

National Aeronautics and
Space Administration



EXPLORESCIENCE

NASA Heliophysics Division Update

NASA Space Exploration & Space Weather Workshop
October 17, 2019

Dr. Nicola J. Fox

Director, Heliophysics Division
Science Mission Directorate

The Dawn of a New Era for Heliophysics



Heliophysics Division (HPD), in collaboration with its *partners*, is poised like never before to --

Explore uncharted territory from pockets of intense radiation near Earth, right to the Sun itself, and past the planets into interstellar space.

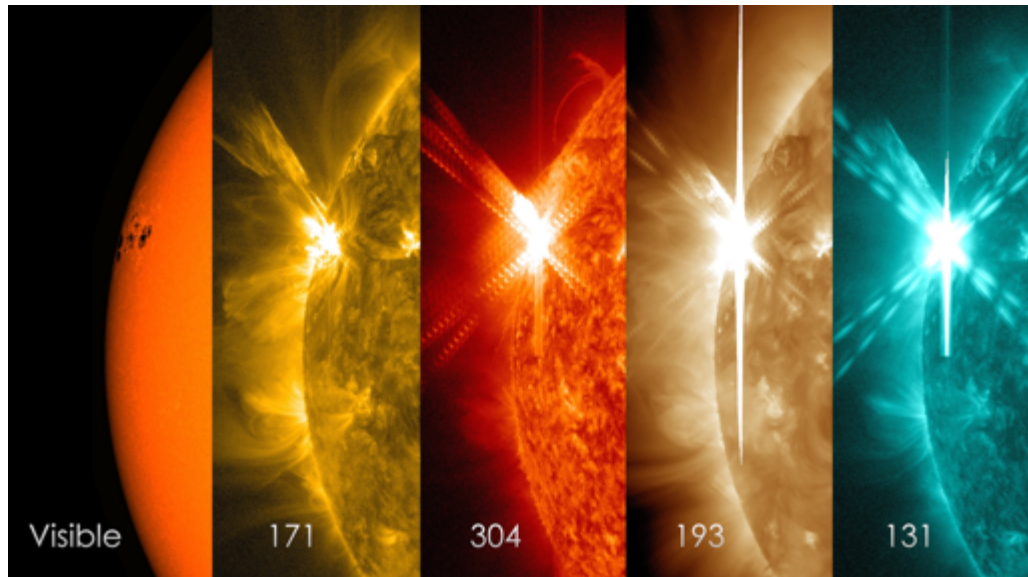
Strategically **combine research from a fleet of carefully-selected missions** at key locations to better understand our entire space environment.

Understand the interaction between Earth weather and space weather – **protecting people and spacecraft.**

Coordinate with other agencies to fulfill its role for the Nation enabling advances in **space weather knowledge and technologies**

Engage the public with research breakthroughs and citizen science

Develop the **next generation** of heliophysicists



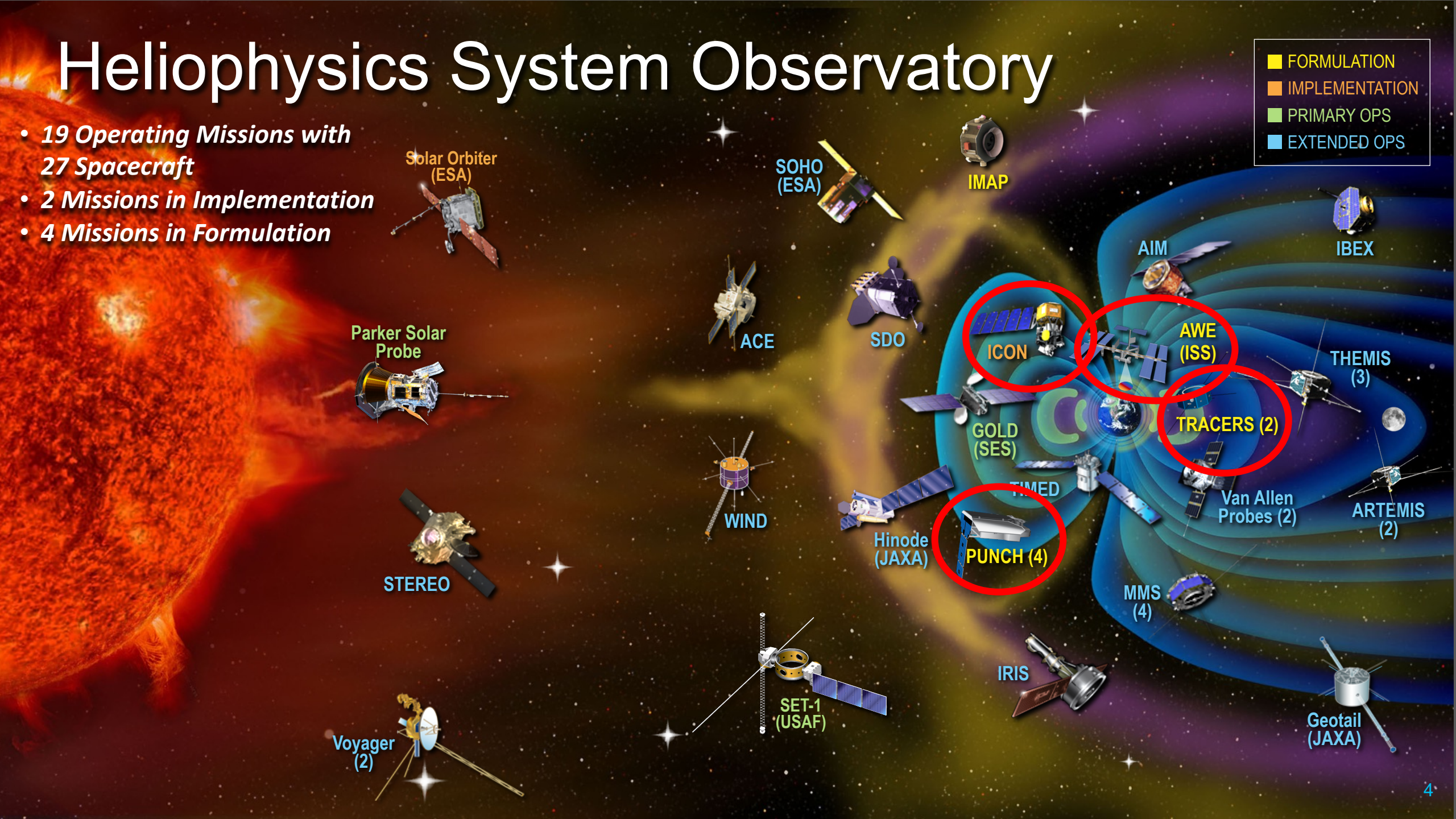
The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space filled with numerous small stars and a prominent, bright blue nebula on the right side. The bottom half features a warm orange and yellow space filled with many small stars and a greenish-yellow nebula on the right side. A light blue horizontal band runs across the middle of the slide, containing the text.

NEW Missions

Heliophysics System Observatory

■	FORMULATION
■	IMPLEMENTATION
■	PRIMARY OPS
■	EXTENDED OPS

- 19 Operating Missions with 27 Spacecraft
- 2 Missions in Implementation
- 4 Missions in Formulation



Ionospheric Connection Explorer (ICON)



Launch Vehicle: Pegasus XL rocket

Launch Site: Cape Canaveral

Launched: October 10, 2019

ICON Principal Investigator: Tom Immel, UC Berkeley

Description:

- ICON will study the frontier of space: the dynamic zone high in our atmosphere where terrestrial weather from below meets space weather above.
- In this region, the tenuous gases are anything but quiet, as a mix of neutral and charged particles travel through in giant winds.
- These winds can change on a wide variety of time scales -- due to Earth's seasons, the day's heating and cooling, and incoming bursts of radiation from the sun.

Next Step: *Instrument commissioning*





Explorers AO 2016 SMEX Selections

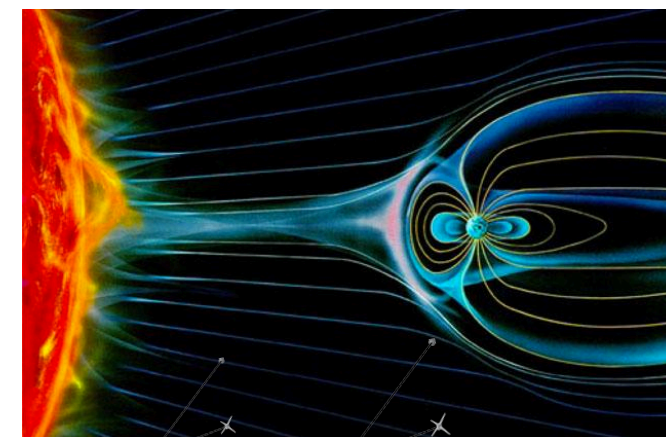
Polarimeter to Unify the Corona and Heliosphere (PUNCH)

- Focuses directly on the Sun's corona, and how it generates the solar wind
- Image and track the solar wind as it leaves the Sun.
- Track coronal mass ejections to better understand their evolution and develop new techniques for predicting such eruptions
- Composed of four suitcase-sized satellites
- **Principal Investigator:** Dr. Craig DeForest at Southwest Research Institute



Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites (TRACERS)

- Observe particles and fields at the Earth's northern magnetic cusp region and study how magnetic fields around Earth interact with those from the Sun.
- First space mission to explore this process in the cusp with two spacecraft, providing observations of how processes change over both space and time.
- **Principal Investigator:** Craig Kletzing at University of Iowa



LRD NLT Aug 2022

"We carefully selected these two missions not only because of the high-class science they can do in their own right, but because they will work well together with the other heliophysics spacecraft advancing NASA's mission to protect astronauts, space technology and life down here on Earth" – Thomas Zurbuchen

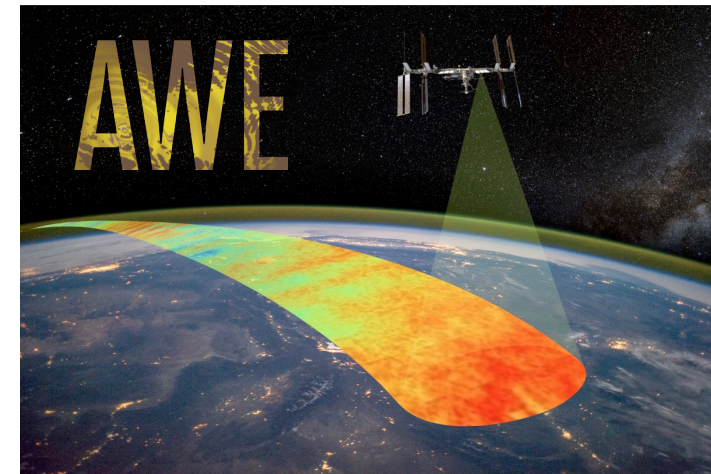




2016 Explorers MO Selections

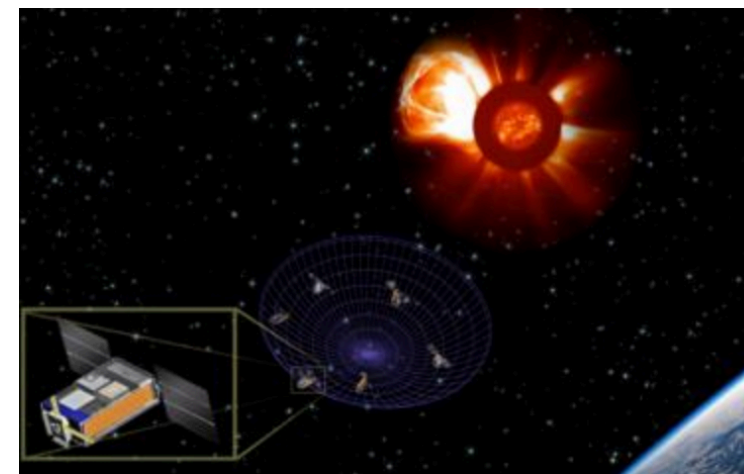
Atmospheric Waves Experiment (AWE)

- Attached to the exterior of the ISS, AWE will focus on airglow to determine what combination of forces drive space weather in the upper atmosphere.
- **Principal Investigator:** Mike Taylor at Utah State University
- LRD NET Aug. 2022



Sun Radio Interferometer Space Experiment (SunRISE)

- Selected for a seven-month, \$100,000 extended formulation study.
- SunRISE would be an array of six CubeSats operating like one large radio telescope to investigate how giant space weather storms from the Sun are accelerated and released into planetary space.
- **Principal Investigator:** Justin Kasper at the University of Michigan in Ann Arbor



Credit: [University of Colorado at Boulder](https://www.colorado.edu/boulder)

2018 STP Science MOs to ride with IMAP

Two missions selected (Aug 13) for nine-month concept studies; down-selection in 2020

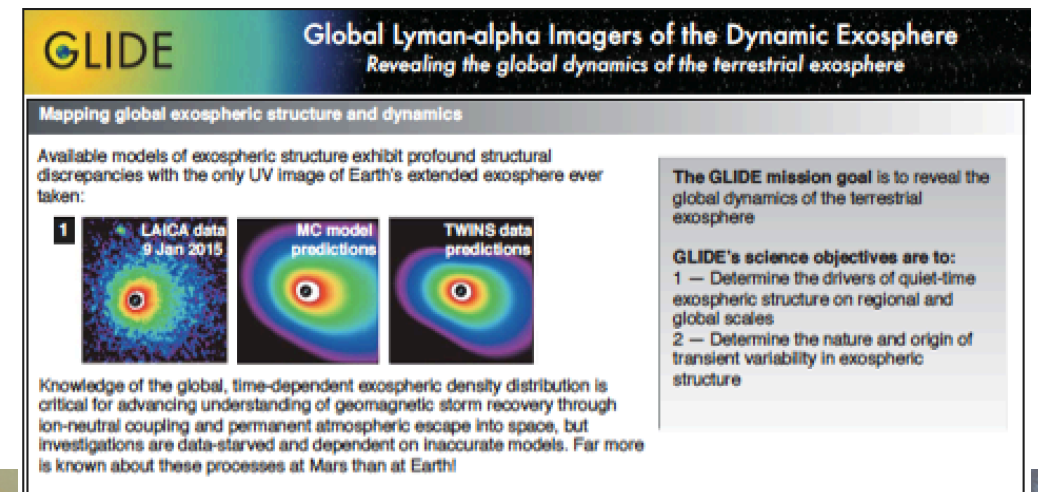
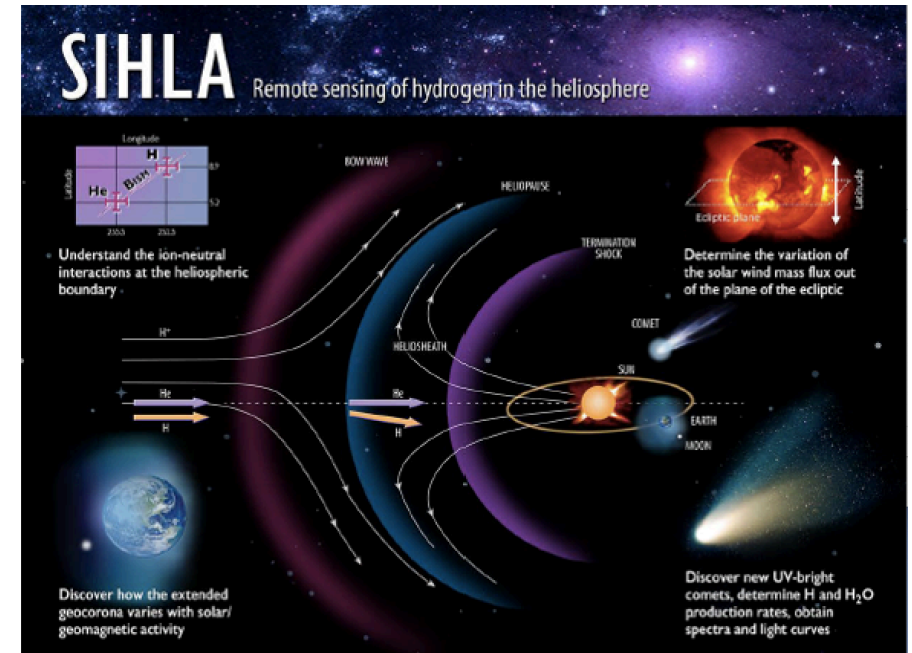
Spatial/Spectral Imaging of Heliospheric Lyman Alpha (SIHLA)

- would focus on mapping the velocity and distribution of the solar wind helping to resolve our understanding of what drives structure in the solar wind and heliopause.
- Principal Investigator:** Larry Paxton at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.

Global Lyman-alpha Imagers of the Dynamic Exosphere (GLIDE)

- would gather ultraviolet light emitted from hydrogen at a high rate, with a view of the entire exosphere.
- Principal Investigator:** Lara Waldrop at the University of Illinois at Urbana-Champaign

LRD Oct 2024



2018 STP Technology Demonstration MOs

Two missions selected (Aug 15) for nine-month concept studies; down-selection in 2020.

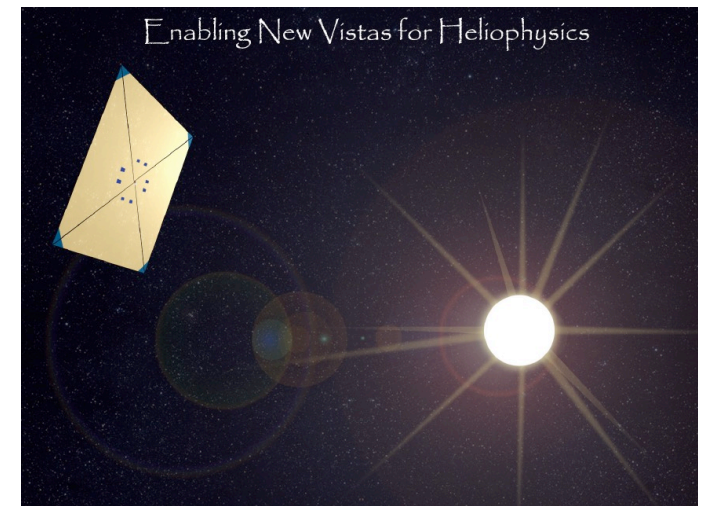
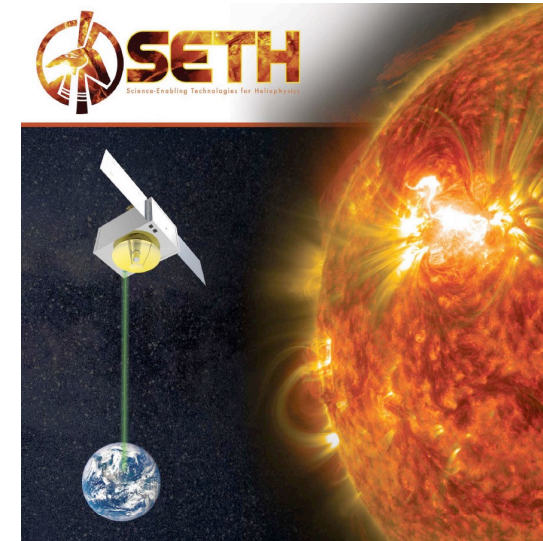
Science-Enabling Technologies for Heliophysics (SETH)

- Demonstrate technologies in two areas:
 1. Deep space small satellite optical communications; and
 2. Solar energetic neutral atom (ENA) detector that detects X-rays and energetic charged particles as well.
- **Principal Investigator:** Antti Pulkkinen at NASA's Goddard Space Flight Center in Greenbelt, Maryland

Solar Cruiser

- Designed to mature solar sail technologies and demonstrate a novel solar coronagraph for SmallSat applications.
- 1666m² solar sail would be the largest ever flown
- **Principal Investigator:** Les Johnson at NASA's Marshall Space Flight Center in Huntsville, Alabama

LRD Oct 2024





3 Explorers Missions of Opportunity to Advance Understanding of Heliophysics

Three missions selected (Sep 3) for nine-month concept studies; down-selection in 2020.

Extreme Ultraviolet High-Throughput Spectroscopic Telescope (EUVST) Epsilon Mission

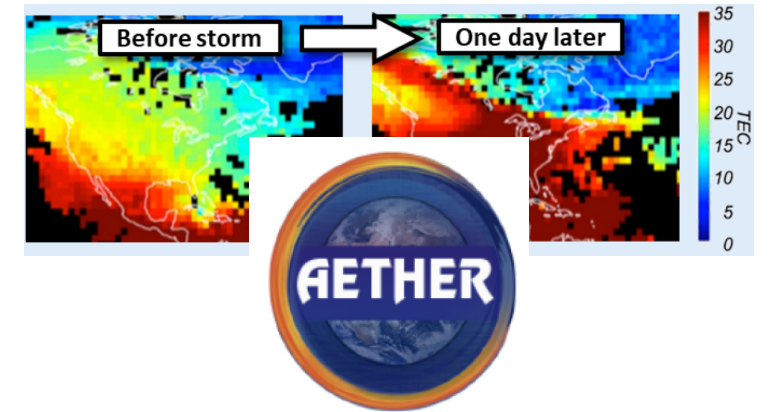
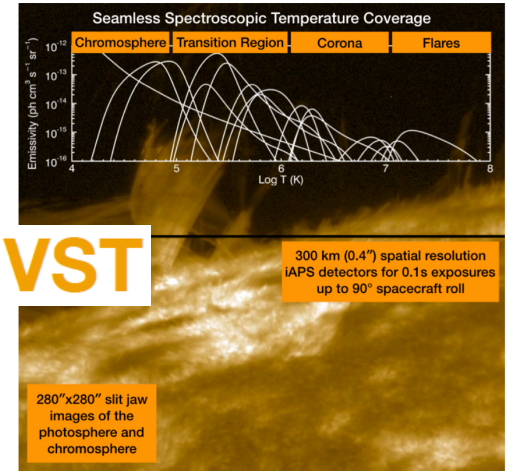
- EUVST would observe simultaneously, for the first time and over a wide range of the lower solar atmosphere, how magnetic fields and plasma interact.
- Instrument to fly on JAXA's Solar-C mission
- **Principal Investigator:** Clarence Korendyke at the U.S. Naval Research Laboratory in Washington, D.C.

Aeronomy at Earth: Tools for Heliophysics Exploration and Research (AETHER)

- AETHER would explore the ionosphere-thermosphere system and its response to geomagnetic storms from a position aboard the International Space Station.
- **Principal Investigator:** James Clemmons at the University of New Hampshire in Durham.

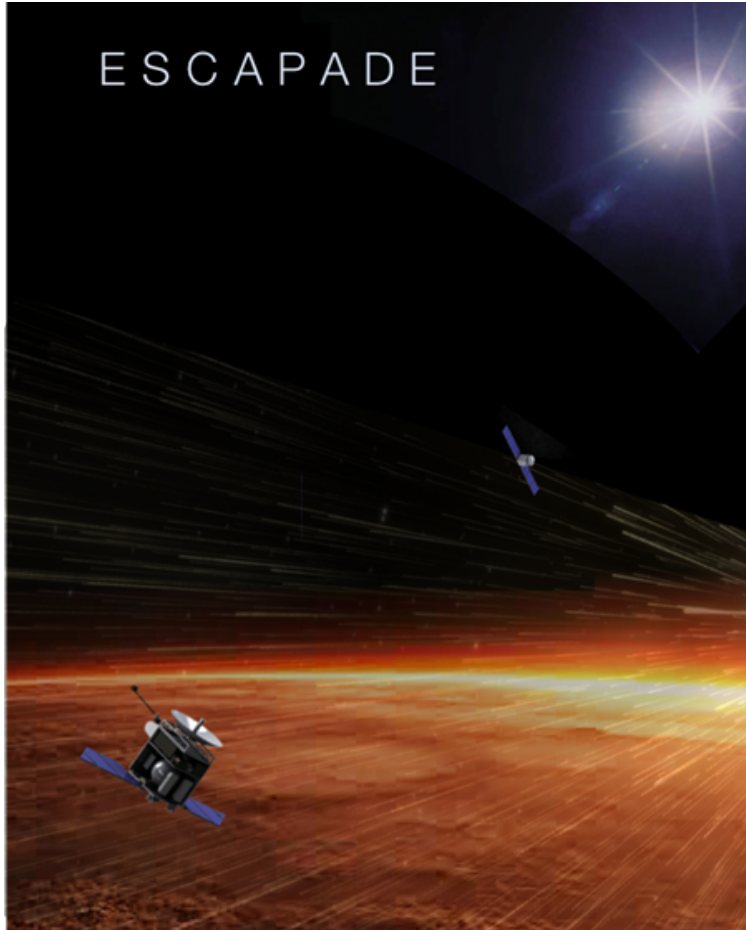
Electrojet Zeeman Imaging Explorer (EZIE)

- EZIE would focus on an electric current known as the auroral electrojet, which circles through the atmosphere around 60 to 90 miles above Earth, near the poles.
- **Principal Investigator:** Jeng-Hwa Yee at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.



Each potential mission has a separate launch opportunity and time frame.

Escape, Plasma Acceleration and Dynamics Explorers (EscaPADE)



Selection Date: Jul 8, 2019

Principal Investigator: Robert Lillis, University of California, Berkeley

Observatory: Dual observatories rideshare hosted on Psyche mission

Instruments:

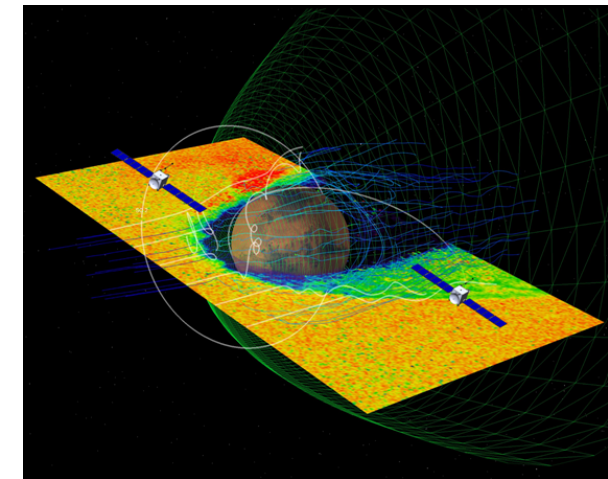
EscaPADE Magnetometer (EMAG)

EscaPADE Electrostatic Analyzer (EESA)

EscaPADE Langmuir Probe (ELP)

With unprecedented two-point plasma measurements, ESCAPADE will untangle temporal from spatial variability and definitively map out the transfer of energy and momentum that leads to ion and sputtering escape, enabling a much more reliable extrapolation of escape rates to early Mars.

LRD Aug 2022



NASA Selects 12 New Lunar Science, Technology Investigations

The selected investigations will go to the Moon on future flights through NASA's **Commercial Lunar Payload Services (CLPS)** project and the NASA Exploration Campaign.

The following four missions support heliophysics science objectives:

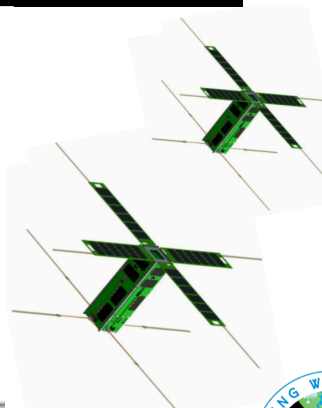
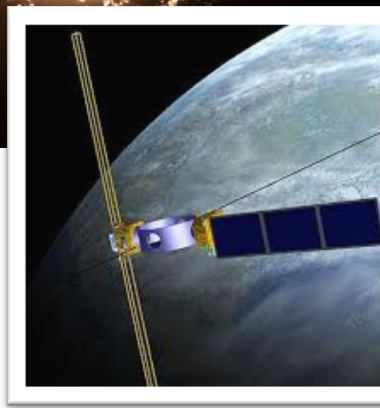
- 1. The Lunar Surface Electromagnetics Experiment (LuSEE):** PI: Stuart Bale, University of California, Berkeley
 - LuSEE will integrate flight-spare and repurposed hardware from the **Parker Solar Probe** FIELDS experiment, the **STEREO/Waves** instrument, and the MAVEN mission to make comprehensive measurements of electromagnetic phenomena on the surface of the Moon.
- 2. The Lunar Environment heliospheric X-ray Imager (LEXI):** PI: Brian Walsh, Boston University
 - LEXI will capture images of the interaction of Earth's magnetosphere with the flow of charged particles from the Sun, called the solar wind.
- 3. Lunar Demonstration of a Reconfigurable, Radiation Tolerant Computer System:** PI: Brock LaMeres, Montana State University, Bozeman
 - Lunar Demonstration of a Reconfigurable, Radiation Tolerant Computer System aims to demonstrate a radiation-tolerant computing technology. Due to the Moon's lack of atmosphere and magnetic field, radiation from the Sun will be a challenge for electronics. This investigation also will characterize the radiation effects on the lunar surface.
- 4. The Lunar Magnetotelluric Sounder:** PI: Robert Grimm, Southwest Research Institute, San Antonio.
 - The Lunar Magnetotelluric Sounder is designed to characterize the structure and composition of the Moon's mantle by studying electric and magnetic fields. The investigation will make use of a flight-spare magnetometer, a device that measures magnetic fields, originally made for the MAVEN spacecraft, which is currently orbiting Mars.

The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space filled with numerous small stars and a prominent, bright blue nebula on the right side. The bottom half shows a similar starry field but with a warm, golden-yellow and greenish glow, suggesting a different nebula or a different spectral filter. The text is centered in a white horizontal band across the middle.

Missions in Operation: Highlights



SET-1 and E-TBEx Launch Aboard Falcon Heavy



- **Space Environment Testbed-1 (SET-1)** hosted payload on Air Force Research Laboratory (AFRL) Demonstration and Science Experiments (DSX) spacecraft
 - Define the mechanisms for induced space environment and effects
 - Reduce uncertainties in the definitions of the induced environment and effects on spacecraft and their payloads
 - Improve design and operations guidelines and test protocols so that spacecraft anomalies and failures due to environmental effects during operations are reduced
- **Enhanced and Tandem Beacon Experiment (E-TBEx)**
 - Pair of 3U CubeSats each carrying tri-frequency radio beacons
 - Measures how radio signals can be distorted by large bubbles that form naturally in the Earth's charged upper atmosphere

Above: SpaceX Falcon Heavy rocket carrying 24 satellites as part of the Department of Defense's Space Test Program-2 (STP-2) mission launches from Launch Complex 39A at NASA's Kennedy Space Center in Florida Tuesday, June 25, 2019.

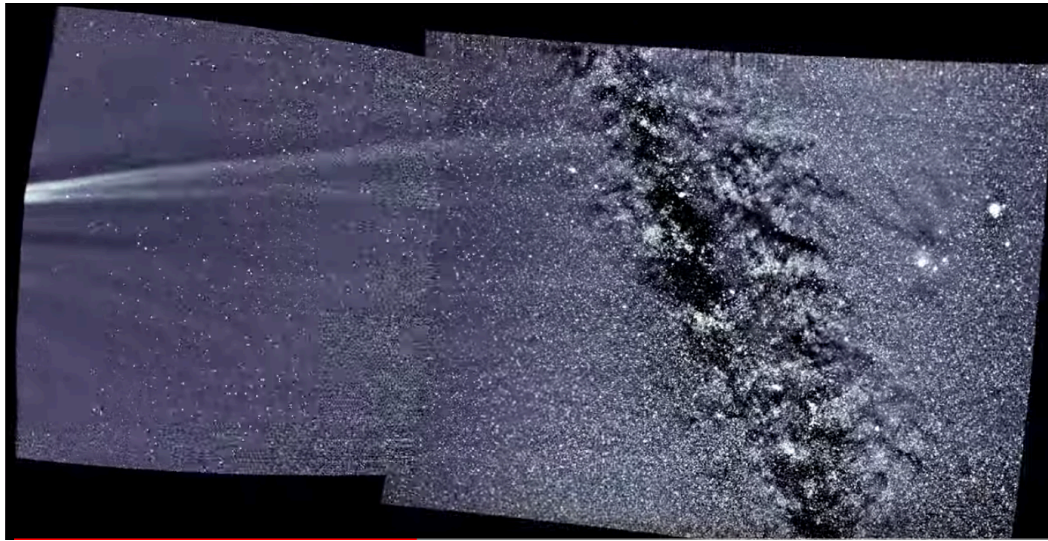




Parker Solar Probe

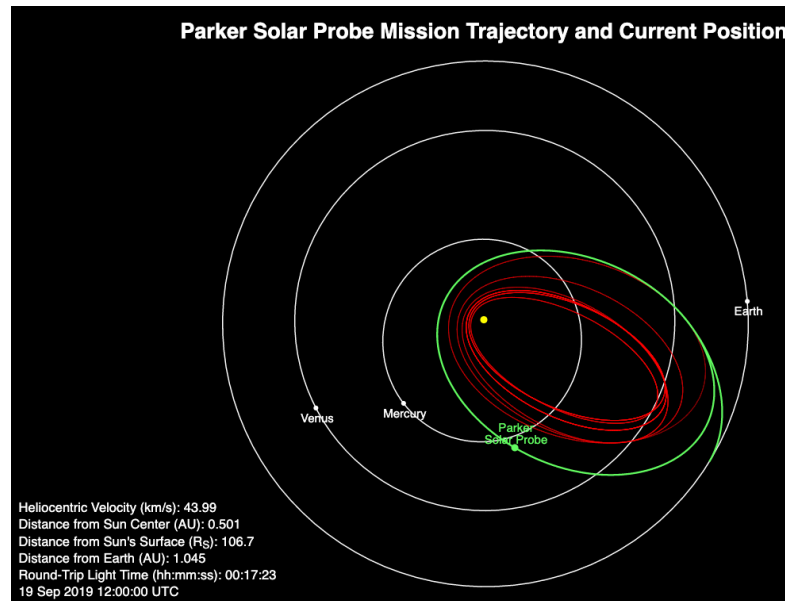
Parker one-year on orbit – August 12, 2019

- First, Second, and Third Solar Solar Encounters complete
- Perihelion #3: September 1, 2019
- Venus Flyby #2: December 26, 2019
- Perihelion #4: January 29, 2020
 - Minimum perihelion of ~ 0.13 AU with max speed of 224,200 mph
- Parker performance sufficiently characterized to reduce the RF margin as well as increase instrument on-time and data production.

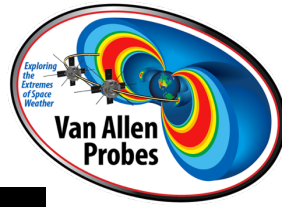


Above: Parker Solar Probe's WISPR instrument saw the solar wind streaming past during the spacecraft's first solar encounter in Nov 2018.

Credits: NASA/Naval Research Laboratory/Parker Solar Probe



Van Allen Decommissioning



Van Allen Probes (VAP) successfully conducted a combined Decommissioning Review and Disposal Readiness Review on July 11 for both spacecraft.

- **Spacecraft B:**

- Jun 20: East-West precession maneuver performed and approximately half the planned distance was reached
- Jul 19: remaining passivation activities were completed

- **Spacecraft A:**

- Aug 29 East-West precession maneuver performed but planned distance was not reached
- Early October earliest passivation



Credit: NASA/Johns Hopkins APL/Craig Weiman

Above: Mission controllers John Eichstedt and Janis Flynn (seated, center), prepare to send the command from Johns Hopkins APL's 60-foot satellite dish to spacecraft B that will end its operations after seven years of scientific discovery.

HPD at a Glance: Operating Missions

Mission	Launch Date	Phase	Extension	M-3	M-2	M-1	Cur. M.	Remarks
Voyager 1 + 2	8/20/1977	Extended	9/30/2021					
Geotail	7/24/1992	Extended	9/30/2021					
Wind	11/1/1994	Extended	9/30/2021					
SOHO	12/2/1995	Extended	9/30/2024					
ACE	8/27/1997	Extended	9/30/2021					
TIMED	12/7/2001	Extended	9/30/2021					
Hinode	9/23/2006	Extended	9/30/2021					
STEREO	10/25/2006	Extended	9/30/2021					
THEMIS+Artemis	2/17/2007	Extended	9/30/2021					
AIM	4/25/2007	Extended	9/30/2021					
IBEX	10/19/2008	Extended	9/30/2021					
SDO	2/11/2010	Extended	9/30/2021					
Van Allen	8/30/2012	Extended	9/30/2021					VAP-B decommissioned Jul 19, VAP-A failed to complete Aug 29 maneuver due to loss of fuel
IRIS	6/27/2013	Extended	9/30/2021					
MMS	3/12/2015	Extended	9/30/2021					
GOLD	1/25/2018	Prime	10/17/2020					
Parker	8/12/2018	Prime	9/30/2025					Completed 3 rd Solar Encounter on Sep 7. Solar Probe Cup anomaly during solar encounter #3.
SET-1	6/25/2019	Prime	7/1/2020					Currently powered-off, s/c problems prevent completion of commissioning

Mission proceeding to meet science requirements
 Area of concern - possible reduction in capability
 Significant problem – possible or probable loss of mission
 Mission Decommissioned



Future Missions & Opportunities

Solar Orbiter Collaboration (with ESA)



Launch Vehicle: U.S. provided Atlas-V 411

Launch Site: Cape Canaveral

LRD: February 5, 2020

Solar Orbiter Collaboration Project Scientist: Chris St. Cyr

U.S. Provided Instruments:

- HIS (Heavy Ion Sensor), part of SWA, and SoloHI (Heliospheric Imager)

Description:

- Aims to make significant breakthroughs in our understanding both of how the inner heliosphere works, and of the effects of solar activity on it.
- Will take a unique combination of measurements: in situ measurements will be used alongside remote sensing close to the Sun to relate these measurements back to their source regions and structures on the Sun's surface.

Next Step: *Qualification Acceptance Review Oct 15*



Interstellar Mapping and Acceleration Probe (IMAP)

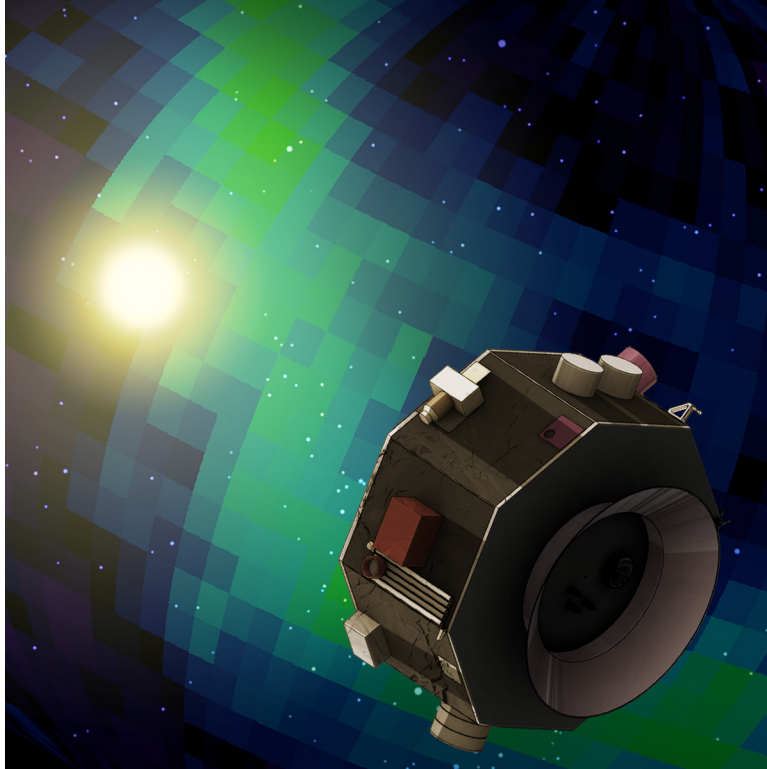


Photo: NASA artist concept of IMAP observing the IBEX Ribbon

Selected: June 1, 2018

LRD: October, 2024

Project Scientist: David McComas, Princeton University

- Project Management and Mission Operations Center at Johns Hopkins University's Applied Physics Laboratory in Laurel, Maryland

Orbit: L1 Lagrangian point

Description:

- Sample, analyze, and map energetic neutral atoms and dust streaming to Earth from the edge of interstellar space.
- Investigate the acceleration of particles in the heliosphere and beyond.
- 10 scientific instruments
- Investigating possible accommodation of a Tech Demo

Rideshare opportunities on the ESPA Grande:

- Competitive Missions of Opportunity including Tech Demo and Science
- SIMPLEX: Trailblazer (lunar)
- NOAA Space Weather Follow-On

Geospace Dynamics Constellation (GDC)

- Decadal Survey identified GDC as the next Living With a Star (LWS) large strategic mission:
 - “...provide the first simultaneous, multipoint observations of how the ionosphere-thermosphere system responds to, and regulates, magnetospheric forcing over local and global scales...”
- Science and Technology Definition Team convened in May 2018
 - Discussions are limited to the science objectives and measurement requirements; no instrument-specific or mission implementation recommendations
 - Final report was debriefed and endorsed at HPAC
- LRD NET 2026

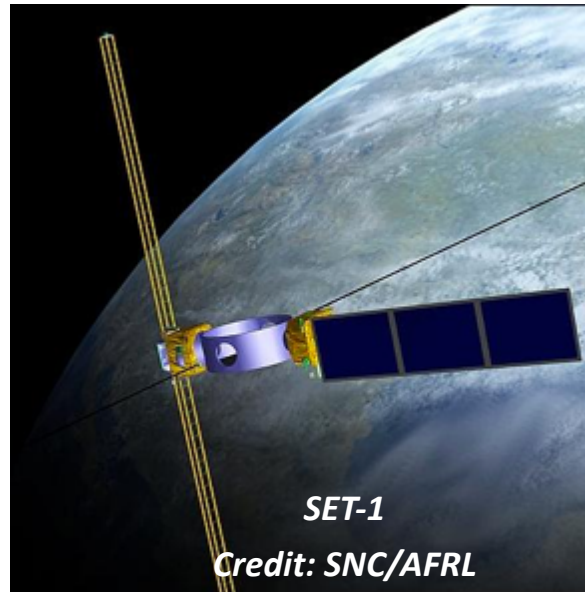




Explorers MIDEX19

- Draft AO release date: May, 2019
- Final AO release date: July 2, 2019
- Step-1 proposals due: September 30, 2019
- PI managed Cost Cap: \$250M

Ability to take advantage of any future Rideshare opportunity



- SMD has embraced Rideshare opportunities as a standard practice to maximize mass to orbit
 - Enabling additional opportunities for science community
- SMD has developed a rideshare policy and a policy team to develop standard rideshare processes
- Rideshare opportunities on IMAP ESPA Grande
- Rideshare opportunity with Pysche (EscaPADE)
- Investigating rideshare for PUNCH & TRACERS
- CSSP report: Agile Responses to Short-Notice Rideshare Opportunities
- **Community workshop on Rideshare, February 25-27 hosted by JHU/APL**



Heliophysics Vision 2050 Workshop

- **HQ-enabled, community-led workshop to lay the groundwork for the next Decadal Survey**
 - Short-, medium-, and long-term science goals and objectives
 - Technology, modeling, and other infrastructure/capabilities to enable those science investigations
- **Part of Division pre-Decadal preparation**
 - Based upon the idea of the Planetary Science Vision 2050, but modified to meet Heliophysics Division needs
 - Create a strategic framework that the community can leverage to provide background and context for their Decadal white papers
 - Focus community attention on work in the next decadal to enable potential missions in later decades
- **Community announcements in the near future**
 - Description of the workshop, schedule, and expected output
 - Solicitation for community organizers



Research



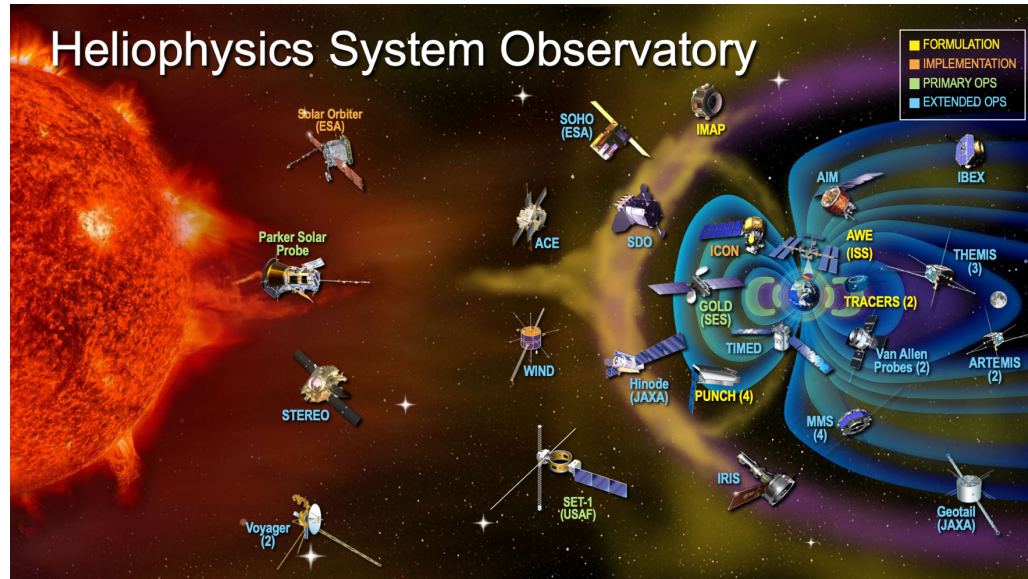
Heliophysics Research: ROSES 19



	ROSES Element		Proposal Due Date	Notify Date	Days Since Received	# Proposals received	# Proposals selected	% selected
2019	HDEE	Data Environment Emphasis	6/20/2019			15		
	HGIO	Guest Investigators Open	7/17/2019			128		
	HSODS	Heliophysics System Observatory Data Support	8/15/2019			6		
	HTIDS	Technology and Instrument Development for Science	8/28/2019			31		
	HSR	Supporting Research	10/18/2019					
	HFORT	Flight Opportunities for Research and Technology	11/1/2019					
	TMS	Theory, Modeling, Simulation	12/3/2019					
	OHGI	Outer Heliosphere Guest Investigator	12/3/2019					
	SWO2R	Space Weather Applications Operations 2 Research	2/13/2020					
	LWS Science	Living With a Star Science	2/27/2020					

- **Outstanding ROSES-18:**
 - LWS 2018 - selections in preparation.
 - SWO2R-2: Improve forecasts of solar energetic particles and heavy ions - review in process.
 - DRIVE Science Centers - review in October.

Three new R&A ROSES 2019 Programs



Heliophysics System Observatory Connect

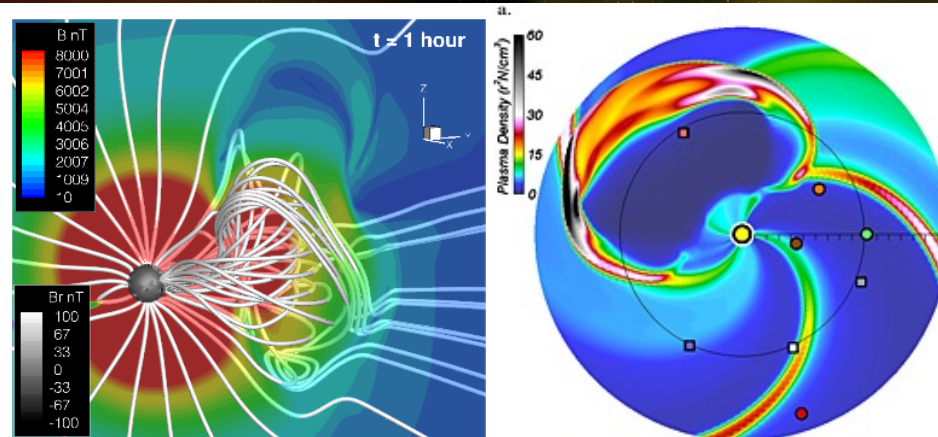
- Diverse interdisciplinary teams working together to use the HSO as an end-to-end system.
- Coordinated observations of Parker Solar Probe with currently operating space missions and ground-based observatories; and observatories not yet launched.

Heliophysics System Observatory Data Support

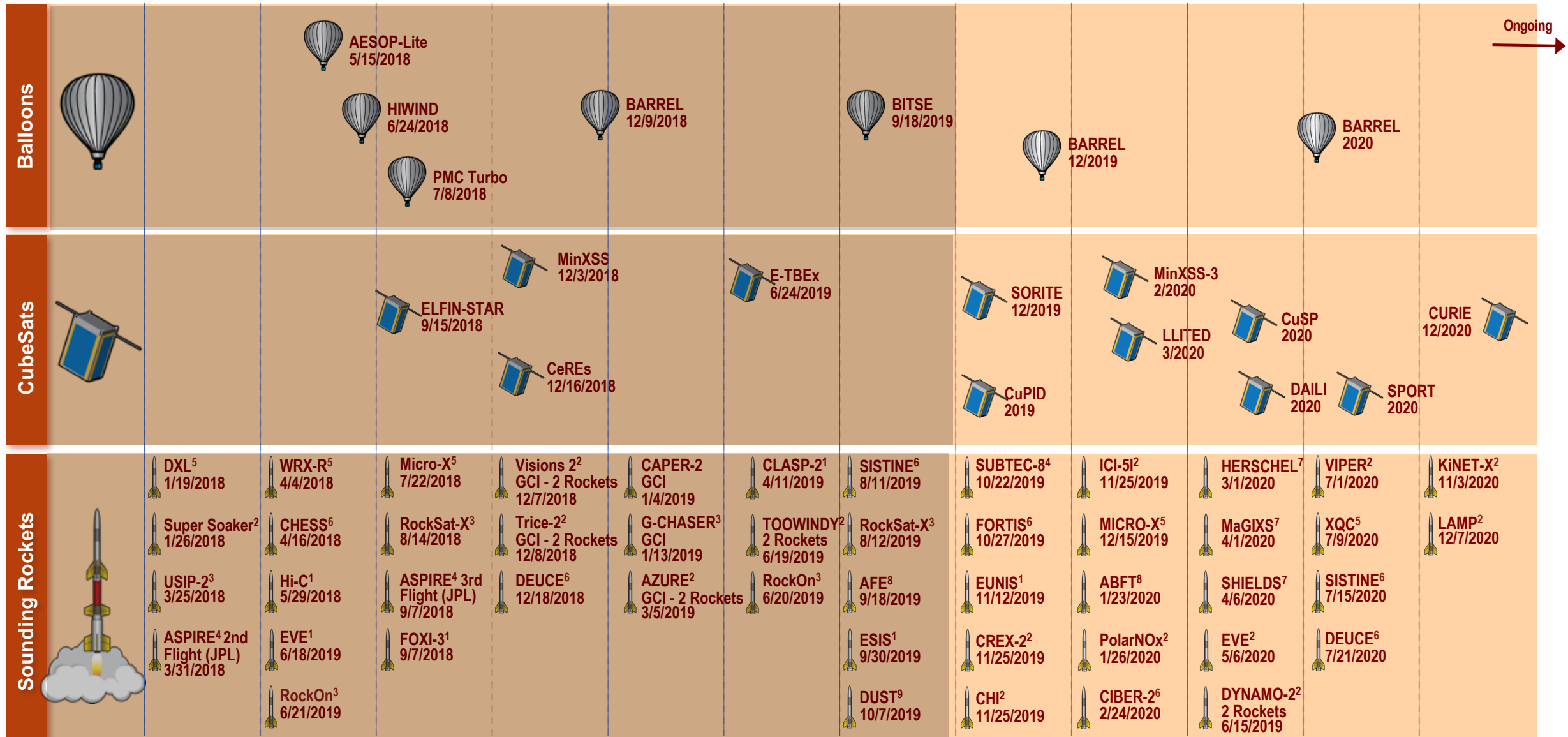
- Targeting ground based solar observatory data; a subset of HSO Connect
 - Received 6 proposals

Outer Heliosphere Guest Investigators

- Focused on analysis of data from Voyager, IBEX, other space assets to study the outer heliosphere.
 - Step-2 proposals due Dec 3, 2019



Heliophysics Suborbital & CubeSats (2018-2021)



Ongoing →

2018

2019

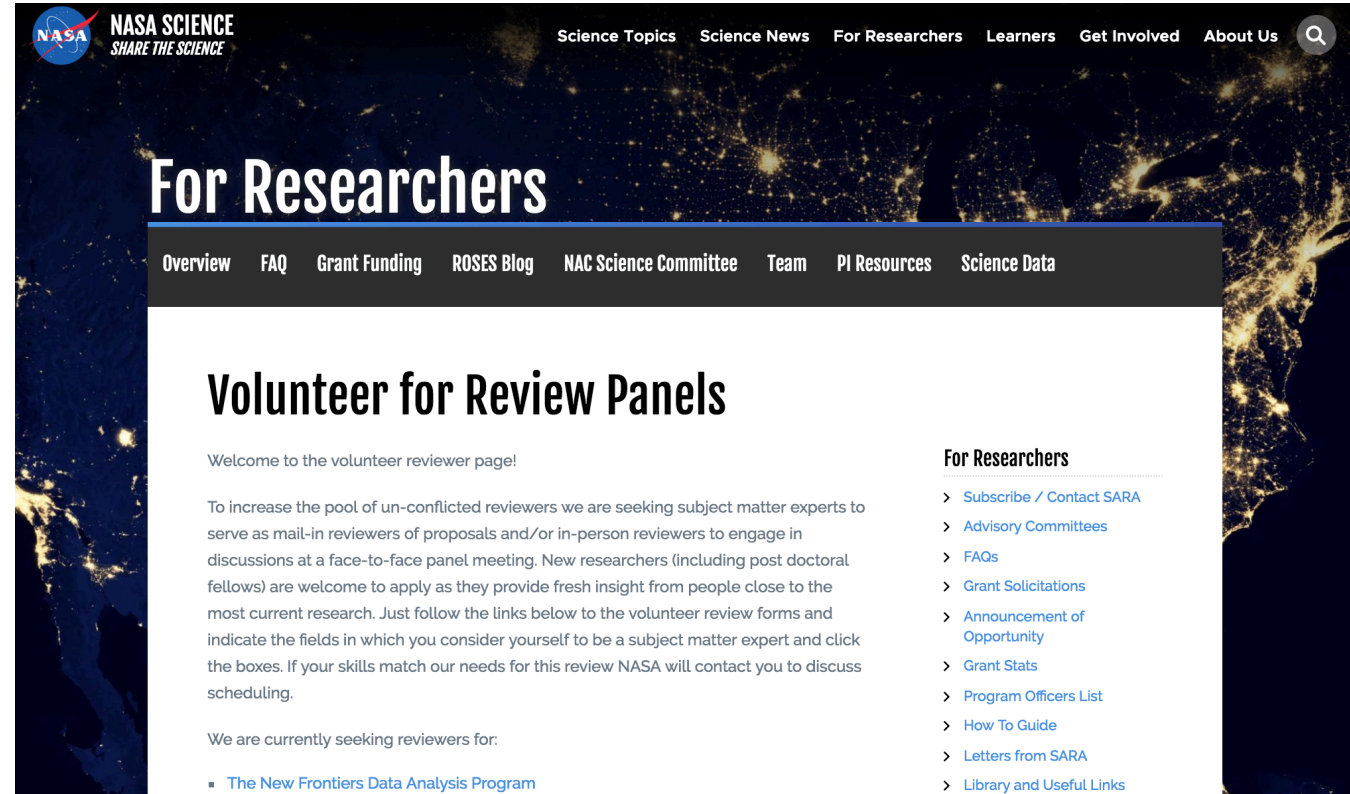
2020

2021

¹Solar
²Geospace
³Education
⁴Tech Development
⁵High Energy Astrophysics
⁶UV Optical Astrophysics
⁷Solar and Heliophysics
⁸Reimbursable
⁹Lab Astrophysics

Volunteer for a Proposal Review Panel!

- We rely on community participation to help with the R&A program's review panels – and we have a full schedule each year.
- This is your chance to see the process in action and provide feedback.
- The Senior Advisor for Research and Analysis (SARA) or SMD Lead for Research helps with the solicitation process; please click the link to the right and volunteer for a proposal review panel.



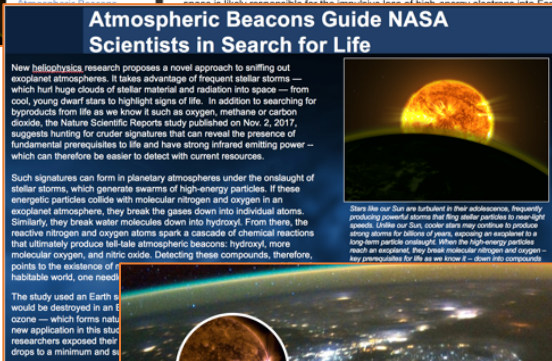
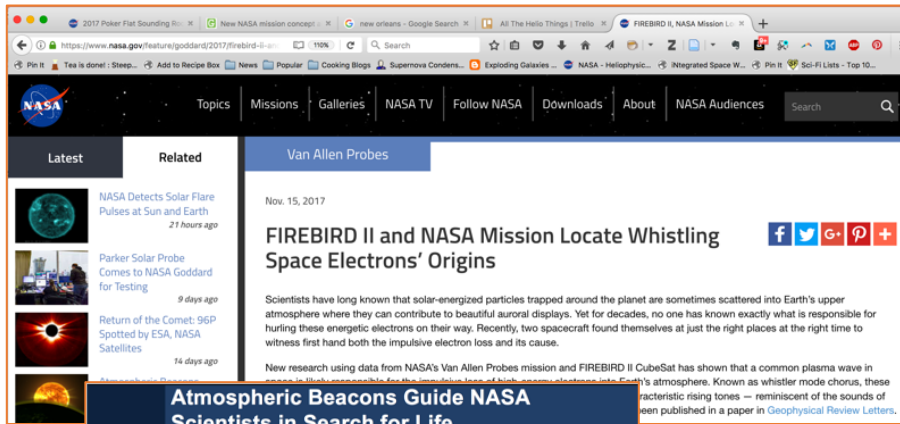
The screenshot shows the NASA Science website's 'For Researchers' page. The header includes the NASA logo and 'NASA SCIENCE SHARE THE SCIENCE'. Navigation links include Science Topics, Science News, For Researchers, Learners, Get Involved, and About Us. A search icon is in the top right. Below the header, a navigation bar lists Overview, FAQ, Grant Funding, ROSES Blog, NAC Science Committee, Team, PI Resources, and Science Data. The main content area features the heading 'Volunteer for Review Panels' and a welcome message: 'Welcome to the volunteer reviewer page!'. The text explains that NASA is seeking subject matter experts to serve as mail-in reviewers or in-person reviewers for proposals. It provides instructions on how to apply, including filling out forms and indicating fields of expertise. A list of currently sought reviewers includes 'The New Frontiers Data Analysis Program'. On the right side, there is a 'For Researchers' sidebar with links to 'Subscribe / Contact SARA', 'Advisory Committees', 'FAQs', 'Grant Solicitations', 'Announcement of Opportunity', 'Grant Stats', 'Program Officers List', 'How To Guide', 'Letters from SARA', and 'Library and Useful Links'.

<https://science.nasa.gov/researchers/volunteer-review-panels>

HELIO CONNECTS through Science

We want to share your research with others at NASA, with the community, with the public and with the media! But we need your help...

- Please let NASA's heliophysics communications team know about:
 - Upcoming papers
 - Upcoming mission events (i.e., testing, anniversaries, records broken)
 - Outreach events: school visits, press interviews, stakeholder interactions, etc.
 - Submit at: bit.ly/SubmitHelioScience
- We can feature your research via numerous outlets:
 - With NASA leadership: weekly and monthly updates
 - With the community: newsletters (sign up for it [here](#))
 - With the public
 - Internet: NASA.gov/sunearth and blogs.nasa.gov/sunspot
 - Social media: [@NASASun](https://twitter.com/NASASun) and facebook.com/NASASunScience
 - Imagery: Videos, visualizations, infographics (<https://svs.gsfc.nasa.gov/Gallery/NASAsHeliophysicsGallery.html>)
 - With the media: Press releases and press briefings



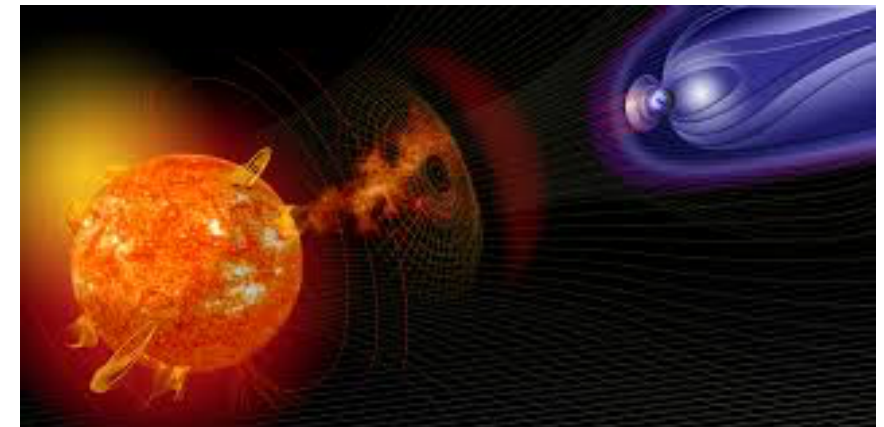
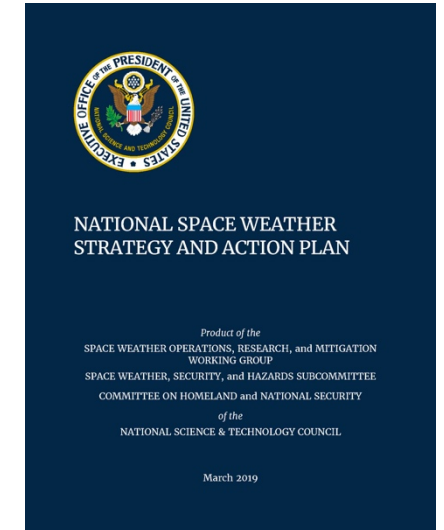
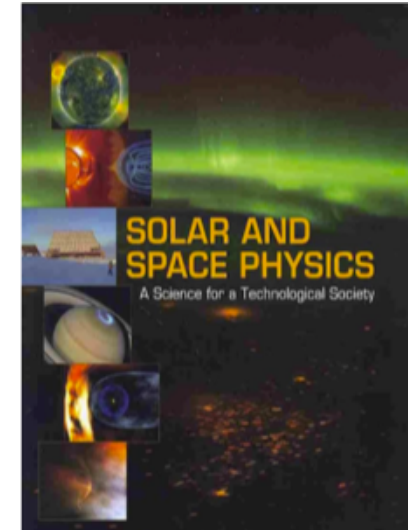
Let us know at: bit.ly/SubmitHelioScience

The background of the slide is a composite of two cosmic images. The top half features a dark blue and black space filled with numerous small stars and a prominent, bright blue nebula on the right side. The bottom half shows a similar starry field but with a warm, golden-yellow and greenish glow, suggesting a different nebula or a different spectral filter. The text 'Space Weather' is centered in a white horizontal band across the middle.

Space Weather

Space Weather Science and Applications (SWxSA)

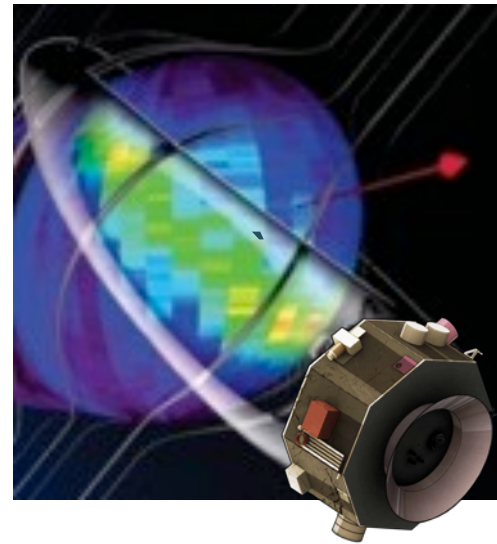
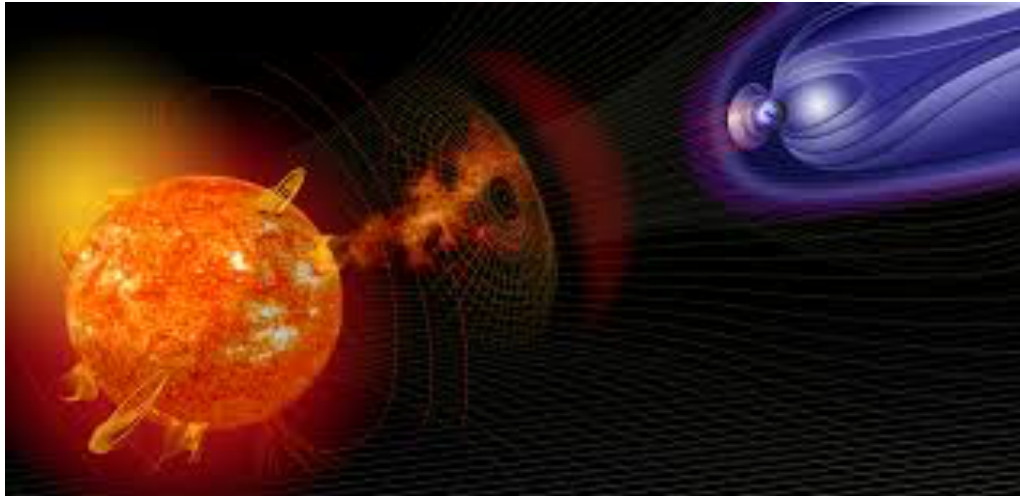
- Establishes an expanded role for NASA in space weather science under single budget element
 - Consistent with the recommendation of the NRC Decadal Survey and the OSTP/SWORM [2019 National Space Weather Strategy and Action Plan](#)
- **Competes** ideas and products, **leverages** existing agency capabilities, **collaborates** with other agencies, and **partners** with user communities
- Distinguishable from other heliophysics research elements in that it is specifically focused on investigations that significantly advance understanding of space weather. This progress is then applied to enable more accurate characterization and predictions with longer lead time
- Transition tools, models, data, and knowledge from research to operational environments
- Focused on Artemis and National Space Weather Capability



The background of the slide is a composite of two cosmic images. The top half features a dark space filled with numerous small stars and a prominent blue nebula on the right side. The bottom half shows a similar starry field but with a large, bright orange and yellow nebula on the left side. A horizontal light blue band runs across the middle of the slide, containing the word 'Summary' in a bold, black, sans-serif font.

Summary

It is a Great Time to be a Heliophysicist!



- The Heliophysics Division is poised like never before to:
- Capitalize on our unique opportunity to study the Sun and its effects throughout the Heliosphere
- Augment the Heliophysics fleet with new, innovative missions, a robust suborbital program, and an enhanced ride share program
- Make research and technology investments to enable science, e.g. interstellar probe, solar sails
- Develop the next generation of Heliophysicists and engage the public with science knowledge
- Fulfill our responsibility for the Nation enabling advances in space weather
- Play a critical role in Exploration supporting the Artemis mission
- Lean forward for success in the next decade

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#HelioRocks