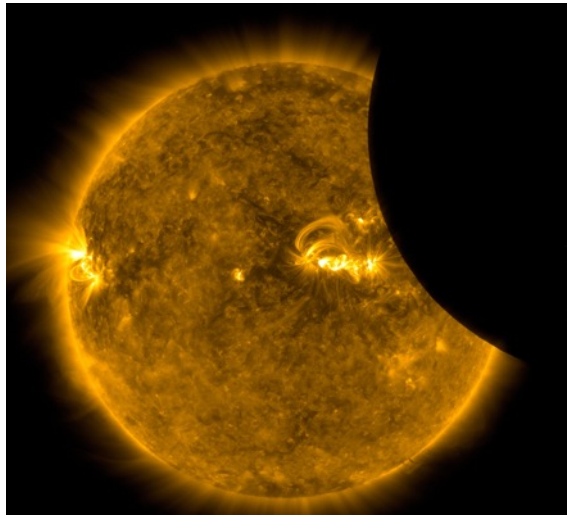
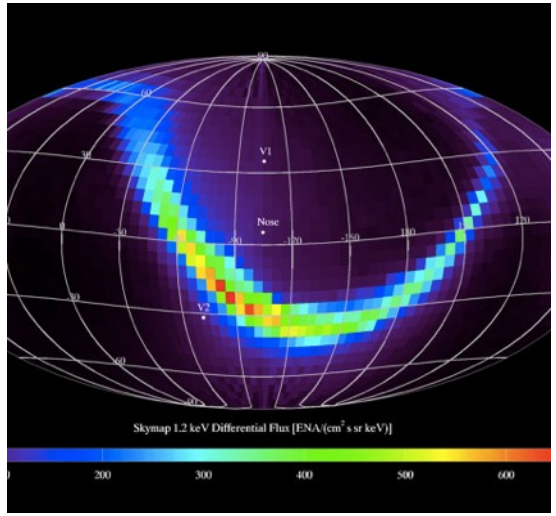
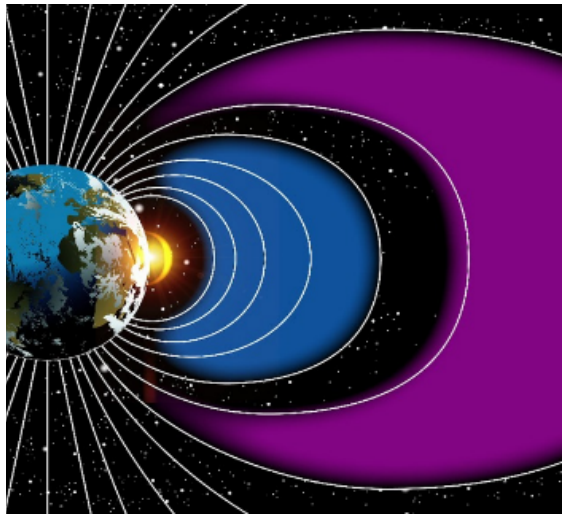
EXPLORE SCIENCE

Dr. NICOLA FOX
Heliophysics Division Director

NASA Heliophysics Division Update
Committee on Space and Solar Physics
March 26, 2019







The Dawn of a New Era for Heliophysics

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

Strategically advance understanding of solar and space physics, make ***amazing discoveries***

Augment the Helio fleet with ***new missions*** and a robust ***suborbital*** program

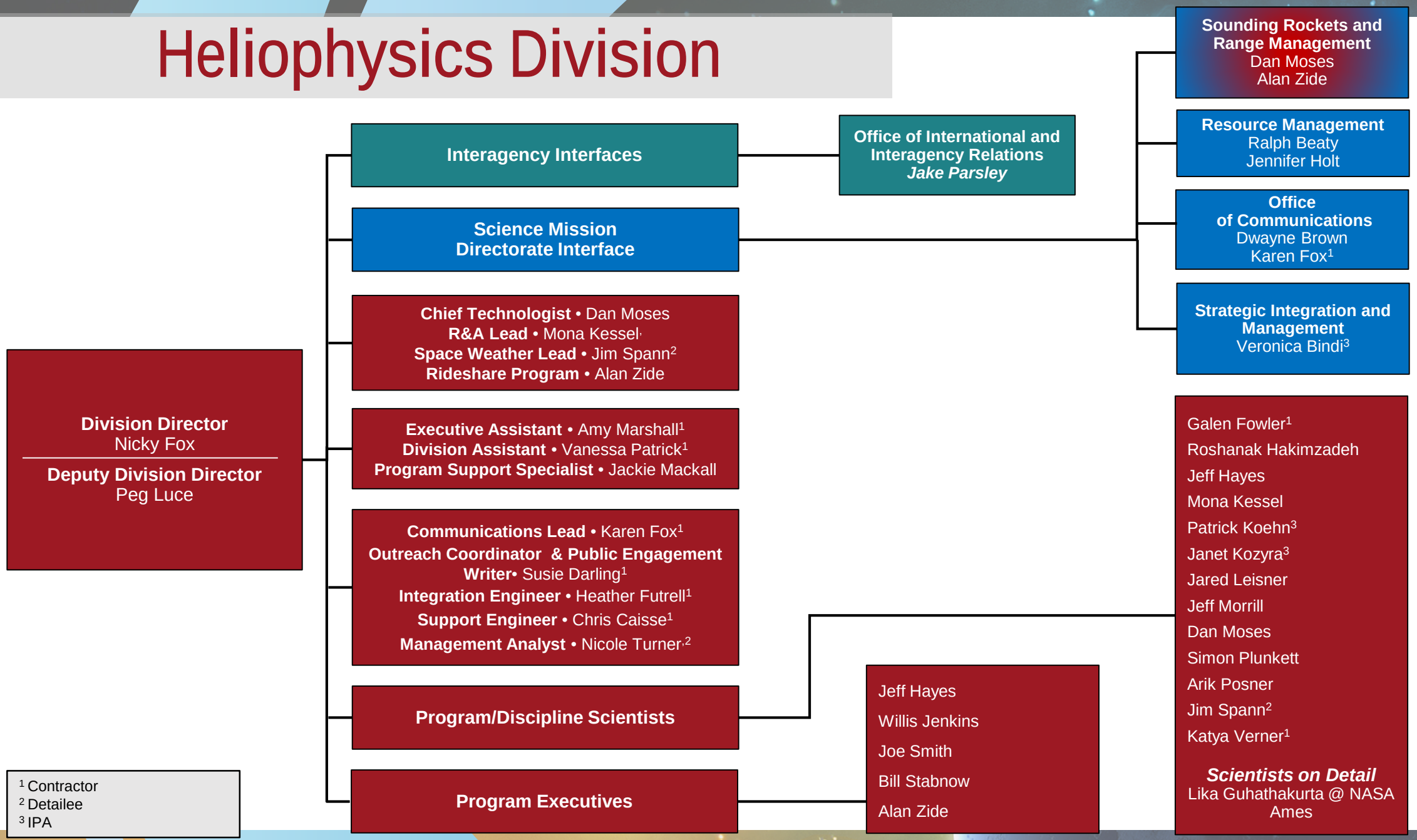
Fulfill its role for the Nation enabling advances in ***space weather***

Engage the public with science knowledge and citizen science

Develop the ***next generation*** of heliophysicists

HPD Organizational Chart

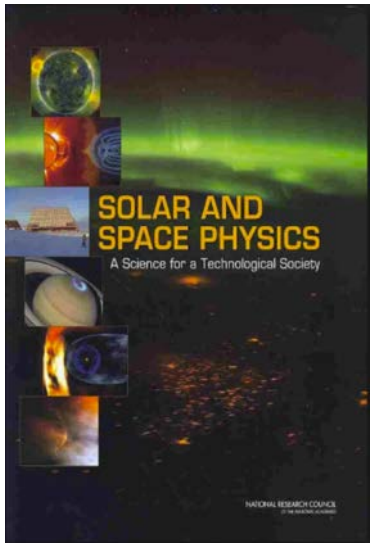
Heliophysics Division



[1] Contractor
[2] Detailee
[3] IPA

Heliophysics Decadal Survey

Review of Progress Toward Implementing the Decadal Survey Vision in Solar and Space Physics: A Science for a Technological Society



- The National Academies of Sciences, Engineering, and Medicine shall convene an ad hoc committee to review the responses of NASA's Heliophysics program and NSF's Geospace program to the 2013 Decadal Survey, "Solar and Space Physics: A Science for a Technological Society."
  - Committee has been appointed to develop mid-term report
  - Expected kick off meeting early in CY 2019
- Assess the degree to which the Agencies' current programs address the strategies, goals, and priorities of the Decadal Survey
- Provide guidance about implementation of the recommended portfolio for the remaining years of the current decadal survey given actual funding levels
- Recommend any actions that could be taken to optimize the science value of the Agencies' programs including how to take into account emergent discoveries and potential partnerships

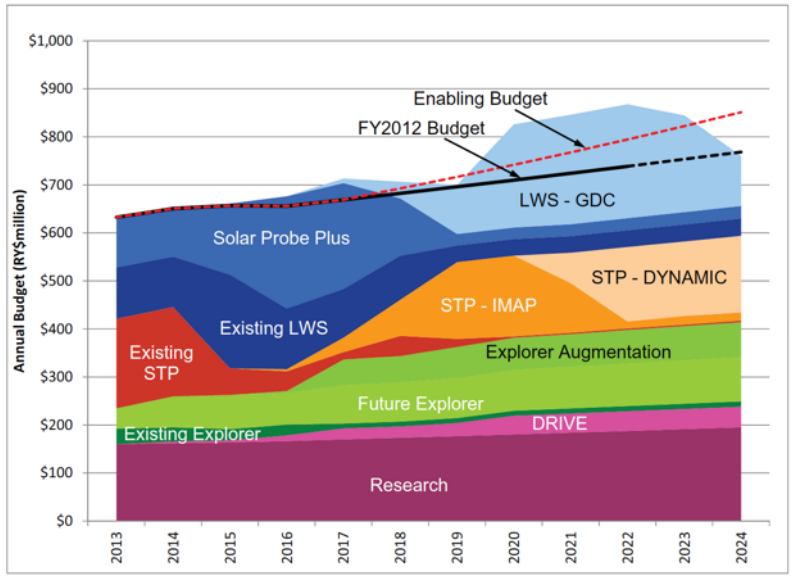
Bottom line upfront

- The heliophysics community has truly benefitted from the advice in the 2013 decadal – particularly reenergizing the Explorer program and restructuring of the Solar Terrestrial Physics line.
- HPD has accomplished nearly all of the recommendations, in addition to capitalizing on the new opportunities presented by SmallSats and rideshare, which have become much more of a reality in the period since the Decadal was written.
- NASA's Heliophysics program has also been strengthened by bipartisan support for Space Weather research, through which funds have been provided for the Space Weather Science and Applications initiative
- The "enabling" budget envisioned by the committee has not yet been realized and, therefore, some recommended missions had to be slipped to the right
- However, the Heliophysics System Observatory fleet has been augmented by Explorers missions implemented since the report was published
- HPD has requested advice from the committee on prioritization of remaining work outlined in the Heliophysics Decadal 2013
  - While it would not be desirable to go into the next Decadal with a number of liens, (or to invest in early phase definition work for programs that may not be endorsed by the next panel), we want to continue with the "lean forward" position and maximize the science that is realizable in the remaining time period

Alignment with Decadal Survey Recommendations

NASA FY19 Budget	
R0.0 Complete the current program	Extended operations of current operating missions as recommended by the 2017 Senior Review; Van Allen Probes; 2 recently launched and now in primary operations (GOLD and Parker); and 3 missions currently in development - ICON, SET, Solar Orbiter
R1.0 Implement DRIVE (Diversify, Realize, Integrate, Venture, Educate)	Implemented DRIVE initiative wedge in FY15; fully funded in FY18 and onwards
R2.0 Accelerate and expand Heliophysics Explorer program	Decadal recommendation of every 2-3 years; Explorer mission AO released in 2016; plan to release next draft Explorer AO in 2019. Notional mission cadence will continue to follow Decadal recommendation going forward. Increased frequency of Missions of Opportunity (MO), including rideshares on IMAP and Tech Demo MO.
R3.0 Restructure STP as a moderate scale, PI-led flight program	IMAP mission (STP-5) selected in 2018 as a PI-led mission with an LRD in 2024
R4.0 Implement a large LWS GDC-like mission	Start of mission formulation targeted for NET 2021. RFI call for innovative ideas yielded 65 responses – inputs provided to GDC STDT that started in 2018.

Implementing the Decadal: Helio Budget 2013-2024



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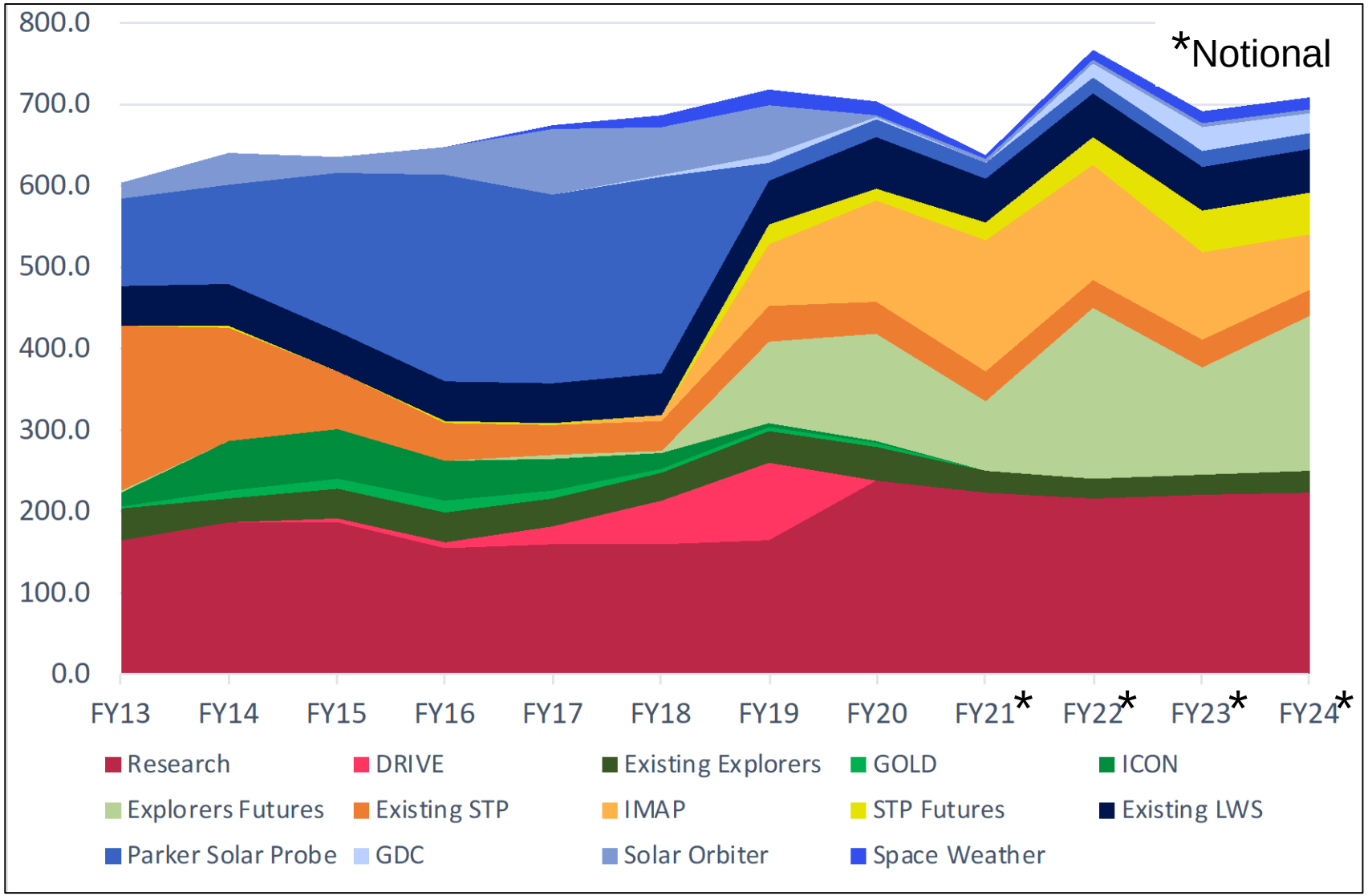


Heliophysics Highlights

Awards and Achievements

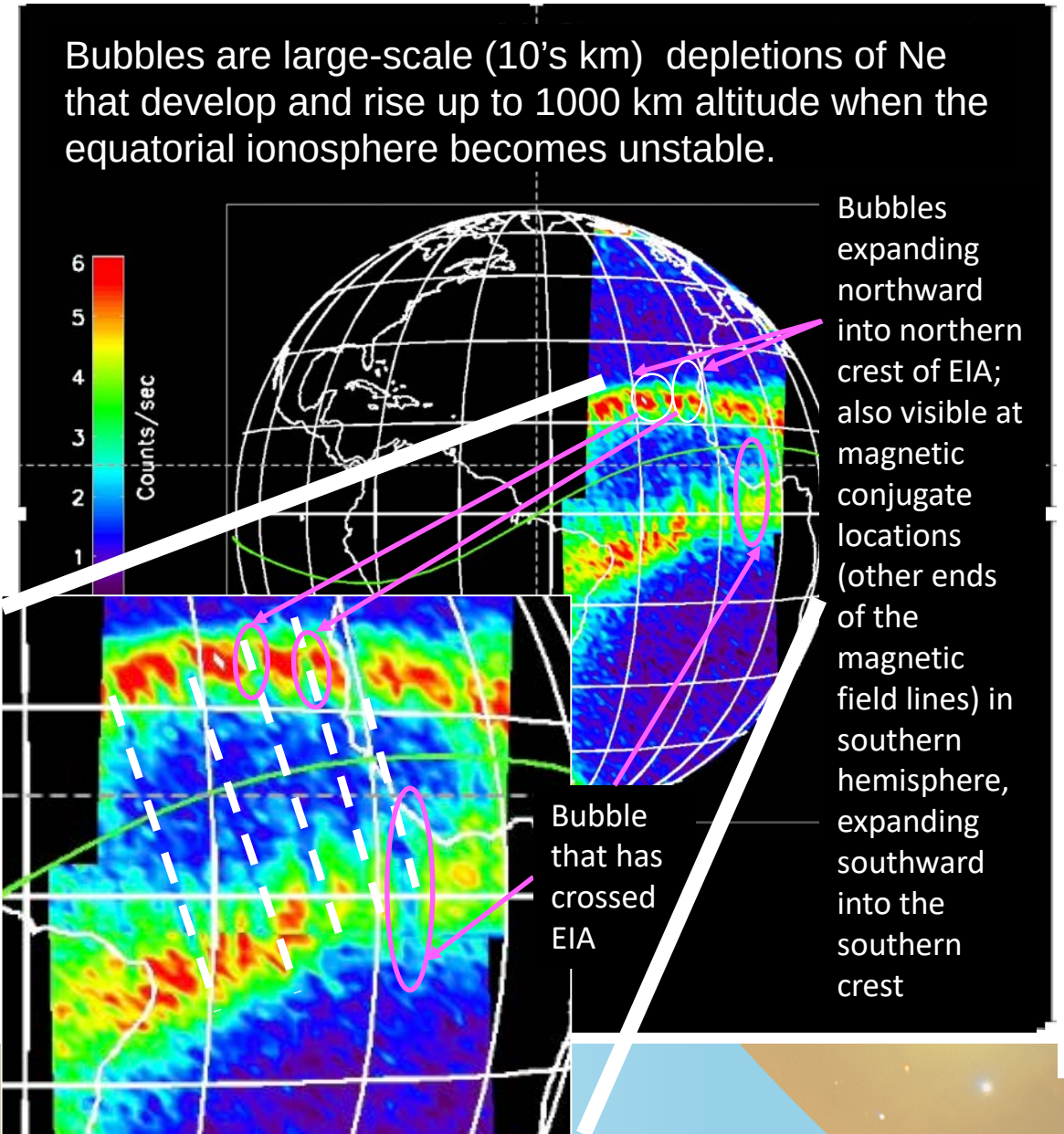
Poker Flat Research Range held 50th anniversary of first sounding rocket launch

Credit: NASA Wallops Flight Facility Wallops, Jamie Adkins and Chris Perry

Goddard Memorial Symposium held March 21

- AAS Neil Armstrong Space Flight Achievement Award
  - Parker solar probe mission team

Global-scale Observations of the Limb and Disk



Surprising Result:

- Significant occurrence of bubbles in the GOLD observations was not expected in solar minimum based on TIMED/Global Ultraviolet Imager (GUVI) experience
- GUVI & GOLD both infer Ne from nightglow at 135.6 nm (radiative recombination of $O^+ + e$). Weak emission for low ionospheric Ne
- In 2007, annual average SSN = 12.6, GUVI saw bubbles in only 5% of orbits [Comberiate & Paxton, 2010]
- In 2018, annual average SSN = 7.0, GOLD saw bubbles in over 50% of October-December images

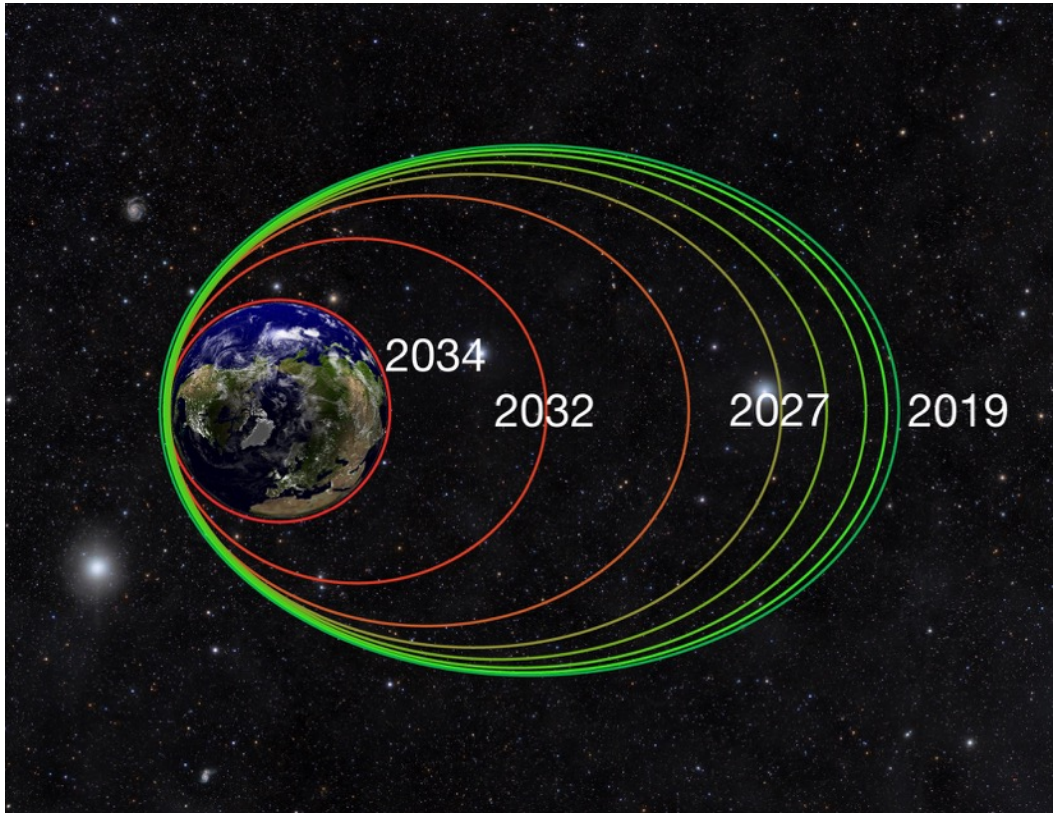
GOLD's position parked over the western hemisphere in geostationary orbit enables:

- Scientific understanding & situational awareness
- View of bubble occurrence and development over large area

Bottom left image, zoomed: bubbles disrupt communications and navigation in a broad band centered on the equator; dotted line traces bubbles

Van Allen Probes Begin Final Phase of Exploration

- On Feb. 12, 2019, Spacecraft B of the Van Allen Probes began a series of orbit descent maneuvers to bring its perigee just under 190 miles closer to Earth, from about 375 miles.
  - Spacecraft A will begin descent March 11-22
- This will position the spacecraft for an eventual re-entry into Earth's atmosphere in about 15 years.
- Launched in 2012, the Van Allen Probes have been orbiting Earth for the past 6.5 years, flying repeatedly through the Van Allen radiation belts.

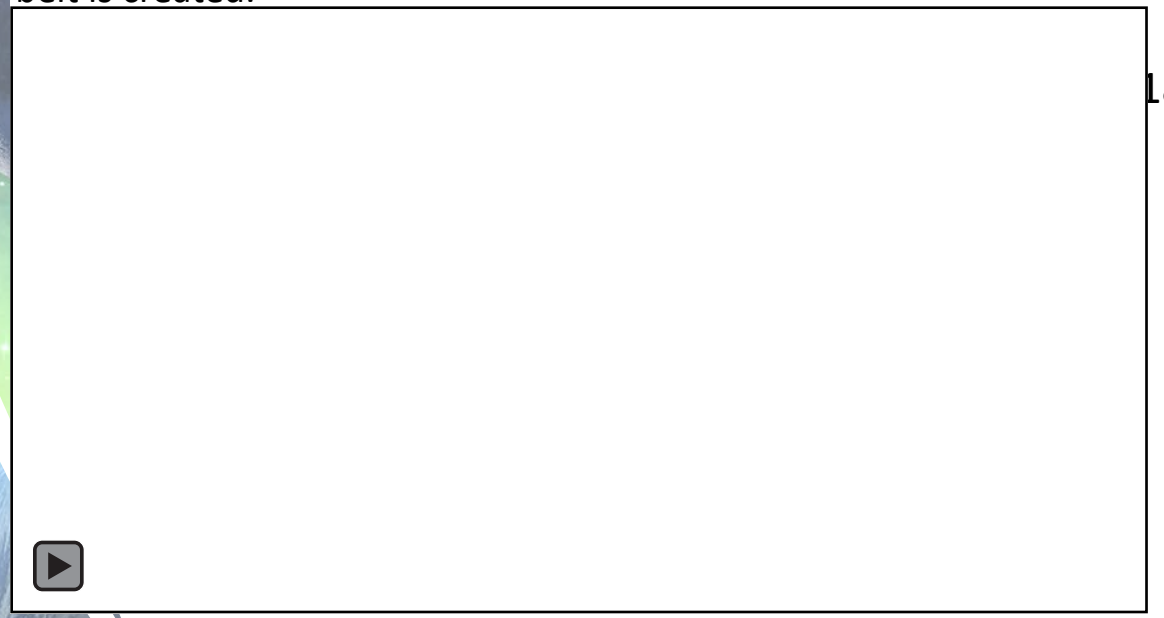


Above: *After performing de-orbit maneuvers in February and March 2019, the Van Allen Probes' highly elliptical orbits will gradually tighten over the next 15-25 years as the spacecraft experience atmospheric drag at perigee, the point in their orbits closest to Earth.* ***Credits: Johns Hopkins APL***

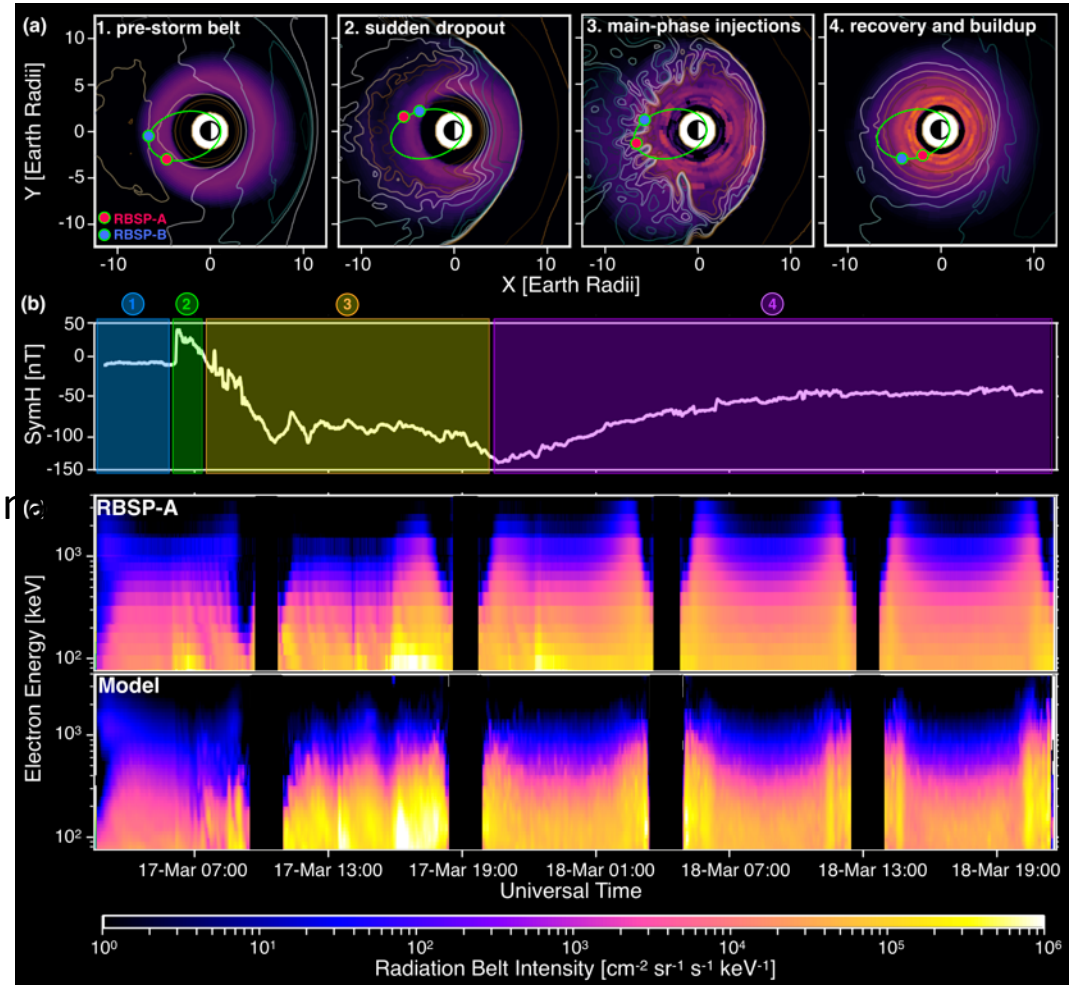
Van Allen Science: New-Generation Radiation Belt Models

During geomagnetic storms radiation belts can exhibit extreme variability over several hour periods. Often observed is the near disappearance of the outer belt at the onset of the storm and its intensification in the aftermath. The relationship between the pre- and post-storm belt had been a long-standing mystery.

New models enabled by the Van Allen Probes (RBSP) mission can now address these questions. They show that at the onset of the storm the existing belt is annihilated and swept into interplanetary space and that during the course of the storm a new, more intense belt is created.



Global Simulations of 17 March 2013 Storm

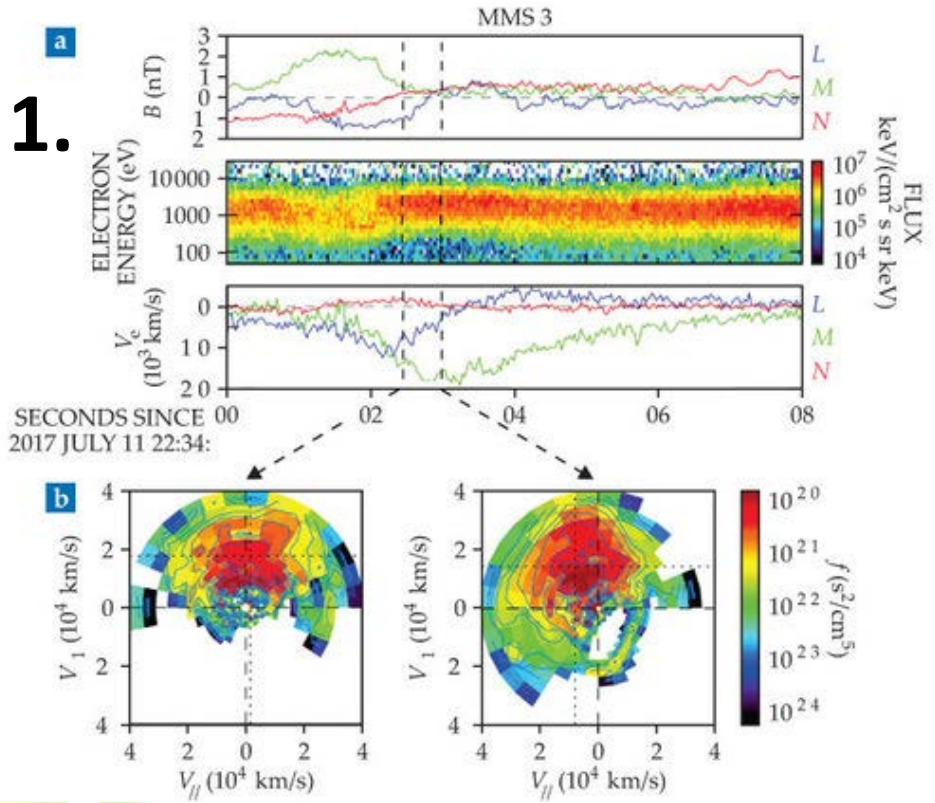


Sorathia et al. (2018), Journal of Geophysical Research, 10.1029/2018JA025506

New models enabled by the Van Allen Probes reproduce the dramatic storm-time variability and the subsequent growth of the electron belt very well. This is an important step towards assessing and mitigating the hazardous effects of elevated radiation belt intensities on spacecraft operations and longevity.

MMS: 3 significant results

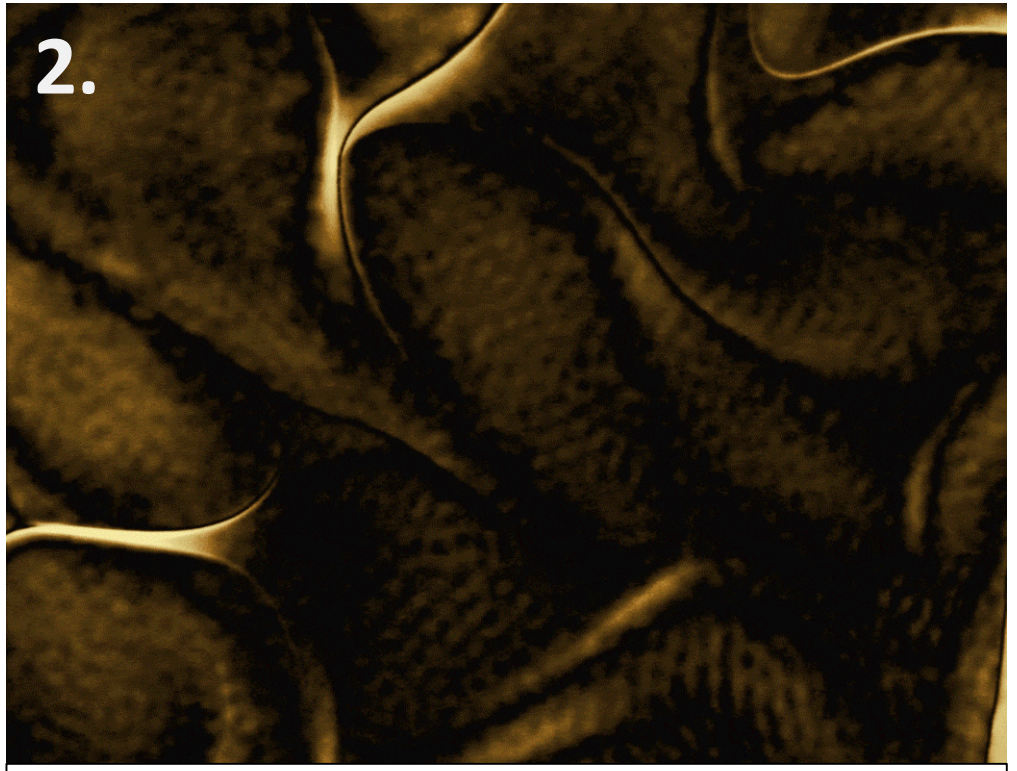
1.



Observed reconnection event: MMS observations **(a)** the magnetic field B (top), electron spectrogram (middle), and electron velocity V_e (bottom) in the electron diffusion region of a magnetic reconnection event on July 11, 2017. During reconnection, the magnetic field vanished and the electron bulk velocity peaked at 15,000 km/s. **(b)** Crescent-shaped structures persisted in the electron velocity distribution during reconnection. Plots of phase-space density as a function of velocity components $V_{\perp 1}$, in the direction perpendicular to the magnetic field, and $V_{\parallel}$, parallel to the magnetic field.

Published in: Rachel Berkowitz, Physics Today, 72, 20-23 (2019), DOI: 10.1063/PT 3.4129

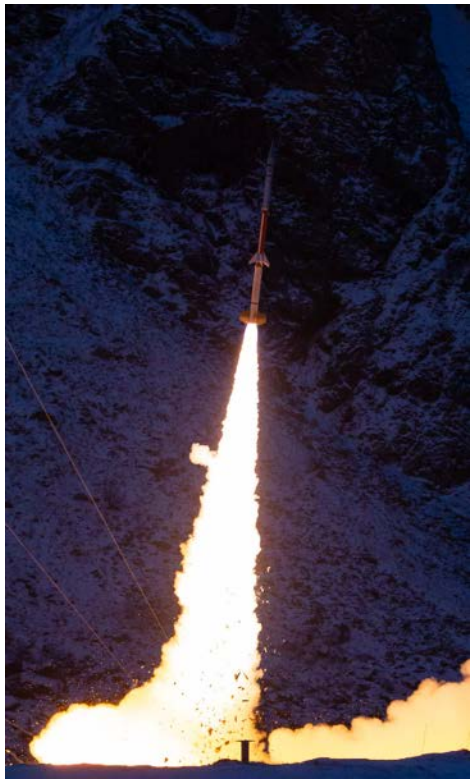
2.



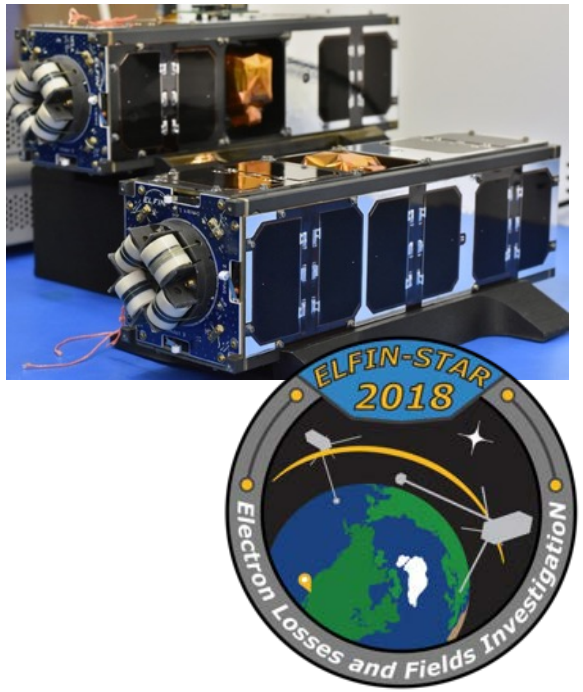
Video: Illustration of microscale magnetic turbulence. Flashes indicate magnetic reconnection triggered when field lines cross and intense electric currents (bright regions) are formed. This represents the discovery of electron magnetic reconnection without ion coupling in Earth's turbulent magnetosheath. Authors T. D. Phan, J. P. Eastwood, […]W. Magnes
https://doi.org/10.1038/s41586-018-0091-5

3. Recently, a powerful method for mapping the position the magnetic reconnection electron diffusion region using the MMS high-resolution 3-D magnetic field observations was developed. This paves the way for studying the elusive and small reconnection site without having to pass directly through it.
https://doi.org/10.1002/2016JA023788

Suborbital Highlights



G-CHASER, short for Grand Challenge Student Rocket launched Jan 13, 2019, Andøya Space Center, Norway, PI Koehler



Electron Loss and Fields Investigation with Spatio-Temporal Ambiguity Resolving (ELFIN-STAR) launched Sep 15, 2018, with ICESat-2 Vandenburg Air Force Base, PI Angelopoulos

Balloon Array for Radiation belt Electron Losses (BARREL), launched Dec 9, 2018, and still in flight, McMurdo Station Antarctica, PI Millan

HPD Suborbital Program

- 2018: 22 NASA missions + 4 reimbursable missions; 3 CubeSats; 4 balloon investigations
- 2019: Planning for 19 NASA missions + 2 reimbursable missions; 3 CubeSats

Grand Challenge

- 4 of 9 launched, AZURE window opens Mar 23

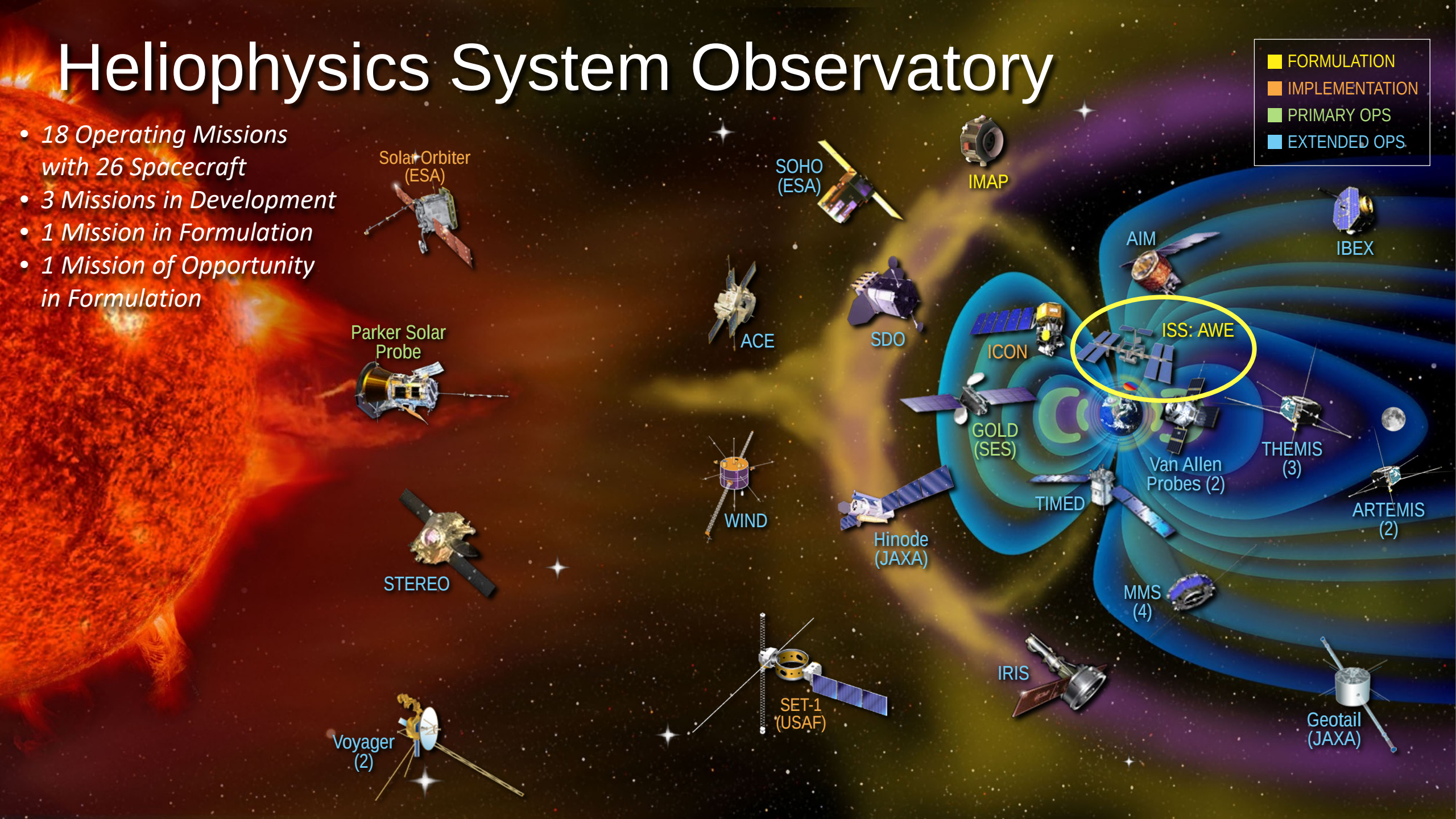
Upcoming campaigns:

- 4 Astrophysics missions targeting May 2020 launch window using new launch location – Australia

Heliophysics Missions

Heliophysics System Observatory

- *18 Operating Missions with 26 Spacecraft*
- *3 Missions in Development*
- *1 Mission in Formulation*
- *1 Mission of Opportunity in Formulation*



Parker Solar Probe

Above: Members of the Parker Solar Probe mission team celebrate on Nov 7, 2018, after receiving a beacon indicating the spacecraft is in good health following its first perihelion.

Credits: NASA/Johns Hopkins APL/Ed Whitman

- First Solar Encounter performed Oct 31 – Nov 11
  - Beacon tones beginning on Nov 7 indicated that the spacecraft was nominal and instruments functioning
  - Minimum perihelion of ~.17 AU occurred on Nov 5, and max speed of 213,200 mph
- Science data transmission from the first Parker solar encounter occurred Dec 7 – 13
- Originally planned data from orbit 1 and 2 downlinked in mid-April
- Parker performance sufficiently characterized to reduce the RF margin as well as increase instrument on time and data production.
  - Pre-launch data return from Orbit 1 + Orbit 2 was expected to be 214 Gb.
  - New data return is expected to be 440 Gb.
- Second Perihelion @ 18:38 EDT on Apr 4, 2019
- Next trajectory control maneuver #7 on May 13, 2019

Ionospheric Connection Explorer (ICON)

Mission Line: Explorers

Launch Vehicle: Pegasus XL rocket

Launch Site: Cape Canaveral

LRD: NET 2nd quarter 2019

ICON Principal Investigator: Tom Immel (UC Berkeley)

Description:

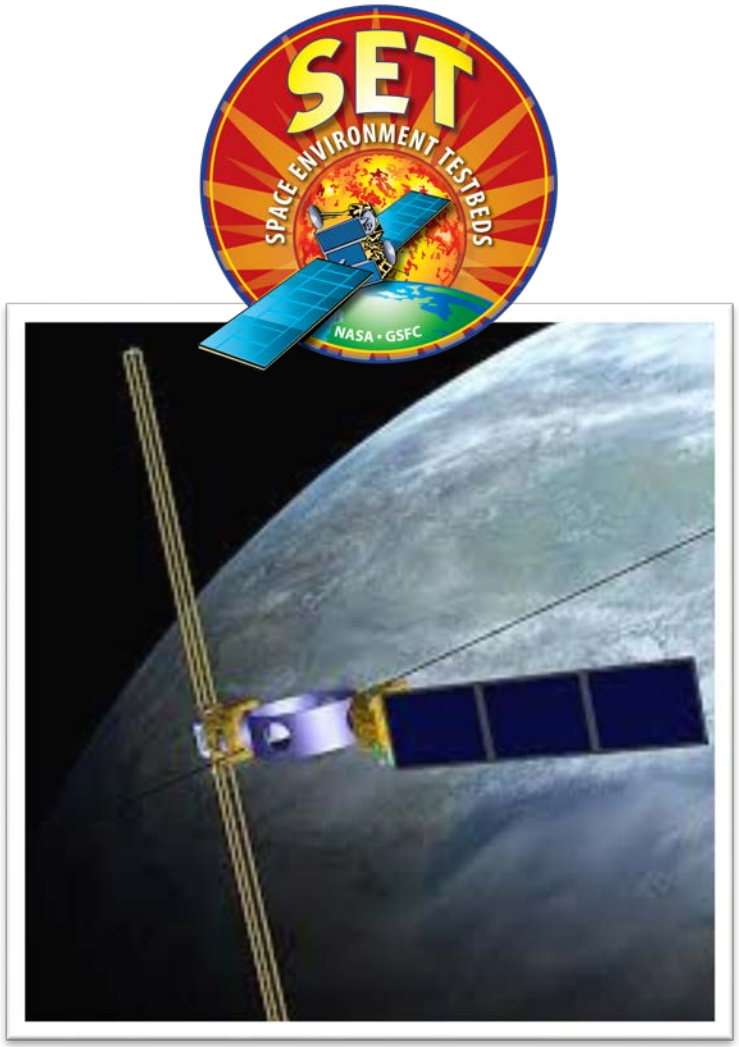
ICON will study the frontier of space: the dynamic zone high in our atmosphere where terrestrial weather from below meets space weather above.

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*: Awaiting launch*

Space Environment Testbed (SET-1) Mission



Mission Line: Living With a Star

Launch Vehicle: Falcon Heavy

Launch Site: Cape Canaveral

LRD: NET June, 2019

Observatory: SET-1 hosted payload on Air Force Research Laboratory (AFRL) Demonstration and Science Experiments (DSX) spacecraft

Description:

- 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

Next Step: *Awaiting launch*

Solar Orbiter Collaboration (with ESA)

Mission Line: Living With Star

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

Launch Site: Cape Canaveral

LRD: Feb 2020

Solar Orbiter Collaboration Project Scientist: Chris St. Cyr

U.S. Provided Instruments:

HIS (Heavy Ion Sensor) part of SWA, SoloHI (Heliospheric Imager) have been delivered.

Description:

Solar Orbiter aims to make significant breakthroughs in our understanding both of how the inner heliosphere works, and of the effects of solar activity on it.

The spacecraft 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: *Sine vibration testing ongoing until Feb 27*

HPD Operating Missions

Mission	Launch	Phase	Extension	M-3	M-2	M-1	Cur. M.	Remarks
Geotail	7/24/1992	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					
Hinode	9/23/2006	Extended	9/30/2021					
ACE	8/27/1997	Extended	9/30/2021					
SOHO	12/2/1995	Extended	9/30/2024					
TIMED	12/7/2001	Extended	9/30/2021					
Voyager 1 + 2	8/20/1977	Extended	9/30/2021					
IBEX	10/19/2008	Extended	9/30/2021					
Wind	11/1/1994	Extended	9/30/2021					
SDO	2/11/2010	Extended	9/30/2021					
Van Allen	8/30/2012	Extended	9/30/2021					
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					

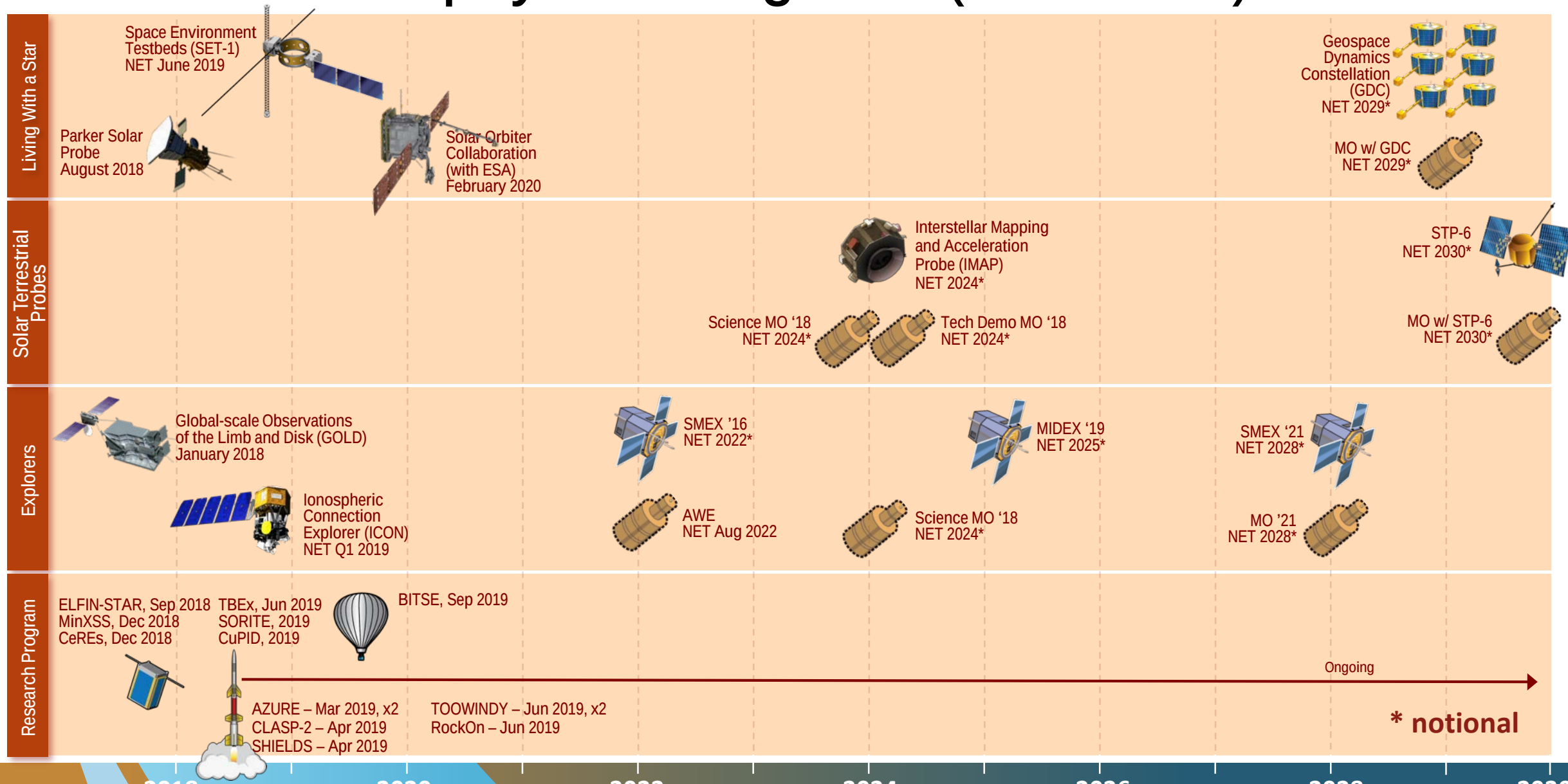
Mission proceeding to meet science requirements

Area of concern - possible reduction in capability

Significant problem – possible or probable loss of mission

Missions in Selection or Definition

Heliophysics Programs (2018-2030)



Interstellar Mapping and Acceleration Probe (IMAP)

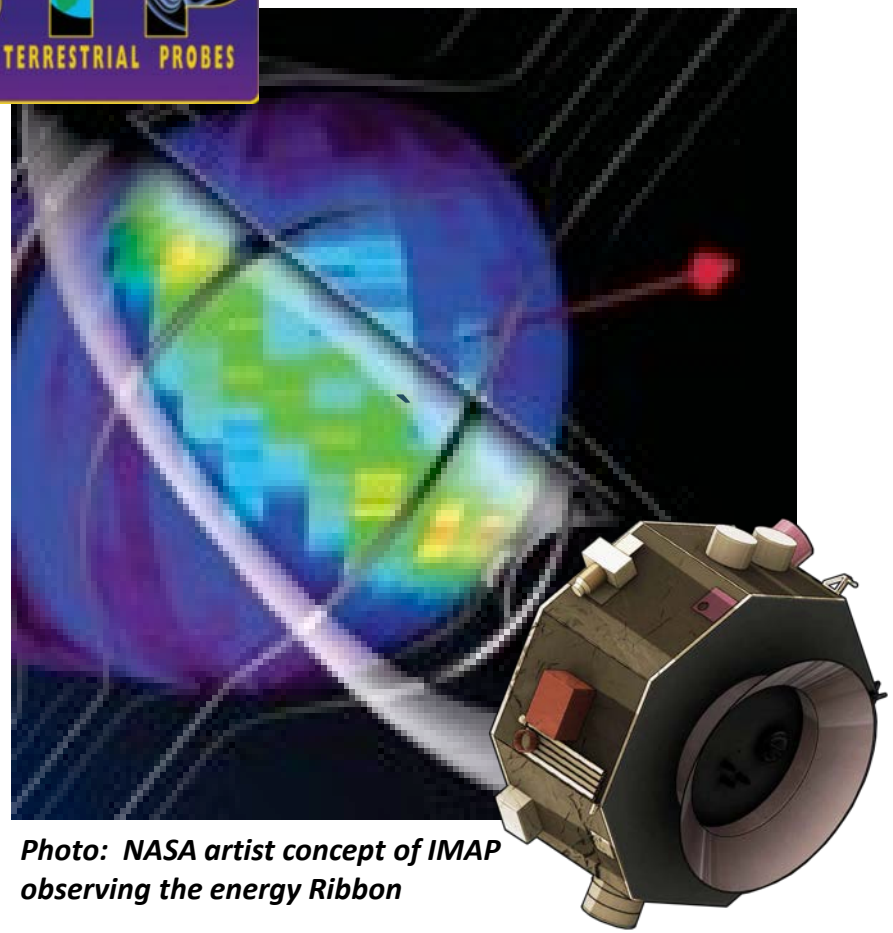


Photo: NASA artist concept of IMAP observing the energy Ribbon

IMAP - Selected: Jun 1, 2018

- LRD: Oct 1, 2024
- PI David McComas of Princeton University
- Project Management and Mission Operations Center at Johns Hopkins University's Applied Physics Laboratory in Laurel, Maryland
- Science Operations Center at LASP/University of Colorado

Orbit: L1 Lagrangian point

Description:

- Sample, analyze, and map particles streaming to Earth from the edge of interstellar space.
- Investigate the generation of cosmic rays in the heliosphere and beyond.
- 10 scientific instruments
- Investigating possible accommodation of a Tech Demo instrument

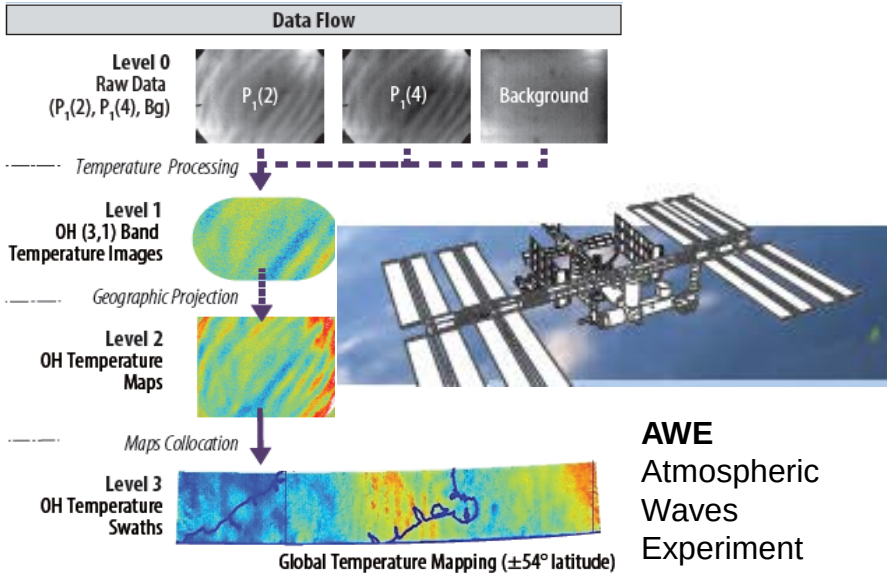
Rideshare opportunities on the ESPA Grande

- Competitive Missions of Opportunity including Tech Demo and Science
- NOAA Space Weather Follow-On L-1

2016 Explorers Mission of Opportunity Selections

Atmospheric Waves Experiment (AWE)

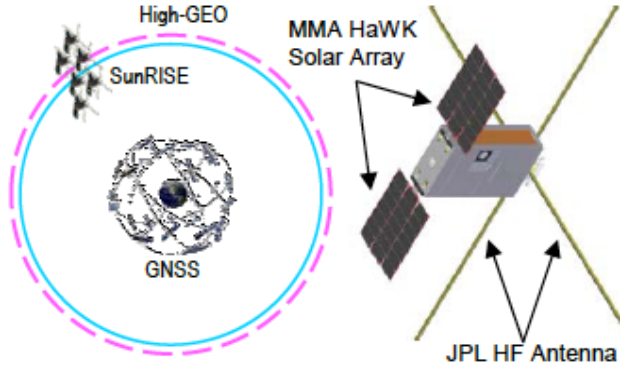
- Attached to the exterior of the ISS, AWE will focus on airglow to determine what combination of forces drive space weather in the upper atmosphere.
- LRD NET August 2022



AWE
Atmospheric Waves Experiment

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.



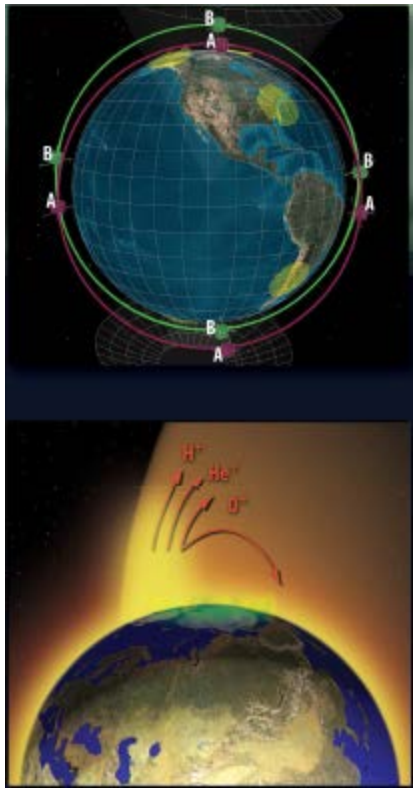
SunRise
Sun Radio Interferometer Space Experiment

Explorers AO 2016 SMEX Selections

Five SMEX missions in competitive Phase A; down-select in 2019:

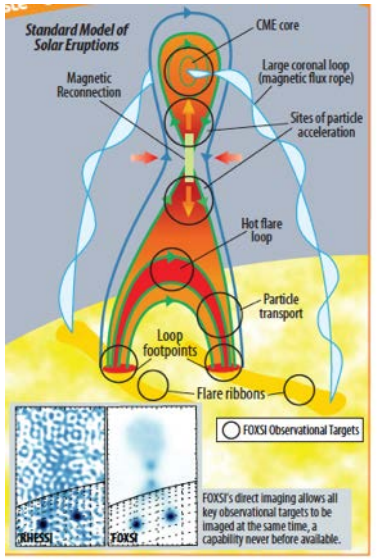
MEME-X, FOXSI, MUSE, TRACERS, PUNCH

LRD ~2022



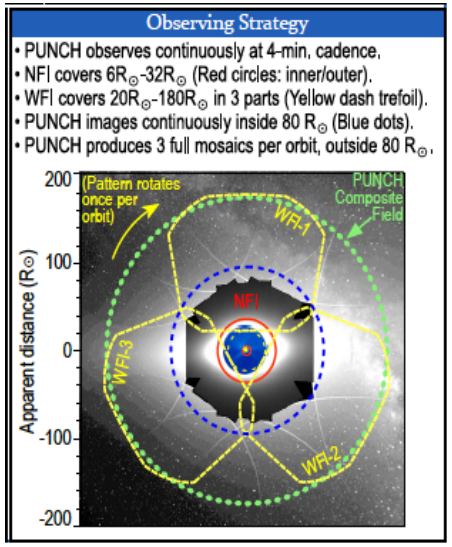
MEME-X

Mechanisms of Energetic Mass Ejection eXplorer



FOXSI

Focusing Optics X-ray Solar Imager

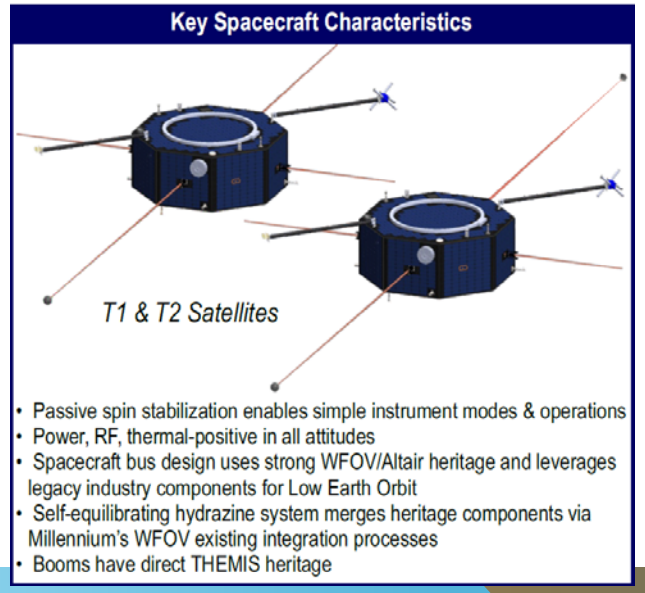


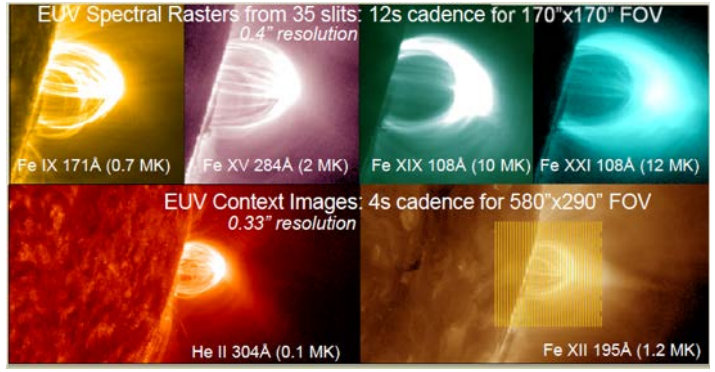
PUNCH

Polarimeter to Unify the Corona and Heliosphere

TRACERS

Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites





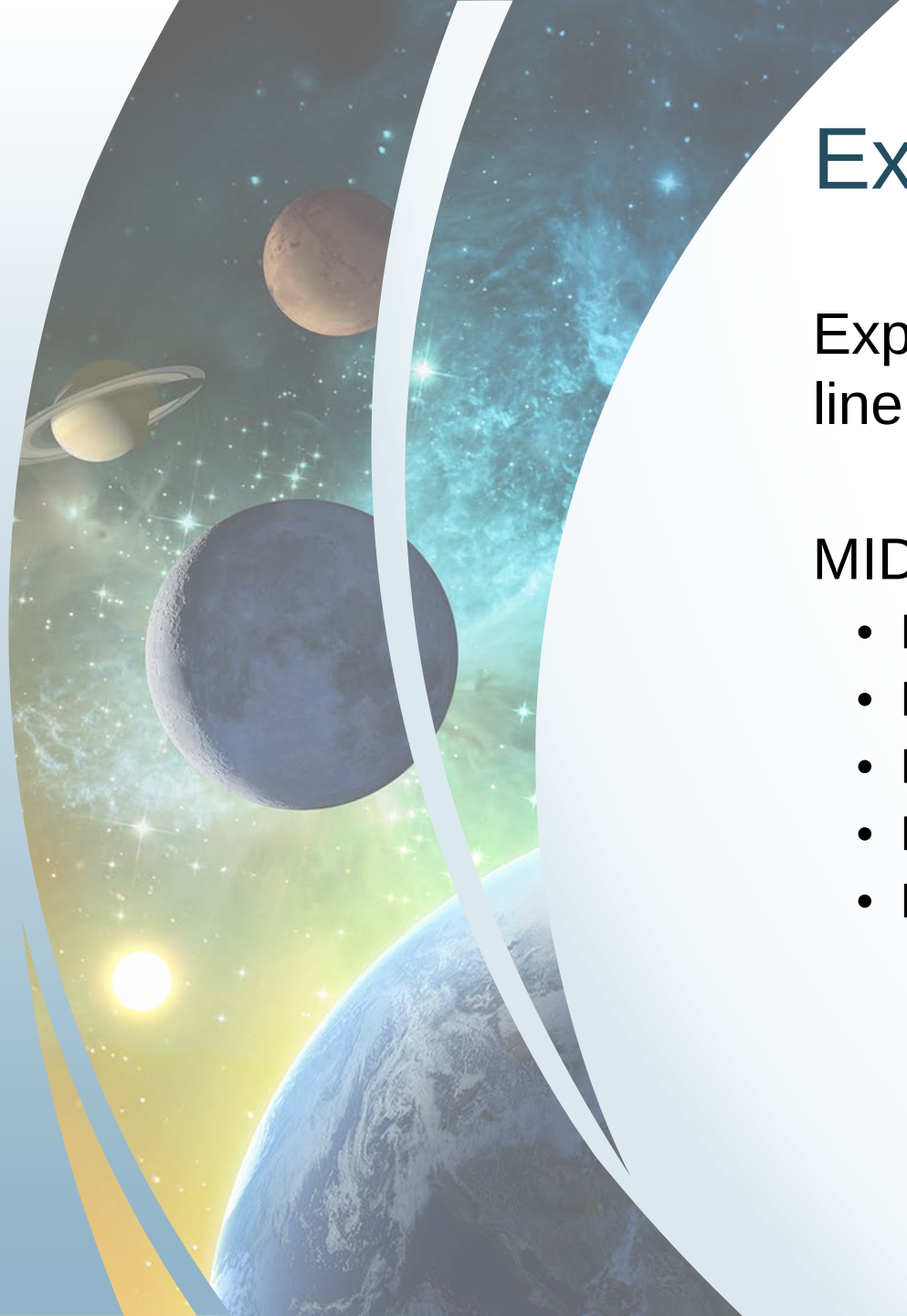
MUSE

Multi-slit Solar Explorer

2018 Heliophysics Opportunities

Within the SALMON AO released Aug 7, 2018, were two Program Element Appendices (PEAs) for Missions of Opportunity (MOs)

- Proposals received Nov 30
- Science MO cost cap $55M
- Science MO small complete mission (SCM) cost cap $75M to ride on ESPA ring
- Technology Demonstration MO SCM cost cap $65M to ride on ESPA ring
- Anticipated Launch Readiness Date: Oct 2024



Explorers Future Missions

Explorers mission cadence every 2-3 years; in-line with current Decadal Survey

MIDEX 19

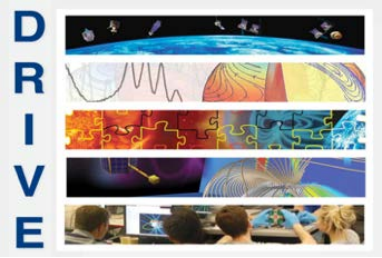
- Draft AO release date: April 2019
- Final AO release date: June 2019
- PI managed Cost Cap: $250M
- Launch Vehicle: Medium Class
- Launch Readiness Date: NLT Feb 2026

Geospace Dynamics Constellation

- Decadal Survey identified GDC as next 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 Study convened in May 2018
  - Discussions are limited to the science objectives and measurement requirements; no instrument-specific or mission implementation details
  - Study report expected to be delivered Jul 2019
- Additional Pre-Formulation activities will be necessary, as discussed at the Dec 2018 HPAC meeting
- LRD anticipated NET 2029

Heliophysics Research & Technology

Fully Funded DRIVE Program



($M)	FY15	FY16	FY17	FY18	FY19
FY15 PBR for DRIVE Elements	150.5	134.1	139.1	139.1	139.1
Actuals for DRIVE Elements	156.3	141.6	162.3	193.1	234.8
DRIVE increase for Elements	5.8	7.5	23.2	54	95.7

- The Decadal Survey recommended implementing DRIVE via augmenting existing Heliophysics research elements and creating new opportunities for competed targeted Guest Investigator programs and Heliophysics Science Centers.
- The funding for Heliophysics Science Centers comes from both the R&A line and LWS Science
- DRIVE funding also within Sounding Rocket and Research Range lines to maintain infrastructure
- Space Weather is an addition to these funding levels

Research DRIVE Elements included:

- HTIDeS:
  - Low Cost Access To Space (LCAS): Sub-orbital and CubeSats
  - Instrument Technology Development (ITD) and LNAPP
- Guest Investigator
  - Open and Mission Focused
- Supporting Research
- Grand Challenge Research
  - Including Heliophysics Science Centers
- Early Career Investigator Program
- LWS Science

From FY15 PBR to current day	
Overall DRIVE increase ($M)	186.2
Overall R&A increase ($M)	155.4
R&A DRIVE % increase	83%

Heliophysics Research

ROSES 18

- Awarded/Selected Elements:
  - Technology and Instrument Development for Science
  - Guest Investigator
  - Space Weather Operations to Research (1st)
  - Data Environment Enhancement
- Awaiting Selection:
  - Supporting Research
  - Early Career Investigator Program
- Open Solicitations:
  - Living With a Star
    - Step 1) Mar 12, Step 2) May 8
  - DRIVE Science Centers
    - Step 1) Mar 1, Step 2) May 2
  - Space Weather Operations to Research (2nd)
    - Step 1) Mar 12, Step 2) May 16

ROSES 19

- Released March 14, 2019
- Elements:
  - Supporting Research
  - Theory, Modeling and Simulations
  - Guest Investigator
  - Living With a Star Science
  - Space Weather Science Applications O2R
  - Technology and Instrument Development
  - Flight Opportunities for Research and Technology
  - Strategic Capabilities
  - Data Environment Emphasis
  - US Participating Investigator

Technology Development: HTIDeS

ROSES 18

LNAPP and ITD

- 13 of 35 proposals selected, 2 LNAPP & 11 ITD

R&T Flight (in-line with NPR7120.8):

- 25 non-prime proposals received (≤$3.5M)
  - 10 LCAS proposals selected
  - 1 CubeSat proposal selected
- 14 prime proposals received (>$3.5M)
  - 1 LCAS proposal selected for concept study
  - 5 CubeSat proposals selected for concept study

ROSES 19

Restructured: Split Into Two Program Elements

- Heliophysics Technology and Instrument Development for Science (H-TIDeS): LNAPP and ITD elements (lower TRL)
- Heliophysics Flight Opportunities for Research and Technology (H-FORT): LCAS, SmallSats and Rideshare Opportunities (SRO); in-line with NPR7120.8
  - Provide flight opportunities for more mature technologies

Living With a Star Program

Overall Status:

- Continue using LPAG to provide community perspective on various issues related to LWS, including future ROSES Focused Science Topics
- Maintaining LWS Institutes, Summer Schools, and Postdoctoral Program
- Plans for international collaboration:
  - Parker Solar Probe includes international science Co-Investigators
  - Solar Orbiter with ESA collaboration, LRD in Feb 2020
  - International participation in the GDC project is under discussion

ROSES 19

- Four new LWS Science FSTs
- Strategic Capabilities will be competed
- Tools and Methods will be competed with a topic on AI applications

Investments in Future Heliophysics Leaders

Students working on RockSat-X payload

FDL 2018 team

- Early Career Investigator Program (ECIP)
  - First year of pilot implementation
  - Anticipated awards Q2 FY19
- Fellowships
  - 6 current Jack Eddy Fellows
  - 12 NASA Earth and Space Science Fellowship (NESSF) in 2018
  - Future Investigators in NASA Earth and Space Science and Technology (FINESST) replaces the 2019 NESSF call
- Heliophysics Summer School
  - 33 students participated in 2018
- RockSat-X sounding rocket
  - 100+ student participated; launched Aug 13, 2018
- Frontier Development Lab
  - In 2018, 28 early career professionals; 4 per team

Space Weather

Space Weather Science and Applications (SWxSA)

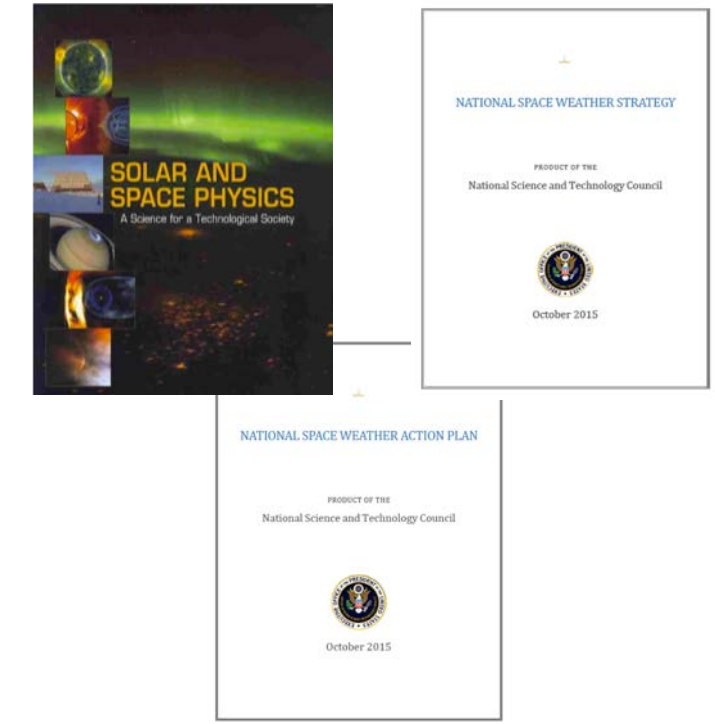
Establishes an expanded role for NASA in space weather science under single budget element

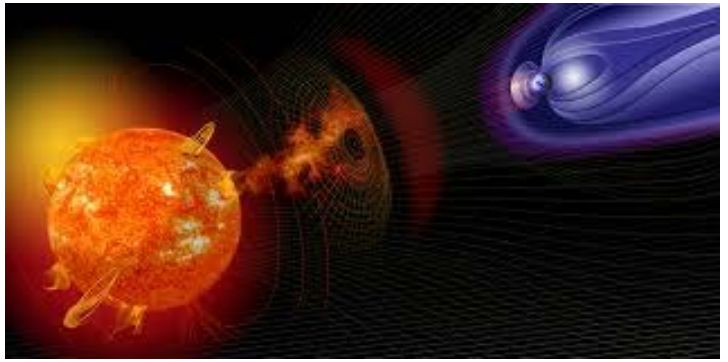
- Consistent with recommendation of the NRC Decadal Survey and the OSTP National Space Weather Strategy

Competes ideas and products, leverages existing agency capabilities, collaborates with other agencies, and partners with user communities

Three main areas of the Space Weather Science and Applications initiative are:

- Collaboration
- Competed Elements
- Directed Components





Space Weather Science and Applications: ROSES

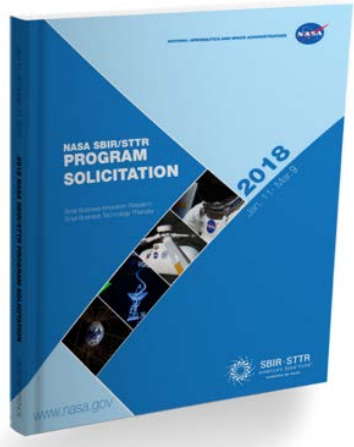
3 calls were made between ROSES 2017 and ROSES 2018 in Space Weather Operations-to-Research (SWO2R)

- 8 selections made for ROSES 2017 SWO2R
  - Focus: Improve predictions of background solar wind, solar wind structures, and CMEs
- 9 selections made for ROSES 2018 (1) SWO2R
  - Focus: Improve specifications and forecasts of the energetic particle and plasma encountered by spacecraft
- ROSES 2018 (2) SWO2R selections upcoming:
  - Focus: Improve forecasts of solar energetic particles and heavy ions

Space Weather Science and Applications: SBIR & STTR

- Preparation and validation of existing science models suitable for transition to operational use
- Development of space weather benchmarks
- Data assimilation innovations for operational space weather community
- Instrumentation concepts, flight architectures, and reporting systems suitable for data assimilation into space weather monitoring and forecasting systems

Empowers small businesses to deliver technological innovation that contribute to NASA's missions, provides societal benefit, and grows the US economy.



2018 SBIR – Funded two Phase I Proposals, currently under consideration for Phase II

- Interactive Tool for Modeling Multiple Solar Eruptions – PI Meaghan Marsh (Predictive Sciences)
- Automated Radiation Measurements for Aerospace Safety - Dual Monitor (ARMAS-DM) – PI Kent Tobiska (Space Environment Technologies)

2019 SBIR – Call for Phase I proposals is open until March 29 - https://sbir.nasa.gov/solicitations

Small Business Innovation Research (SBIR)

Small businesses engage in Federal R&D, with potential for commercialization

Small Business Technology Transfer (STTR)

Cooperative R&D between small business and U.S. research institutions, with potential for commercialization

Space Weather Science and Applications: Infrastructure and Benchmarking

Investments in improving Infrastructure

- CCMC enhancement for model assessment and transition
- High-End Computing capability to enable large scale predictive modeling development

Next Steps Benchmarking Activity beginning

- Community input to the update of the Space Weather Action Plan Benchmarks (Winter)
- Geoff Reeves (LANL) will chair community steering group

  Overseen by the Science and Technology Policy Institute, supported by NSF funding

  - Logistics provided by NASA
- Workshop hosted spring/summer where draft document created
- Town Hall in Fall 2019 for final document release

Heliophysics Committees

2018 Heliophysics Committee Meetings

HPAC Meeting

- Apr 5-6: 2017 Senior Review Recommendations were briefed
- Oct 22-23, 2018: GPRAMA Review
- Dec18-20, 2018: HPAC Meeting

GDC Science and Technology Definition Team

- May 15-18, 2018: 1st Meeting
- Jul 31 – Aug 3, 2018: 2nd Meeting
- Nov 27-30, 2018: 3rd Meeting

LWS Program Analysis Group meeting in College Park, MD

- Oct 22-23, 2018: ROSES 19 Focus Science Topics input, discussed future strategic capability, TRT metrics

CSSP

- Oct 16-18, 2018: Irvine CA
- Mar 26-28 ,2019: Washington DC

Partnerships

Intra- and Interagency Partners

Planetary:

- Co-selected LWS grants; joint ROSES Juno Participating Scientist Program

Astrophysics:

- Joint “Impact of Stellar Properties on the Habitability of Exoplanets” research opportunity

NASA-NOAA (MOU):

- Collaboration between CCMC and NOAA/SWPC on space weather modeling capability
- Co-funding O2R proposals
- Accommodation for SWFO mission on IMAP launch

NASA-NSF:

- Coordinating ICON & GOLD opportunities (joint NASA mission GI and NSF CEDAR solicitations)
- Consulted on solicitation design for Science Centers
- Co-funding CCMC
- New opportunity focused on Computational Aspects of Space Weather

NASA-NSF-NOAA:

- Pilot O2R research activity, MOU signed

NASA-USGS

- NASA collaborating with USGS to enable Magneto-Telluric Survey in southwest

International Partners

Partner	Mission(s)/Campaigns/Models
Austrian Aeronautics and Space Agency	THEMIS, MMS
Belgium – University of Liege, Belgian Federal Science Policy Office (BELSPO)	ICON, SOC, Parker
Brazilian Space Agency (AEB)	Van Allen, SPORT (forthcoming)
CNES, Centre National d'Études Spatiales	STEREO, MMS, LWS/SETI, SOC, Parker, SET, SOHO, THEMIS, WIND
National Commission on Space Activities (CONAE) of the Argentine Republic for Cooperation in Solar and Space Physics	Van Allen
CSA, Canadian Space Agency	THEMIS
Academy of Sciences of the Czech Republic – Institute of Atmospheric Physics	Van Allen
DLR, Deutsches Zentrum für Luft- und Raumfahrt	STEREO, THEMIS, Parker, sounding rocket campaigns
ESA, European Space Agency	SOHO, SOC
ISRO, Indian Space Research Organisation	Aditya-1 mission collaboration, space weather modeling, long-term strategic collaboration focus areas
JAXA, Japan Aerospace Exploration Agency	Hinode, MMS, Geotail, CLASP and CLASP-2 Sounding Rockets missions
KASI, Korea Astronomy and Space Science Institute	BITSE, Van Allen, SDO, KASI Geomagnetic Storm Forecast Model
Norway Space Center	IRIS
Roscosmos, Russian Academy of Sciences	SDO, STEREO, WIND, Hi-C Sounding Rocket Mission
Swedish National Space Board	MMS
Swiss Space Office, University of Bern	STEREO, SOC, IBEX
UKSA, United Kingdom Space Agency	Hinode, STEREO, LWS/SETI, SOC, SET

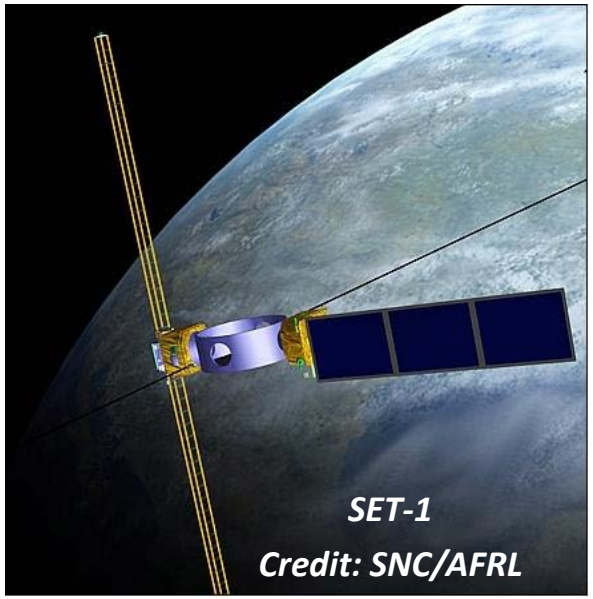
International Partners

Heliophysics New Initiatives

Whole Helio Initiative

- Coordinated observation and theory-modeling program covering full breadth of Heliophysics **across agencies** and **interdisciplinary**
- Coordinate Parker, DKIST, SolO, & other space, suborbital & ground-based assets
- Track the transit of features through interplanetary space
- Observe and characterize the geospace response
- Integration of Theory and Modeling throughout solar system and beyond
- ”Test Run” called Whole Heliosphere and Planetary Interactions led by Sarah Gibson and Barbara Thompson (https://whpi.hao.ucar.edu/)

Ability to take advantage of any future Rideshare opportunity



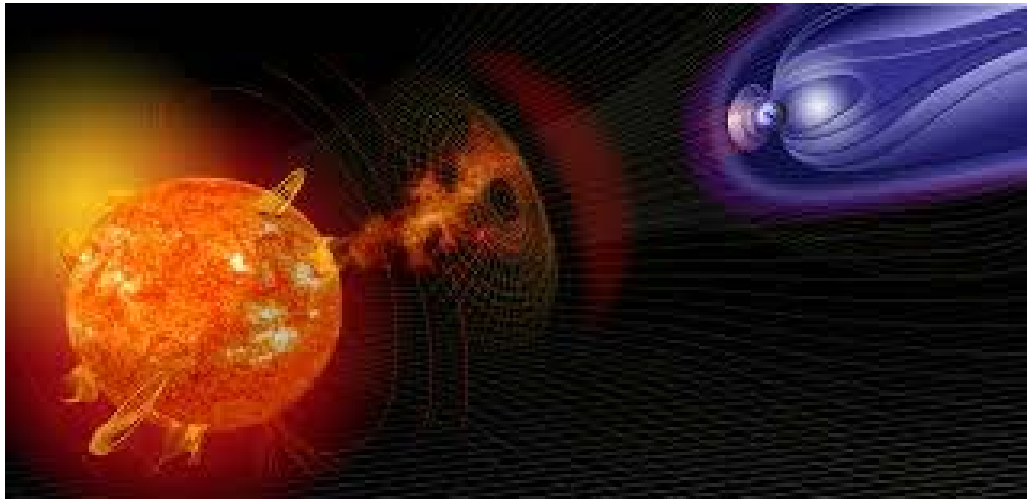
- SMD has embraced Rideshare opportunities as a standard practice to maximize mass to orbit
  - Enabling additional opportunities for science community
- In support of rideshare, HPD is developing a mission-unique ESPA Systems Interface Specification
- Goal: Implement innovative selection process to allow agility to respond to any given ride opportunity
  - Similar to Planetary Science Division call for instrument packages for lunar landers
  - Solicit high TRL investigations to create HPD portfolio which could be quickly integrated
  - Possibly fund through investigation CDR then hold until ride is available?

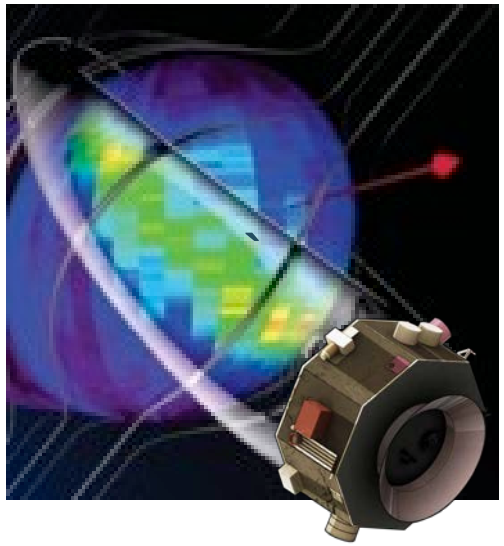
Heliophysics and the Lunar Gateway

- The Gateway presents new opportunities to conduct high priority heliophysics investigations
  - Observing geospace from lunar distances, enables advancement of knowledge and understanding for the coupling of the magnetosphere/ITM/upper atmosphere regions and interactions of the high/mid/equatorial regions can be obtained
  - The platform provides the opportunity to develop sensor technologies and observational capabilities for solar and space physics research
- The Gateway will leverage the application of heliophysics science to mitigate space weather impacts on human exploration at the Moon and beyond.
  - Development of Earth-Independent capability for space weather monitoring and prediction for exploration missions at the Moon and beyond is made possible by the Heliophysics Division Space Weather Science and Application initiative
  - In preliminary discussions with HEOMD to establish space weather capability requirements for the Gateway and for human exploration beyond geospace

Summary

It is a Great Time to be a Heliophysicist!





- Launched its most ambitious mission ever to touch the Sun (Parker), and the first NASA instrument aboard a commercial satellite (GOLD)
  - both within budget and on schedule
- New Missions of Opportunity selected and solicited
- Blazing a trail with enhanced ride share program
- Established the genesis of a Space Weather Science and Applications (SWxSA) in collaboration with sister federal agencies, academia, and industry
- Fully funded Decadal-proposed DRIVE initiative with provisions for early career, technology, diverse elements
  - Equals a very healthy R&A program!
- Instituted a strategic approach following the Decadal Survey recommendations
- Unique opportunity to study the Sun and its effects throughout the Heliosphere

Back-up

Acronyms [1/5]

AA	Associate Administrator
ABC	Agency Baseline Commitment
ACE	Advanced Composition Explorer
AFRL	Air Force Research Laboratory
AI	Artificial Intelligence
AIA	Atmospheric Imaging Assembly
AIM	Aeronomy of Ice in the Mesosphere
AO(s)	Announcement of Opportunity (Opportunities)
APL	Applied Physics Laboratory
APMC	Agency Program Management Council
ARTEMIS	Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun
AWE	Atmospheric Waves Experiment
BARREL	Balloon Array for Radiation belt Electron Losses
BITSE	Balloon-borne Investigation of Temperature and Speed of Electrons
BPR	Baseline Performance Review
Cat	Category
CCMC	Community Coordinated Modeling Center
CDF	Common Data Format
CEDAR	Coupling, Energetics, and Dynamics of Atmospheric Regions
CeREs	Compact Radiation Belt Explorer
CGMS	Coordinated Group for Meteorological Satellites
CINDI	Coupled Ion-Neutral Dynamics Investigations
CMC	Center Management Council
CME	Coronal Mass Ejection
COSIE	Coronal Spectrographic Imager in the EUV

COSPAR	Committee on Space Research
DEE	Data Environment Enhancements
Demo	Demonstration
DOE	Department of Energy
DPMC	Mission Directorate Program Management Council
DRIVE	Diversify, Realize, Integrate, Venture, Educate
DSX	Demonstration and Science Experiments
DXL	Diffuse X-rays from the Local Galaxy
ECIP	Early Career Investigator Program
EELV	Evolved Expendable Launch Vehicle
ELFIN-STAR	Electron Loss and Fields Investigation with Spatio-Temporal Ambiguity Resolving
EPD	Energetic Particle Detector
ESA	European Space Agency
ESPA	EELV Secondary Payload Adapter
EUI	Extreme Ultraviolet Imager
EUV	Extreme Ultra-Violet
EVM	Earned Value Management
FACA	Federal Advisory Committee Act
FAST	Fast Auroral SnapshoT Explorer
FDL	Frontier Development Lab
FIELDS	Fields Experiment
FINESST	Future Investigators in NASA Earth and Space Science and Technology
FITS	Flexible Image Transport System
FORT	Flight Opportunities for Research and Technology
FOV	Field of View

Acronyms [2/5]

FOXSI	Focusing Optics X-Ray Solar Imager
FRR	Flight Readiness Review
FSTs	Focus Science Topics
FUV	Far Ultra-Violet
FY	Fiscal Year
G-CHASER	Grand Challenge Student Rocket
GCR	Grand Challenge Research
GDC	Geospace Dynamics Constellation
GEM	Geospace Environment Modeling
GI	Guest Investigator
GOLD	Global-scale Observations of the Limb
GPRA	Government Performance and Results Act
GPRAMA	Government Performance and Results Act Modernization Act
GRC	Glenn Research Center
GSFC	Goddard Space Flight Center
GUVI	Global Ultraviolet Imager
HEC	High End Computing
HEK	Heliophysics Events Knowledgebase
HIS	Heavy Ion Sensor
HPAC	Heliophysics Advisory Committee
HPD	Heliophysics Division
HQ	Headquarters
HSCs	Heliophysics Science Centers
IABG	Industrieanlagen-Betriebsgesellschaft mbH

IAG	International Astronomical Union
IAGA	International Association of Geomagnetism and Aeronomy
IAMAS	International Association of Meteorology and Atmospheric Sciences
IAU	International Astronomical Union
IBEX	Interstellar Boundary Explorer
ICAO	International Civil Aviation Organization
ICAO	Committee on Earth Observing Satellites
ICON	Ionospheric Connection Explorer
IDL	Interactive Data Language
IMAP	Interstellar Mapping and Acceleration Probe
IOC-UNESCO	Intergovernmental Oceanographic Commission - United Nations Educational, Scientific and Cultural Organization
IPA	Intergovernmental Personnel Act
IRIS	Interface Region Imaging Spectrograph
IS⊙IS	Integrated Science Investigation of the sun
ISCU	International Council for Science
ISES	International Space Environment Service
ISFM	Internal Scientist Funding Model
ISRO	Indian Space Research Organization
ISWI	International Space Weather Initiative
ITD	Instrument and Technology Development
ITM	Ionosphere-Thermosphere-Mesosphere
IUGG	International Union of Geodesy and Geophysics

Acronyms [3/5]

IUPAP	International Union of Pure and Applied Physics
IVM	Ion Velocity Meter
JAXA	Japan Aerospace Exploration Agency
JCL	Joint confidence level
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KASI	Korean Astronomy and Space Science Institute
KDP	Key Decision Point
KSC	Kennedy Space Center
LASP	Laboratory for Atmospheric and Space Physics
LCAS	Low Cost Access to Space
LCC	Life-Cycle Cost
LNAPP	Laboratory Nuclear, Atomic, and Plasma Physics
LPAG	LWS Program Analysis Group
LRD	Launch Readiness Date
LVRR	Launch Vehicle Readiness Review
LWS	Living With a Star Program
Mag	Magnetosphere
MAVEN	Mars Atmosphere and Volatile Evolution Mission
MDAA	Mission Directorate Associate Administrator
MEME-X	Mechanisms of Energetic Mass Ejection eXplorer
MIDEX	Medium-Class Explorers
MIGHTI	Michelson Interferometer for Global High-resolution Thermospheric Imaging

MinXSS-2	Miniature X-ray Solar Spectrometer
MMS	Magnetospheric Multiscale
MMS	Magnetospheric Multiscale Guest Investigators
MO	Mission of Opportunity
MO&DA	Mission Operations and Data Analysis
MOU	Memorandum of Understanding
MSFC	Marshall Space Flight Center
MUSE	Multi-slit Solar Explorer
NAC	National Advisory Committee
NAIRAS	Nowcast of Atmospheric Ionizing Radiation System
NAS	The National Academy of Sciences
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NESSF	NASA Earth and Space Science Fellowship before FINESST
NET	No Early Than
NGSPM	Next Generation Solar Physics Mission
NOAA	National Oceanic and Atmospheric Administration
NRA	NASA Research Announcement
NRC	National Research Council
NRL	Naval Research Laboratory
NSAC	National Science Advisory Committee
NSF	National Science Foundation
NSROC	NASA Sounding Rocket Operations Contract
NSRP	NASA Sounding Rocket Program

Acronyms [4/5]

NSTC	National Science and Technology Council
O2R	Operations to Research
OATK	Orbital ATK
Ops	Operations
ORNL	Oak Ridge National Laboratory
ORR	Operational Readiness Review
OSTP	Office of Science and Technology Policy
PBR	President's Budget Request
PCA	Program Commitment agreement
PDR	Preliminary Design Review
PE	Program Executive
PEA	Program Element Appendices
PFRR	Poker Flats Research Range
PHI	Polarimetric and Helioseismic Imager
PI	Principal Investigator
PIR	Program Implementation Review
PP	Program Plan
PPBE	Planning, Programming, Budgeting, and Execution
PS	Program Scientist
PSP	Participating Scientists Program
PSR	Pre-Ship Review
PUNCH	Polarimeter to Unify the Corona and Heliosphere
R&A	Research and Analysis
R&T	Research and Technology
R2O	Research to Operations
RAPTOR	Research and Analysis Program Tracking of Resources
RFI	Request for Information

RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
ROSES	Research Opportunities in Earth and Space Science
RPW	Radio and Plasma Waves
R_S	Solar Radii
SAMPEX	Solar Anomalous and Magnetospheric Particle Explorer
SBIR	Small Business Innovation Research
SBTT	Small Business Technology Transfer
SC	Science Committee
SCAR	Scientific Committee on Antarctic Research
SCOSTEP	Scientific Committee on Solar Terrestrial Physics
SDAC	Solar Data Analysis Center
SDO	Solar Dynamic Observatory
SDP	Science Data Package
SES	Societe Europeenne des Satellites
SET	Space Environment Testbeds
SHINE	Solar, Heliosphere and INterplanetary Environment
SIR	System Integration Review
SIS	Suprathermal Ion Spectrograp
SMD	Science Mission Directorate
SME	Subject Matter Expert
SMEX	Small Explorers
SNOE	Student Nitric Oxide Explorer
SOC	Solar Orbiter Collaboration
SOHO	Solar and Heliospheric Observatory
SoloHi	Solar Orbiter Heliospheric Imager
SPASE	Space Physics Archive Search and Extract

Acronyms [5/5]

SPDF	Space Physics Data Facility
SPICE	Spectral Imaging of the Coronal Environment
SpWx	Space Weather
SR	Senior Review
SR	Supporting Research
SRO	SmallSats and Rideshare Opportunities
SRPO	Sounding Rocket Program Office
STDT	Science and Technology Definition Team
STEREO	Solar Terrestrial Relations Observatory
STIX	X-ray Spectrometer/Telescope
STMD	Space Technology Mission Directorate
STP	Solar Terrestrial Probes
SunRISE	Sun Radio Interferometer Space Experiment
SW	Space Weather
SWA	Solar Wind Plasma Analyser
SWAP	Space Weather Action Plan
SWEAP	Solar Wind Electrons Alphas and Protons
SWFO	Space Weather Forward Observatory
SWORM	Space Weather Operations, Research, and Mitigation
SWPC	Space Weather Predication Center
SWRC	Space Weather Research Center
SwRI	Southwest Research Institute
TBC	To Be Confirmed
Tech	Technology
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIDeS	Technology and Instrument Development for Science
TIMED	Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics
TMS	Theory, Modelling and Simulations
ToF	Time of Flight
TPS	Thermal Protection System
TRACERS	Tandem Reconnection and Cusp Electrodynamics Reconnaissance Satellites
TRL	Technology Readiness Level
TWINS	Two Wide-angle Imaging Neutral-atom Spectrometers
UCB	University of California - Berkeley
UFE	Unallocated Future Expenses
ULA	United Launch Alliance
UM	University of Michigan
UNCOPUOS	United Nations Committee on Peaceful Use of OuterSpace
UNH	University of New Hampshire
URSI	International Union of Radio Science
USPI	United States Participating Investigator
UT	Universal time
VAFB	Vandenberg Air Force Base
VAP	Van Allen Probes
VSO	Virtual Solar Observatory
VxOs	Virtual x Observatory
WBS	Work breakdown structure
WFF	Wallops Flight Facility
WIGOS	WMO Integrated Global Observing System
WISPR	Wide-field Imager for Solar PRobe
WMO	World Meteorological Organization
WSMR	White Sands Missile Range