the detection of methane sources, which will utilize differential absorption to achieve sensitivity equivalent to larger missions, but with a much finer spatial resolution and in a compact form factor. The active thermal architecture in this project is a transition from STMD's Small Spacecraft technology Program, SSTP

For more details: https://esto.nasa.gov/selections-invest20/

Earth Science Flight Opportunities

Open solicitation/In review | Completed solicitation

Mission	Mission Type	Release	Selection	Major Milestone
EVS-1 (EV-1) (AirMoss, ATTREX, CARVE, DISCOVER-AQ, HS3)	5 Suborbital Airborne Campaigns	2009	2010	Completed KDP-F
EVM-1 (CYGNSS)	Class D SmallSat Constellation	2011	2012	Launched Dec. 2016
EVI-1 (TEMPO)	Class C Geostationary Hosted Instrument	2012	2012	Delivered to storage Dec. 2018
EVI-2 (ECOSTRESS & GEDI)	Class C & Class D ISS-hosted Instruments	2013	2014	Launched June & Dec. 2018
EVS-2 (ACT-America, ATOM, NAAMES, ORACLES, OMG, CORAL)	6 Suborbital Airborne Campaigns	2013	2014	Completed KDP-F
EVI-3 (MAIA & TROPICS)	Class C LEO Hosted Instrument & Class D CubeSat Constellation	2015	2016	MAIA Delivery 2022; TROPICS Launch 2022
EVM-2 (GeoCarb)	Class D Geostationary Hosted Instrument	2015	2016	Launch TBD
EVI-4 (EMIT & PREFIRE)	Class C ISS-hosted Instrument & Class D Twin CubeSats	2016	2018	EMIT Launch 2022; PREFIRE Delivery 2023
EVS-3 (ACTIVATE, DCOTSS, IMPACTS, Delta-X, SMODE)	5 Suborbital Airborne Campaigns	2017	2018	4 in deployment. Delta-X is in post-deployment phase.
EVI-5 (GLIMR)	Class C Geostationary Hosted Instrument	2018	2019	Delivery NLT 2024
EVC-1 (Libera**)**	Class C JPSS-Hosted Radiation Budget Instrument	2018	2020	Delivery NLT 2025
EVM-3 (INCUS)	Full Orbital	2020	2021	Launch ~2026
EVI-6	Instrument Only	2022	2023	Delivery NLT 2027
ESE	Explorer Mission	2022	2024	Launch ~2029 & ~2031
EVC-2	Continuity Measurements	2023	2024	Delivery NLT 2028
EVS-4	Suborbital Airborne Campaigns	2023	2024	N/A
ESE	Explorer Mission	2024	2026	Launch TBD
EVI-7	Instrument Only	2024	2025	Delivery NLT 2030
EVM-4	Full Orbital	2024	2025	Launch ~2030
EVC-3	Continuity Measurements	2026	2027	Delivery NLT 2031
EVS-5	Suborbital Airborne Campaigns	2027	2028	N/A

EVS
Sustained sub-orbital investigations
(~4 years)

EVM
Complete, self-contained, small missions
(~4 years)

EVI
Full function, facility-class instruments Missions of Opportunity (MoO)
(~3 years)

EVC
Complete missions or hosted instruments targeting “continuity” measurements
(~3 years)

ESE *(NEW)*
Medium-size instruments and missions
(~2 years)

EVI-6 Announcement of Opportunity (AO)

Final AO released April 19 2022

Proposals due Sept. 2nd 2022

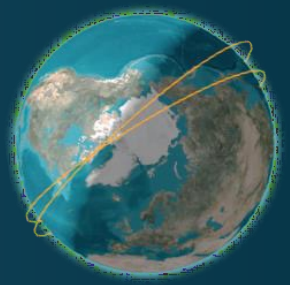
- PI-Managed Mission Cost Cap of $37M (FY24)
- NASA will determine platform and launch vehicle
- Solicits Class D instruments and SmallSats
- Selection anticipated in early 2023

EVI-1
TEMPO

EVI-2
GEDI &
ECOSTRESS

EVI-3
TROPICS

EVI-3
MAIA

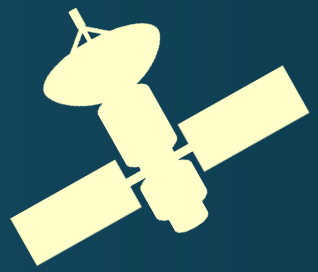


EVI-4
PREFIRE

EVI-4
EMIT

EVI-5
GLIMR

EVI-6
TBD



EARTH SYSTEM OBSERVATORY

INNOVATION & COMPETITION
EARTH EXPLORER MISSIONS

Greenhouse Gases

Ozone and Trace Gases

Atmospheric Winds

Ice Elevation

Snow Depth and Water Content

3D Ecosystem Structure

Ocean Surface Winds and Currents

Ask Me Anything Panel # 3
Lead NASA Organization: Earth Science Division, ESTO

National Aeronautics and Space Administration

Description of NASA Organization

Earth Remote Sensing from LEO, GEO / Earth Venture, InVEST, IIP, ACT, SLI-T, DSI

Impact / Importance of tech demos – reduce risk for larger missions, serve as pathfinders for constellations – which provide new measurement capabilities

Target Audience – Academia, Industry, NASA Centers, OGA, NGA's, FFRDC's, non-profits

Challenges & Lessons Learned:

- COVID impacts: supply chain issues and inflation, dynamic labor market,"just in time" spectrum licenses
- Don't use SD cards, or take short cuts testing, test as you fly, leverage commercial services

Current Opportunities/Status

EVI-6: mandatory NOI's June 2, 2022 with proposals due Sept. 1st, 2022, cost cap - $37M
https://essp.larc.nasa.gov/EVI-6/

Future Plans:

ROSES-23,24*

- InVEST Q1 FY24
- SLI-T Q1 FY23
- IIP Q1 FY24
- DSI Q3 FY24

*subject to change pending budget appropriation

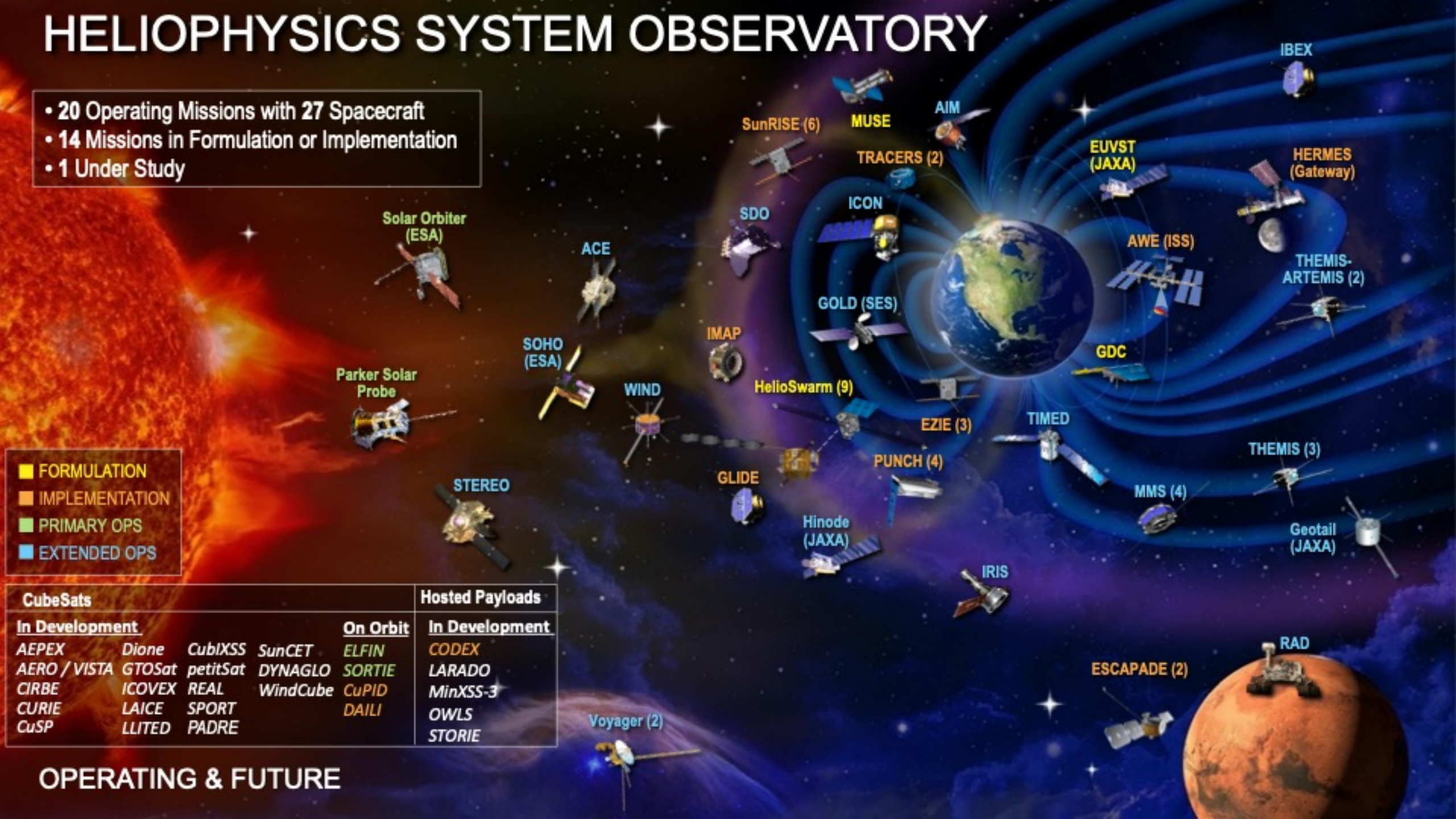
For more information contact:

Pamela Millar, Director of Earth Science Technology Office, or Sachi Babu, InVEST, SLI-T PM
Pamela.S.Millar@nasa.gov
sachidananda.r.babu@nasa.gov

See: https://esto.nasa.gov/

HELIOPHYSICS SYSTEM OBSERVATORY

- **20** Operating Missions with **27** Spacecraft
- **14** Missions in Formulation or Implementation
- **1** Under Study



- FORMULATION
- IMPLEMENTATION
- PRIMARY OPS
- EXTENDED OPS

CubeSats					Hosted Payloads
In Development				**On Orbit**	**In Development**
AEPEX	*Dione*	*CubIXSS*	*SunCET*	*ELFIN*	*CODEX*
AERO / VISTA	*GTOSat*	*petitSat*	*DYNAGLO*	*SORTIE*	*LARADO*
CIRBE	*ICOVEX*	*REAL*	*WindCube*	*CuPID*	*MinXSS-3*
CURIE	*LAICE*	*SPORT*		*DAILI*	*OWLS*
CuSP	*LLITED*	*PADRE*			*STORIE*

OPERATING & FUTURE

NASA Science Mission Directorate, Heliophysics Division Programs

National Aeronautics and Space Administration

Research

Highlights the newest mission data, utilizes the latest advances in modeling and machine learning, and develops the most innovative technological solutions.

Solar Terrestrial Probes (STP)

Addresses fundamental science questions about the very nature of space itself, and the flow of material and energy throughout the solar system– from the Sun to Earth to other planets to the interstellar boundary.

Explorers

Provides frequent flight opportunities for world-class scientific investigations from space utilizing innovative, streamlined and efficient management approaches within the heliophysics and astrophysics science areas.

Living With a Star (LWS)

Targets specific aspects of the Sun-Earth system that affect life and society: provides a predictive understanding of the Sun-Earth system, linkages among the interconnected systems, and, specifically, space weather conditions at Earth and the interplanetary medium.

Space Weather

Advances the science of space weather to empower a technological society safely thriving on Earth and expanding into space.

Technology

The Heliophysics Technology Program Office (HESTO) enables more focused, impactful, and innovative technology investments.

NASA Science Mission Directorate, Heliophysics Division
ROSES-2022 https://nspires.nasaprs.com/

National Aeronautics and Space Administration

Status	Solicitation	Release Date	Due Date
Open	B.10 Heliophysics Flight Opportunities Studies	2/14/22	9/1/22
Open	B.12 Heliophysics Data Environment Enhancements	2/14/22	3/29/23
Open	B.15 Heliophysics Innovation in Technology and Science	2/14/22	3/29/23
Open	B.16 Heliophysics Artificial Intelligence/Machine Learning-Ready Data	2/14/22	1/18/23
Open	B.17 Interdisciplinary Science for Eclipse: due dates TBD	2/14/22	2/14/23
Open	B.2 Heliophysics Supporting Research	2/14/22	2/14/23
Open	B.20 Heliophysics Tools and Methods	2/14/22	3/29/23
Open	B.22 Space Weather Centers of Excellence	2/14/22	See Details
Open	B.3 Heliophysics Theory, Modeling and Simulations	2/14/22	3/14/22
Open	B.5 Living with a Star Science	2/14/22	10/10/22
Open	B.8 Heliophysics Technology and Instrument Development for Science	2/14/22	8/31/22
Open	B.9 Heliophysics Low-Cost Access to Space: due dates TBD	2/14/22	2/14/23
Due in 30 days	B.14 Heliophysics Early Career Investigator Program	2/14/22	7/28/22
Due in 30 days	B.21 Heliophysics Citizen Science Investigations	2/14/22	8/18/22
Due in 30 days	B.4 Heliophysics Guest Investigators-Open	2/14/22	8/9/22
Draft	Draft 2022 Heliophysics Explorer Mission of Opportunity (MO) AO	6/22/22	Comments 7/22/222
Draft	Draft 2022 Heliophysics Small Explorer (SMEX) AO	6/22/22	Comments 7/22/22
Closed	B.11 Heliophysics Flight Opportunities for Research and Technology	2/14/22	6/22/22
Closed	B.7 Space Weather Science Application Research-to-Operations-to-Research	2/14/22	6/14/22

Ask Me Anything Panel # 3
Lead NASA Organization: Science Mission Directorate/Planetary Science

National Aeronautics and Space Administration

NASA's Planetary Science Division (PSD) sponsors Small Innovative Missions for Planetary Exploration (SIMPLEx), a component of NASA's Discovery Program

Smallsats provide an opportunity to do deep space planetary science at a low cost, utilizing ridesharing with other primary missions

Universities are a major component of the SIMPLEx target audience

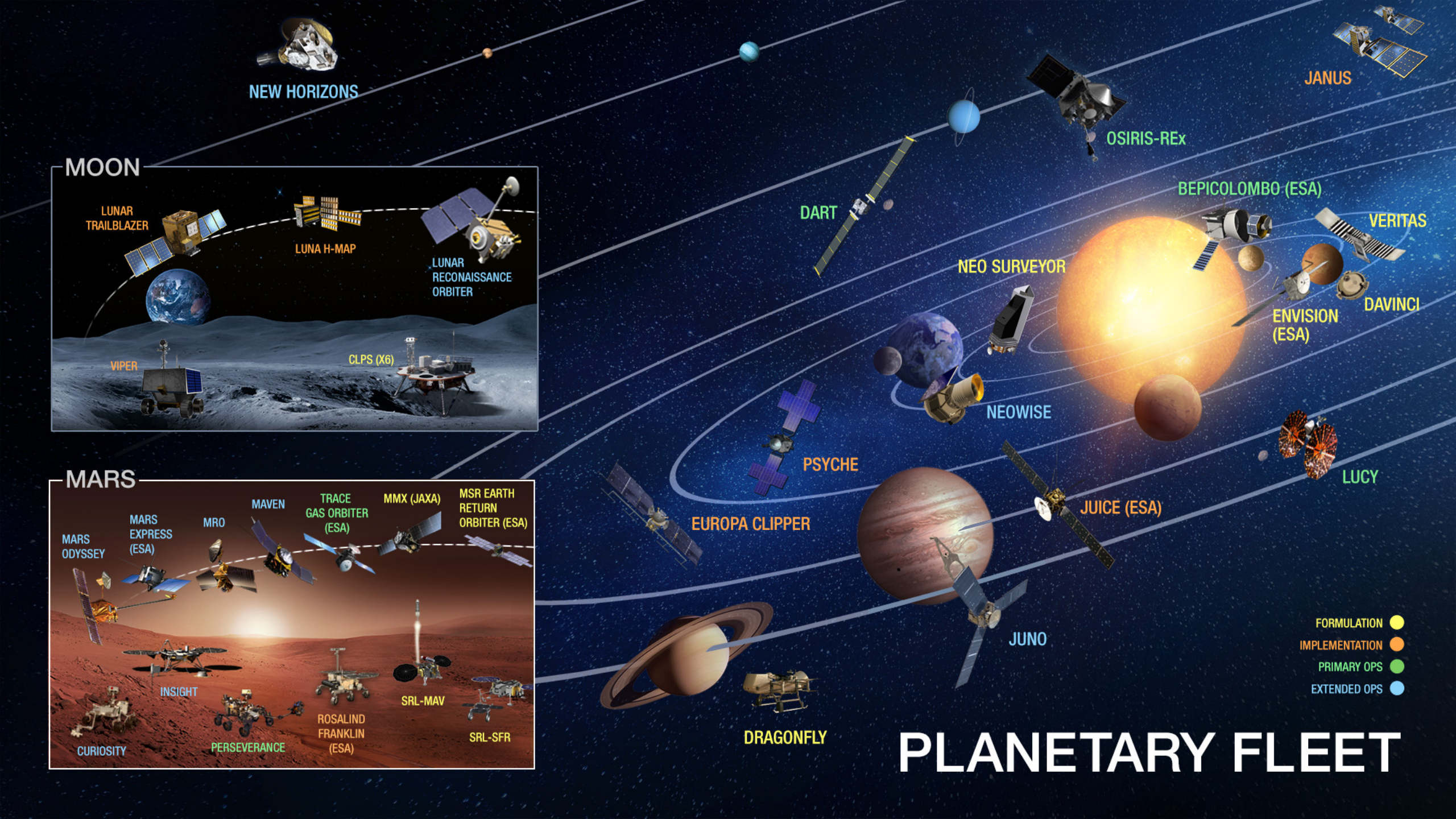
Lessons Learned from SIMPLEx-2 are currently being compiled

A SIMPLEx-3 call is being considered within PSD at this time

Future call dates are currently TBD

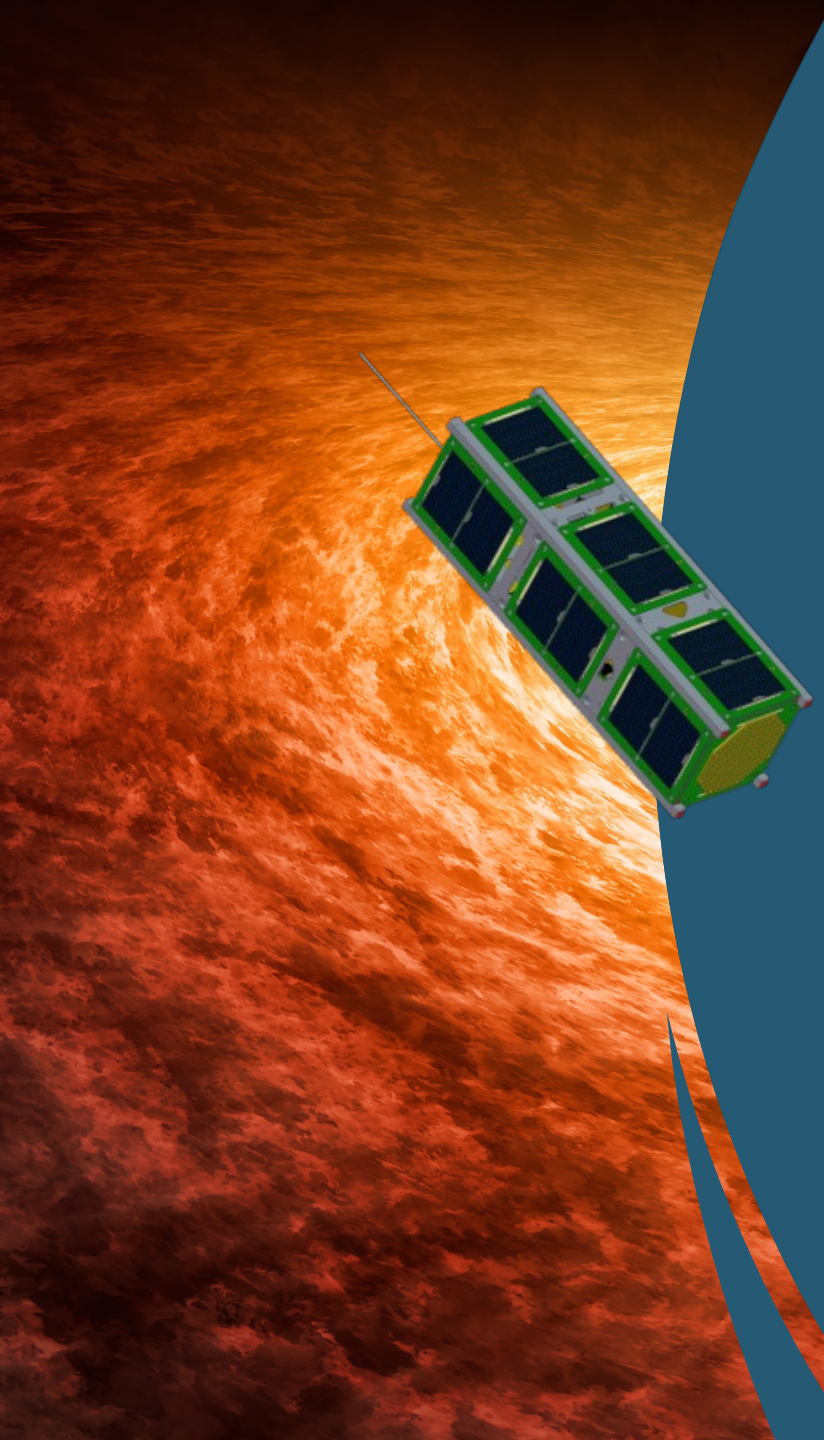
For more information contact:

William Knopf (wknopf@hq.nasa.gov)
Doris Daou (doris.daou-1@nasa.gov)


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

CubeSat Particle Aggregation and Collision Experiment (Q-PACE)

PI: Joshua Colwell, University of Central Florida



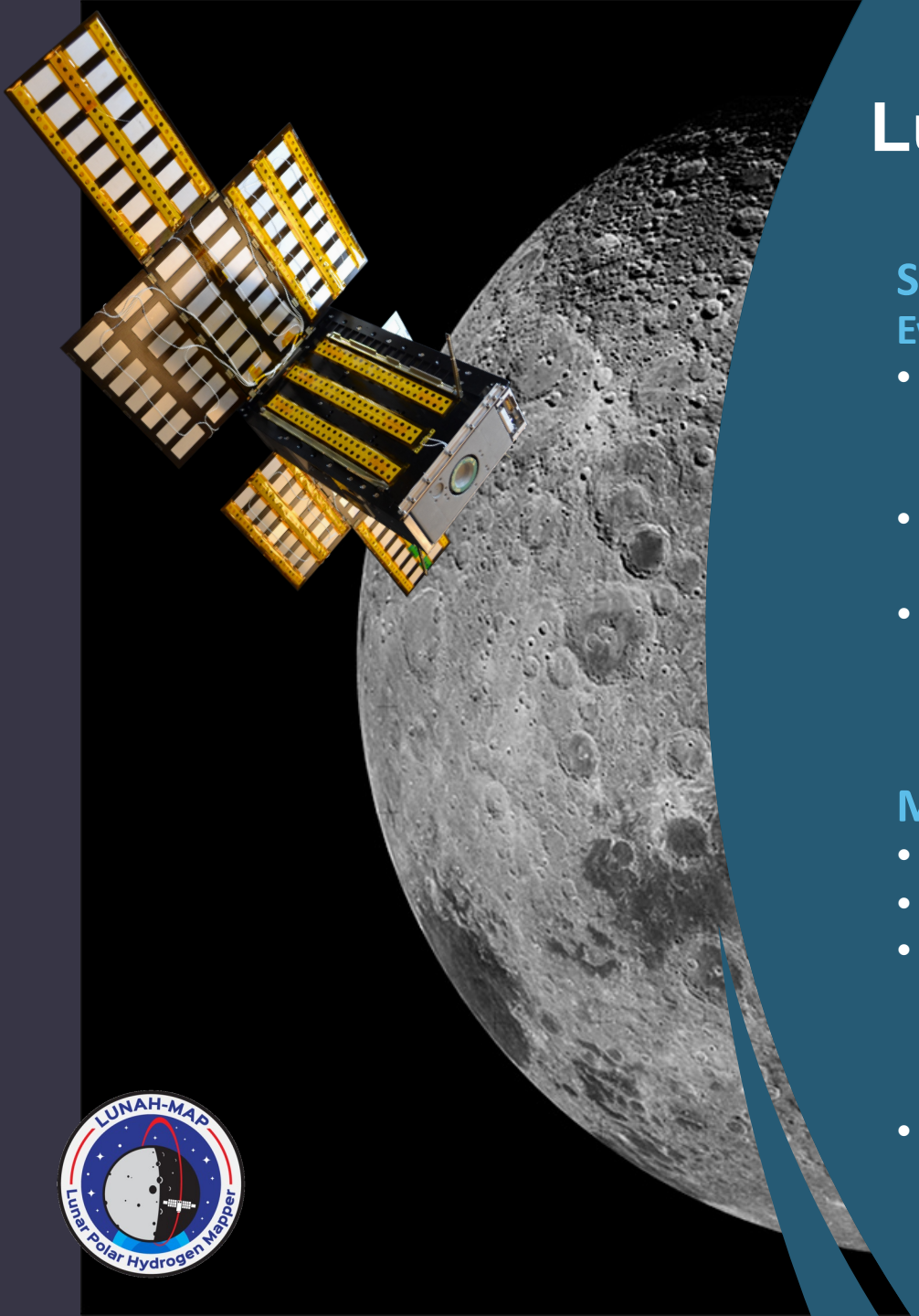
Science Objective:

Explore the fundamental properties of low velocity particle collisions to understand accretion in protoplanetary disks and planetary ring systems

- Particles introduced into mechanically-shaken experiment test chamber
  - 1 cm glass marbles
  - 1-2 mm glass beads and chondrules
  - 0.1-1.0 mm dust aggregates (from 1-10 micron SiO2)
  - Velocities from <1 mm/s to several cm/s
- 3 year mission duration increases the likelihood of observing rare adhesion and fragmentation events

Mission Facts:

- Selected in 2015 under SIMPLEx-1, budget <$500K
- 3U CubeSat, solar powered
- **Launched to 500 km orbit on Virgin Orbit LauncherOne Jan 17, 2021**
  (under NASA's ELaNa program)
- Contact with spacecraft never established; mission declared lost



Small Innovative Missions for Planetary Exploration (SIMPLEx-1)

Lunar Polar Hydrogen Mapper (LunaH-Map)

PI: Craig Hardgrove, Arizona State University

Science Objective:

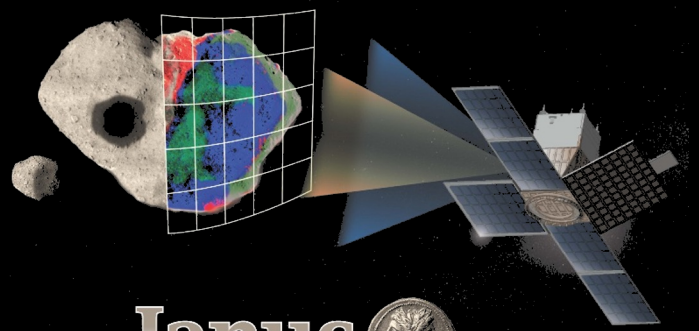
Evaluate uniformity of bulk hydrogen abundance at the lunar south pole

- Determine if the top meter of the lunar south pole hydrogen distribution is consistent with expected permafrost depths and frost distributions
- Spatially resolve the permanently shadowed regions and determine if hydrogen enrichments are contained within 15 square-km
- Determine if hydrogen is enhanced in regions of the lunar south pole outside of permanent shadow and where ice is not predicted to be stable <1m

Mission Design:

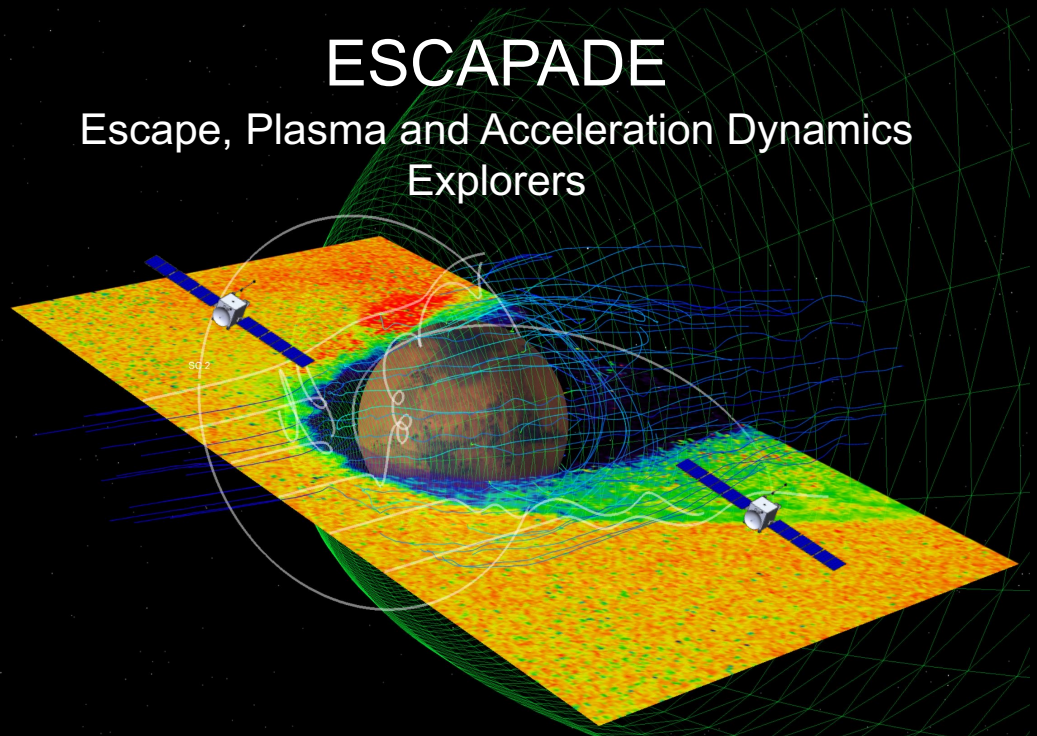
- 6U CubeSat
- Will be launched on Artemis I (current launch date: August 29, 2022)
- Solar electric propulsion used to enter highly elliptical lunar polar orbit (~10 km periapsis)
  - 70 days for lunar capture; 360 days to reach science orbit; 60 days prime mission
- Miniature Neutron Spectrometer (Mini-NS) with novel CLYC ($Cs_2LiYCl_6:Ce$) scintillator will provide high-resolution maps of hydrogen within ~5 degrees of the pole

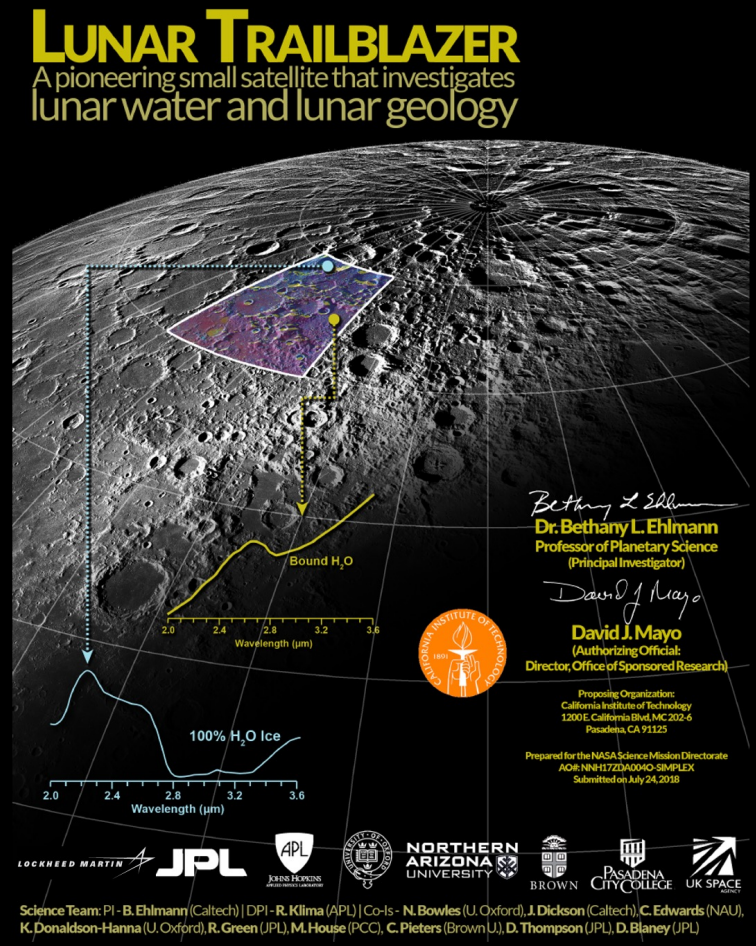
Small Innovative Missions for Planetary Exploration (SIMPLEx-2)



ESCAPADE

Escape, Plasma and Acceleration Dynamics Explorers





Janus is nearing ATLO completion; Awaiting decision on Psyche path forward

ESCAPADE supported by the Heliophysics Division CDR held June 2022

Lunar Trailblazer managed by PSD and supported by Exploration Science Strategy and Integration Office Currently in ATLO

NASA Scienced Mission Directorate Astrophysics Division

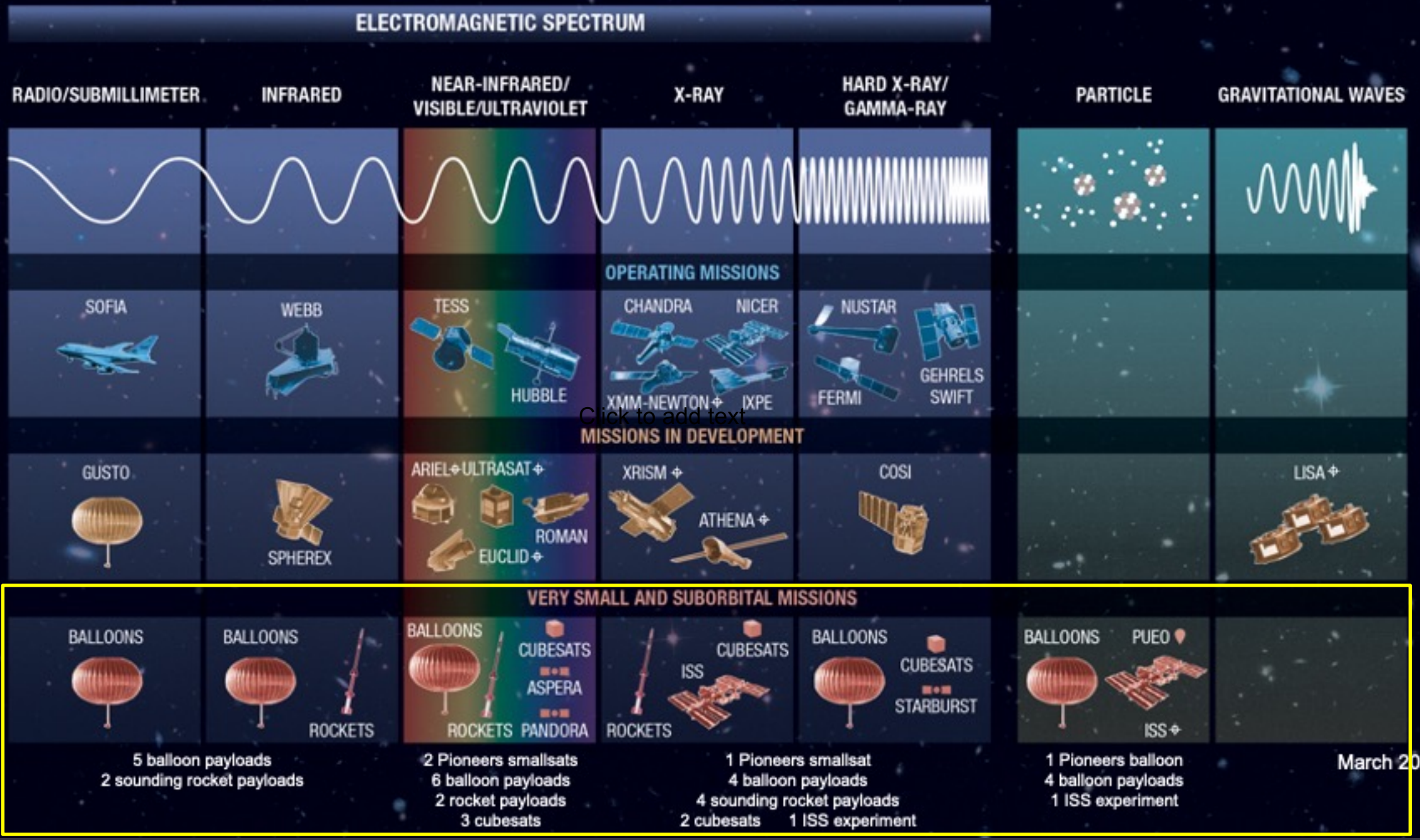
National Aeronautics and Space Administration

In the Science Mission Directorate (SMD), the Astrophysics Division (APD) studies the universe with the goal of seeking to understand the universe and our place in it.

In support of these goals APD seeks to discover how the universe works, explore how it began and is evolving, and search for life on planets around other stars.

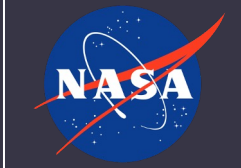
The recently launched JWST will see the first stars and the first galaxies formed after the Big Bang, revealing the full history of the universe.

https://science.nasa.gov/astrophysics


ELECTROMAGNETIC SPECTRUM
RADIO/SUBMILLIMETER
INFRARED
NEAR-INFRARED/ VISIBLE/ULTRAVIOLET
X-RAY
HARD X-RAY/ GAMMA-RAY
PARTICLE
GRAVITATIONAL WAVES
OPERATING MISSIONS
SOFIA
WEBB
TESS
HUBBLE
CHANDRA
NICER
XMM-NEWTON
IXPE
NUSTAR
FERMI
GEHRELS SWIFT
Click to add text
MISSIONS IN DEVELOPMENT
GUSTO
SPHEREX
ARIEL
ULTRASAT
ROMAN
EUCLID
XRISM
ATHENA
COSI
LISA
VERY SMALL AND SUBORBITAL MISSIONS
BALLOONS
ROCKETS
CUBESATS
ASPERA
PANDORA
ISS
STARBURST
PUEO
5 balloon payloads
2 sounding rocket payloads
2 Pioneers smallsats
6 balloon payloads
2 rocket payloads
3 cubesats
1 Pioneers smallsat
4 balloon payloads
4 sounding rocket payloads
2 cubesats
1 ISS experiment
1 Pioneers balloon
4 balloon payloads
1 ISS experiment
March 2022

NASA Scienced Mission Directorate Astrophysics Division Pioneers

National Aeronautics and Space Administration



Astrophysics Pioneers

The Pioneers Program is a new program started in 2020 which is intended to do compelling astrophysics science at a lower cost cap than missions in the Explorers Program and larger.

Missions will include SmallSats, major Balloon payloads, (cis)-lunar payloads, and modest payloads attached to the International Space Station with a $20M cost cap (excluding launch).

Current Pioneers Missions

Four concepts chosen for further study in January 2021, and after passing a gate review all four were approved for development to flight and operations.

- ASPERA
- Pandora
- PUEO
- StarBurst

Latest selection: TIGERISS!

https://science.nasa.gov/astrophysics/programs/astrophysics-pioneers

NASA Scienced Mission Directorate Astrophysics Division APRA

National Aeronautics and Space Administration

Astrophysics CubeSats

Astrophysics CubeSats are solicited annually via ROSES/APRA (D.3).

CubeSats are reviewed along with other sub-orbital proposals, including balloons, sounding rockets, and ISS attached payloads.

Current CubeSat Missions

- **CUTE** – in operation
- **BurstCube** – in development
- **SPRITE** – in development
- **SPARCS** – In development
- **BlackCat** – in development
- **CANDELS** – in development