Heliophysics Space Weather at NASA: Research and Small Satellites

James Spann, Nicola Fox, Daniel Moses, Roshanak Hakimzadeh - Heliophysics Division

COSPAR Symposium: Space Weather and Small Satellites

February 11, 2019

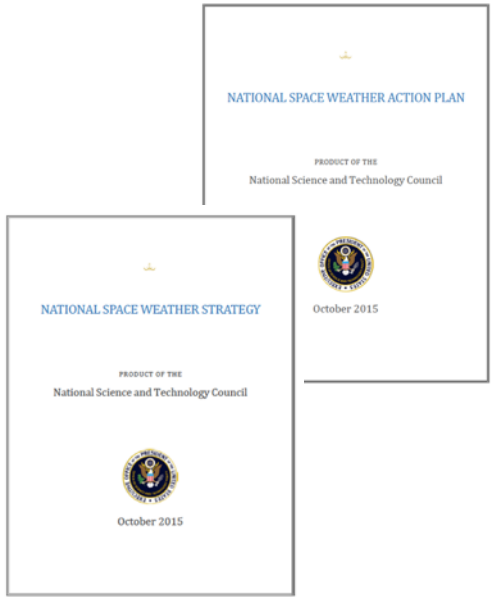
Overview

- Space Weather Science Applications Programs
  - Research
  - Infrastructure
  - International and Interagency Partnerships
- New Initiatives
  - Whole Helio Month campaigns
  - NASA Science Mission Directorate Rideshare policy
  - Heliophysics and the Lunar Gateway
- Small Satellites
  - NASA Activities
  - Heliophysics Small Satellite Missions

Space Weather Science Applications Program

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

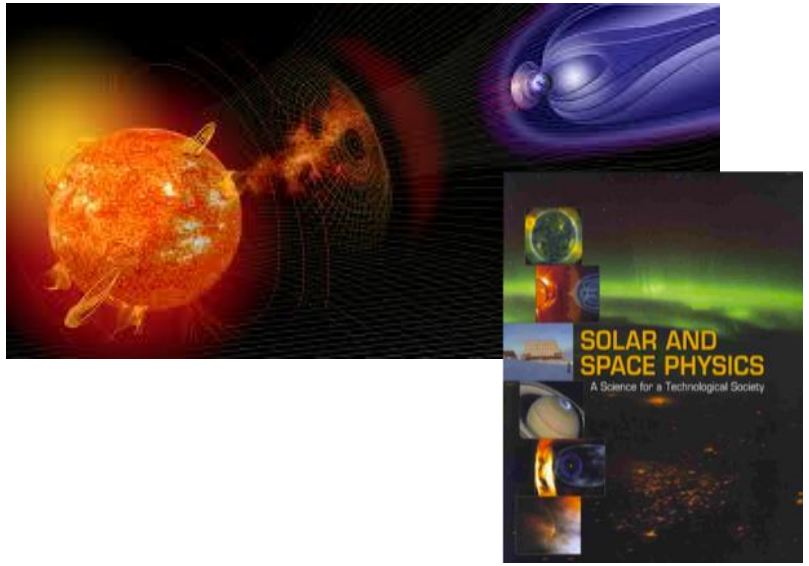
- Consistent with recommendation of the NRC Decadal Survey and the OSTP National Space Weather Strategy



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

Three main areas of the Space Weather Science Applications Program are:

- Collaboration
- Competed Elements
- Directed Components



Heliophysics Space Weather Science Applications Transition Strategy, first meeting held Nov. 28

Space Weather Science Applications Program (1)

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
  - Step 1 proposals due 2/1/19; Step 2 proposals due 4/5/19
- ROSES 2019 will include a SWO2R call

Small Business Innovation Research (SBIR) Program

- Selected two space weather proposals for 2018; continued participation in 2019 SBIR Program

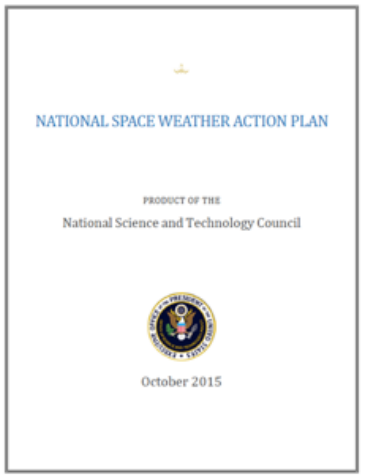
Space Weather Science Applications Program (2)

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
- 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



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)
- Co-funding Living With a Star Strategic Capabilities, Science Centers, 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

ESA (Europe):

- Solar Orbiter and SOHO

KASI (Korea):

- Development towards prototype coronagraph (BITSE) for balloon flight in 2019
- Van Allen downlink and SDO data archiving
- KASI Geomagnetic Storm Forecast Model

AEB (Brazil):

- SPORT CubeSat Mission, LRD 2020

ISRO (India):

- Three sub-working groups established
- Aditya-1 mission collaboration, space weather modeling, long-term strategic collaboration focus areas

JAXA (Japan):

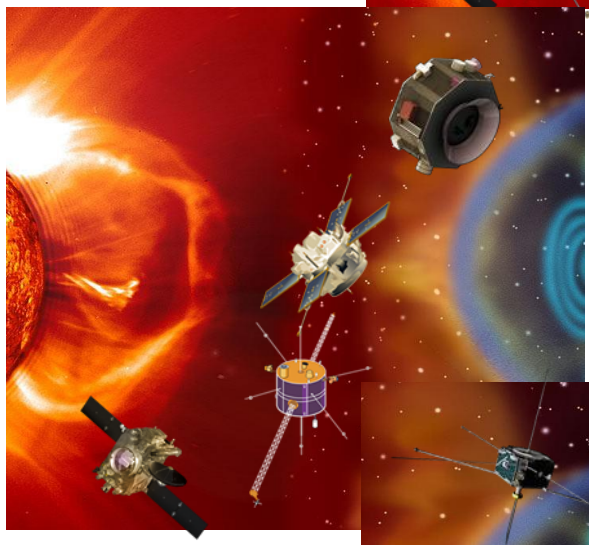
- Working with JAXA on approach for Next Generation Solar Physics Mission (NGSPM)
- Cooperation on Hinode, Geotai,l and sounding rockets (CLASP and the upcoming CLASP2)

Now Initiatives in Heliophysics

- Whole Helio Month
- Heliophysics Rideshare
- Heliophysics and the Lunar Gateway

Whole Helio Month (1/2)

- Coordinated observation and theory-modeling program covering full breadth of Heliophysics **across agencies** and **interdisciplinary**
- Centered on perihelion passes for Parker which are visible from Earth or other planets
- 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

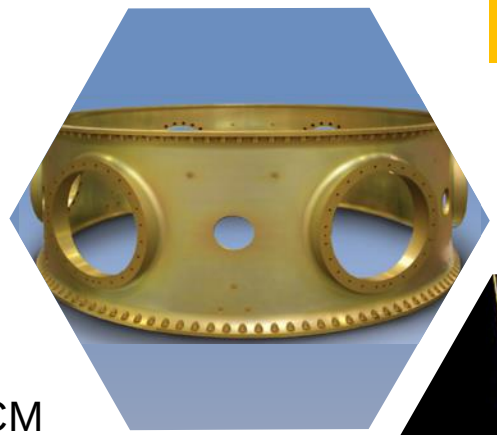


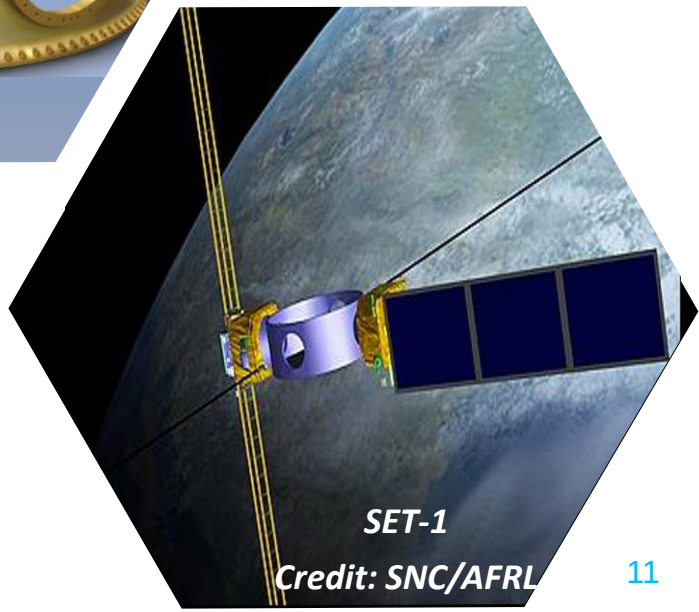
Whole Helio Month (2/2)

- ”Test Run” this summer centered on Solar Minimum called Whole Heliosphere and Planetary Interactions led by Sarah Gibson and Barbara Thompson (https://whpi.hao.ucar.edu/)
- Novel interdisciplinary scientist program to drive connected research and discovery
  - Large scale IDS teams led by a PI
  - Grants for individual contributors who will provide their data and conduct independent research.
- Follow up workshop after first observing period
  - Collaboration after campaign plus planning meeting for the next campaign.
- Workshops would continue to be scheduled at a regular cadence – organized by IDS teams

HPD Rideshare

- SMD has embraced Rideshare opportunities as a standard practice to maximize mass to orbit
  - Enabling additional opportunities for science community
- SMD has formed a rideshare policy team to develop standard rideshare processes
- The first HPD rideshare opportunity is using a standard (non-propulsive) ESPA Grande
  - Releasing RFI to capture private sector capability and interest in ESPA integration.
- Rideshare opportunities on IMAP ESPA
  - Science MO SCM & Technology Demonstration MO SCM
  - NOAA Space Weather Forward Observatory
  - If there are open ESPA ports after the above missions are accommodated, they will be offered to other SMD investigations under new Rideshare Policy.
- In support of rideshare, HPD is developing a mission-unique ESPA Systems Interface Specification





Expanded Rideshare Program

- 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

Planetary Science
New Worlds, New Discoveries

earth science

ASTROPHYSICS

Industry

Heliophysics and the Lunar Gateway

- Use a new platform for Geospace investigations including space weather observations, and for prototype telescopes
- Staging and deployment of multi-spacecraft missions

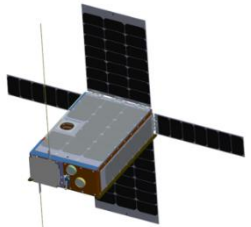
Small Satellites

- NASA Activities
- Heliophysics Small Satellite Missions

NASA SmallSat Activities

NASA's Mission Directorates have organized an integrated and flexible set of program elements, which leverage their mutual systems and are strategically working to exploit the growing capabilities of small satellites as an increasingly important tool to enable NASA's goals:

- Conducting Earth and Space science investigations, and developing precursor instrument technologies for future science measurements. Providing opportunities for secondary payloads in mission opportunities. (SMD)
- Developing and demonstrating new small spacecraft technologies and capabilities for NASA's missions in science, exploration and space operations. (STMD)
- Providing launch opportunities to the U.S. CubeSat Community (academia, government, and non-profits). (HEOMD/Launch Services Program)
- Developing missions to address strategic knowledge gaps for exploration. (HEOMD)
- Coordinating spectrum frequency management and licensing for all NASA sponsored missions. (HEOMD)
- Through its Small Spacecraft Community of Practice, developing lessons learned and streamlined SMA approaches. (OSMA)



Small Spacecraft Technology Program / STMD

Scientific Research / SMD

Access to Space - CubeSat Launch Initiative (CSLI) HEOMD

NASA SmallSat Activities

Activities within three NASA Mission Directorates (SMD, STMD and HEOMD) are leveraging their strategic interests to exploit the growing capabilities of small satellites as an increasingly important tool to achieve NASA's goals

- Conducting Earth and Space science investigations, and developing precursor instrument technologies for future science measurements. Providing opportunities for secondary payloads in mission opportunities. (SMD)
- Developing and demonstrating new small spacecraft technologies and capabilities for NASA's missions in science, exploration and space operations. (STMD)
- Providing launch opportunities to the U.S. CubeSat Community (academia, government, and non-profits) via the CubeSat Launch Initiative (CSLI in HEOMD-LSP)
- Sponsoring missions to address strategic knowledge gaps for exploration. (HEOMD)
- Coordinating frequency management and licensing for all NASA related missions. (HEOMD-SCaN)

NASA SmallSat Missions

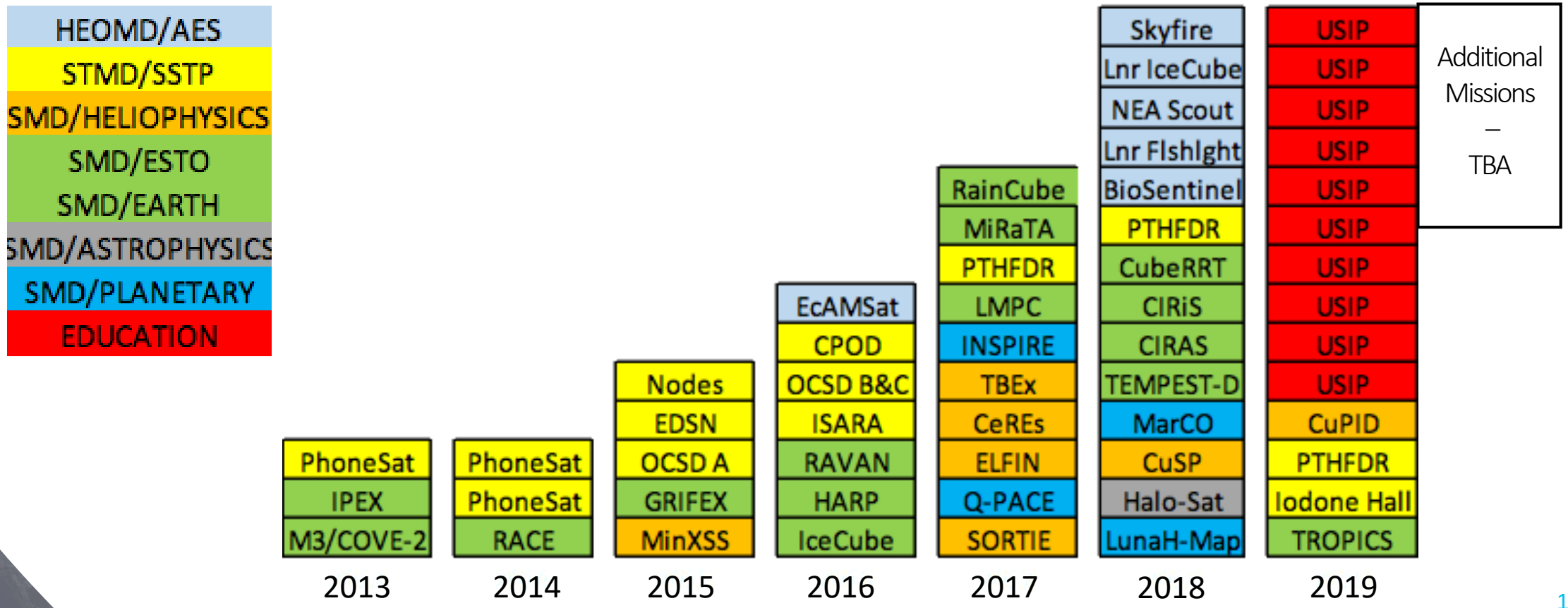
NASA
66 missions
91 CubeSats

SMD
23 missions
37 CubeSats

SSTP
15 missions
26 CubeSats

AES
6 missions
6 CubeSats

OE/SMD
22 missions
22 CubeSats



NASA SMD Heliophysics Cubesat Activities

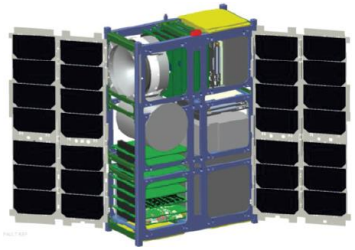
- SMD CubeSat Initiative Panel (SCIP) is a SMD technology group charged with exploring the utility of CubeSats to achieve SMD science objectives.
- Nine (9) CubeSat missions have been initiated in this program.
- All missions selected via peer review of proposals submitted to open solicitations.
- Program management of these missions conducted by the SCIP in order to determine the optimal management approach for CubeSat science missions.
- SCIP also gathers CubeSat implementation and technology information from across the agency to optimize SMD application and provide feedback to the agency on future technology development needs.

Current Research and Analysis SCIP Missions

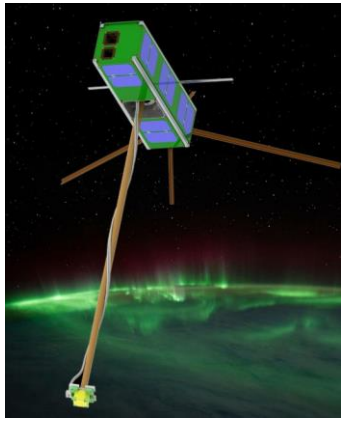
Fiscal Year	Sponsor	Mission	PI	Institution	Discipline	Access to Space
2014	SMD	IceCube	Wu	GSFC	Earth	CSLI (2013)
2014	SMD	TBEx	Tsunoda	SRI	Helio	CSLI (2015)
2014	SMD	MinXSS	Woods	U Colo	Helio	Orb-4/Nanoracks
2014	SMD	CuSP	Desai	SwRI	Helio	EM-1
2014	SMD	SORTIE	Crowley	ASTRA	Helio	CSLI (2015)
2014	SMD	ELFIN	Angelopoulos	UCLA	Helio	CSLI (2014)
2015	SMD	Halo-Sat	Kaaret	U Iowa	Astrophysics	TBD
2015	SMD	LunaH-Map	Hardgrove	Arizona State	Planetary	EM-1
2015	SMD	Q-PACE	Colwell	Central Florida	Planetary	CSLI (2015)

SCIP Science Investigations

CuSP (The CubeSat mission to study Solar Particles) – SwRI, JPL, GSFC
Heliophysics Science Division (HPD) – CuSP+ is a 6U CubeSat investigation of the sources and acceleration mechanisms of solar and interplanetary (IP) particles and support space weather research. CuSP+ will be launched as a SLS EM-1 secondary payload into an interplanetary, heliocentric orbit - interior to and leading the Earth's orbit. In this orbit, CuSP+ will observe interplanetary solar particles traveling along the Parker spiral interplanetary magnetic field before those particles reach the Earth.

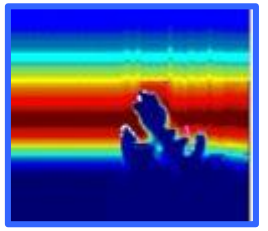


ELFIN (Electron Losses and Fields Investigation) – UCLA
Heliophysics Science Division (HPD) investigation to advance our understanding of Geospace Storms, and the dominant wave-loss mechanism of relativistic "killer" electrons from the radiation belts. ELFIN will measure, for the first time, the angle and energy distribution of precipitating electrons, and will compare the measured loss rates and electron properties during storms with theoretical models. ELFIN launched on September 15, 2018.



SCIP Funded Science Investigations

TBeX (Tandem Beacon-Explorer)– Michigan, Heliophysics Division (HPD) – TBeX will address a scientific challenge in 2012 NRC Decadal Survey: Understand how forcing from lower atmosphere acts through plasma-neutral coupling processes to give rise to local, regional, and global-scale structures and dynamics in the atmosphere-ionosphere-magnetosphere system. TBEx will monitor (1) response of bottom side F layer to wavelike disturbances from below, with sampling intervals less than orbital period, and (2) development of equatorial plasma structure, including 'equatorial plasma bubbles' (EPBs). TBEx mission is expected to provide a better understanding of the physics that controls the day-to-day variability in development of EPBs (space weather)



Equatorial Plasma Bubble

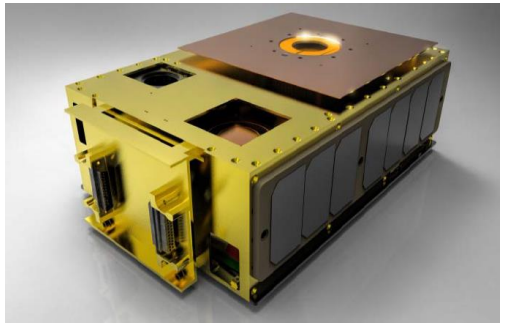
Ionosphere

Coupling

Troposphere

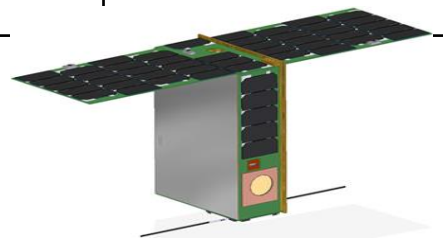
Weather

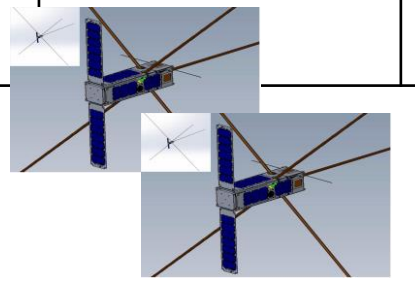
SORTIE (Scintillation Observations and Response of The Ionosphere to Electrodynamics) – ASTRA, SDL Heliophysics Division (HPD) – SORTIE will measure phase delay between the plasma velocity components parallel and perpendicular to the magnetic field and the plasma density perturbation to discover the sources of wave-like plasma perturbations in the F-Region ionosphere; to determine the relative role of dynamo action and more direct mechanical forcing in the formation of wave-like plasma perturbations.

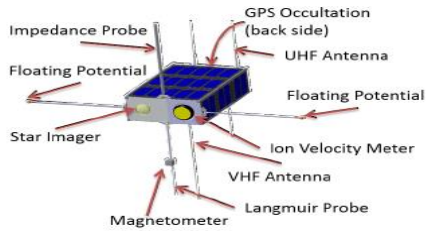


2016 SMD Heliophysics CubeSat Selections

Spacecraft	petitSat	LLITED	CURIE	SPORT
PI	Klenzing	Bishop	Sundkvist	Spann
Size	6U	Two 1.5U	Two 3U	6U
Goals	**Plasma Enhancements in The Ionosphere-Thermosphere Satellite with connection to MSTIDs** What are the observed drift, density, and O+/H+ signatures of plasma enhancements as a function of magnetic latitude?	**Low-Latitude Ionosphere/Thermosphere Enhancements in Density** 1. What is the mesoscale variability of the the Equatorial Temperature and Wind Anomaly (ETWA) as a function of season etc? 2. What is the relationship between neutral winds (i.e., tides) and the EIA zonal structure? 3. Are the small-scale wave fluctuations in neutral atmosphere quantities, such as those observed by earlier missions exhibited in the ionospheric density?	**Cubesat Radio Interferometry Experiment** To study radio burst emissions from solar eruptive events such as flares and coronal mass ejections (CMEs) in the inner heliosphere.	**Scintillation Prediction Observations** Looking at the formation of Equatorial Spread F (ESF) and linking plasma conditions to radio scintillations, with a high significance to downstream space weather applications.







The Dawn of a New Era for Heliophysics

Heliophysics Division, in collaboration with its partners, is poised like never before to:

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

Backup

Heliophysics System Observatory

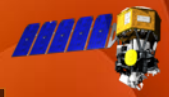
- *17 Operating Missions with 24 Spacecraft*
- *4 Missions in Development*
- *1 Mission in Formulation*

Formulation
Implementation
Primary Ops
Extended Ops


IMAP


SOHO (ESA)

NET Q1 2019


ICON

Aug 2018


Parker Solar Probe

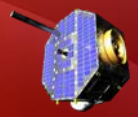

ACE


SDO

Jan 2018


GOLD (SES)


AIM


IBEX


Van Allen Probes (2)

NET Feb 2020


Solar Orbiter (ESA)


TIMED


THEMIS (3)


Wind


Hinode (JAXA)

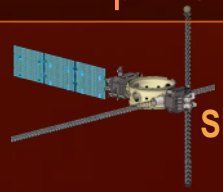

STEREO (1)


MMS (4)


ARTEMIS (2)

NET Apr 2019


IRIS


SET-1 (USAF)

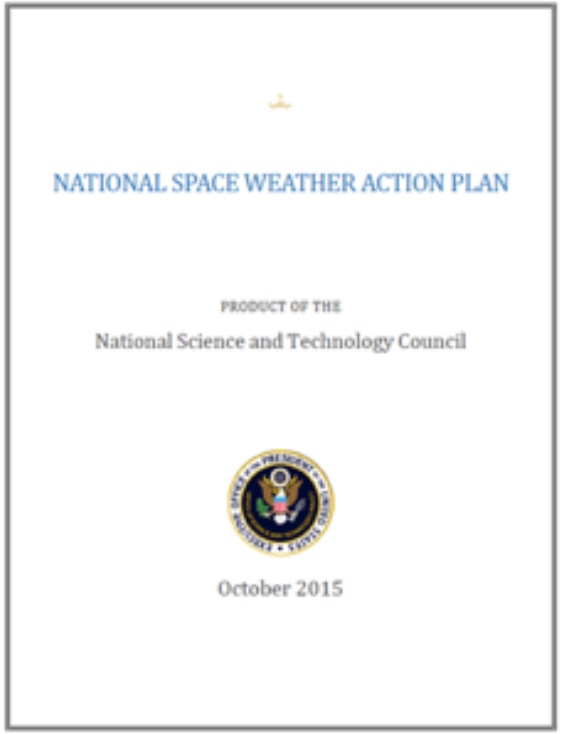

Geotail (JAXA)


Voyager (2)

Revised National Space Weather Action Plan

Three components:

- **Protect** – focused on National Security, understanding the impacts to infrastructure and relevant technologies, and mitigating those impacts
  - Lead agencies: DHS, DoD
- **Plan** – focused on planning, testing, evaluating, exercising the plan
  - Lead agencies: DoD, DHS
- **Characterize, Forecast, disseminate** – Focused on identifying sustaining capabilities, improved capabilities, understanding of space weather, dissemination of this information
  - Lead agencies: DOC/NOAA, NASA



National Space Weather Strategy

Administration Priorities

- Promote leadership, technology, and innovation
- Promote American resilience to threat of natural and induced space weather disasters
- Enhance space weather forecasts, alerts and services
- Space Weather policy extends beyond Low Earth Orbit
- Strengthen space weather capabilities to enhance National Security
- Advance American influence and leadership in space

NASA Strategic Plan, 2018

- Agency Strategic Objective 1.1: Understand The Sun, Earth, Solar System, And Universe,
- Context: Safeguarding and Improving Life on Earth

Acronyms [1/4]

AA	Associate Administrator
ABC	Agency Baseline Commitment
ACE	Advanced Composition Explorer
AFRL	Air Force Research Laboratory
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
BPR	Baseline Performance Review
Cat	Category
CCMC	Community Coordinated Modeling Center
CDF	Common Data Format
CEDAR	Coupling, Energetics, and Dynamics of Atmospheric Regions
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
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

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
FIELDS	Fields Experiment
FITS	Flexible Image Transport System
FOV	Field of View
FOXI	Focusing Optics X-Ray Solar Imager
FRR	Flight Readiness Review
FUV	Far Ultra-Violet
FY	Fiscal Year
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
H-TIDeS	Heliophysics Technology and Instrument Development for Science
HEC	High End Computing
HEK	Heliophysics Events Knowledgebase
HIS	Heavy Ion Sensor
HPAC	Heliophysics Advisory Committee
HPD	Heliophysics Division

Acronyms [2/4]

HQ	Headquarters
HSCs	Heliophysics Science Centers
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
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
MMS	Magnetospheric Multiscale
MMS	Magnetospheric Multiscale Guest Investigators
MO&DA	Mission Operations and Data Analysis
MoO (MO)	Mission of Opportunity
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

Acronyms [3/4]

NESSF	NASA Earth and Space Science Fellowship
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
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
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
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	Heliospheric Imager

Acronyms [4/4]

SPASE	Space Physics Archive Search and Extract
SPDF	Space Physics Data Facility
SPICE	Spectral Imaging of the Coronal Environment
SR	Senior Review
SR	Supporting Research
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
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
THOR	Turbulence Heating ObserveR
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
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