



Heliophysics



*Heliophysics Division FY17 Budget & Update
NASA Advisory Council Science Committee
10 March 2016
Steven W. Clarke, Director*



Overview Topics



- **Budget Update**
- **Mission Update**
- **National Space Weather Strategy**
- **Outreach**



Budget Update

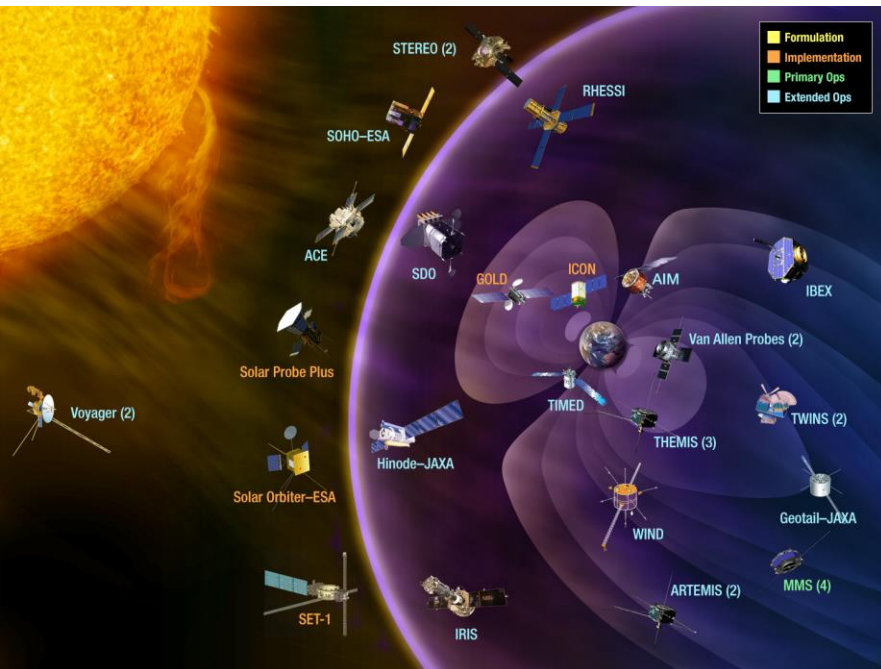


Heliophysics



Outyears are notional

(\$M)	2016	2017	2018	2019	2020	2021
Heliophysics	\$650	\$699	\$684	\$698	\$715	\$724



- Continues Solar Orbiter Collaboration (SOC) partnership with ESA (2018 launch)
- Continues development of Solar Probe Plus (SPP), Ionospheric Connection Explorer (ICON), and Global-scale Observations of the Limb and Disk (GOLD) all to be launched in FY 2018
- Operates over 17 Heliophysics missions (31 individual spacecraft)
- Triples funding for the CubeSat project in FY 2017
- Supports the National Space Weather Strategy and Action plan
- Increases support for Research and Analysis, and maintains support of the Sounding Rockets program



FY17 Heliophysics President's Budget



	Op Plan	Request	FY17	FY18	FY19	FY20	FY21
	FY15	FY16					
<u>Heliophysics</u>	<u>636.1</u>	<u>651.0</u>	<u>698.7</u>	<u>684.0</u>	<u>698.3</u>	<u>714.8</u>	<u>723.9</u>
<u>Heliophysics Research</u>	<u>192.0</u>	<u>158.5</u>	<u>180.1</u>	<u>192.0</u>	<u>210.0</u>	<u>215.9</u>	<u>214.2</u>
Heliophysics Research and Analysis (791926)	34.1	34.0	38.9	48.9	53.9	53.9	53.9
Sounding Rockets (962880)	66.2	48.3	53.3	59.0	61.1	63.1	63.1
Research Range (153825)	21.3	21.6	21.7	21.7	25.1	25.1	25.2
Science Planning and Research Support (527813)	6.5	6.6	6.7	6.8	6.8	6.8	6.8
Directed Research & Technology (526310)	18.4	2.9	3.9	5.4	3.2	6.3	4.5
CubeSat (964105)	6.5	5.0	15.0	5.0	5.0	5.0	5.0
Voyager (925575)	5.5	5.7	5.6	5.5	5.6	5.5	5.5
SOHO (789743)	2.2	2.2	2.3	2.2	2.3	2.3	2.3
WIND (958044)	1.8	2.2	2.2	2.2	2.2	2.2	2.2
GEOTAIL (943305)	0.2	0.2	0.2	0.2	0.2	0.2	0.2
CLUSTER-II (959194)	0.2						
SOLAR Data Center (378077)	0.9	1.0	1.1	1.2	1.3	1.1	1.2
Data & Modeling Services (944022)	2.0	2.8	2.8	2.7	3.0	3.0	3.0
Space Physics Data Archive (380543)	2.0	2.0	2.3	2.3	2.3	2.3	2.3
Guest Investigator Program (955518)	10.8	10.5	10.3	15.2	24.3	24.7	24.7
Community Coordinated Modeling Center (382230)	2.2	2.0	2.2	2.2	2.3	2.4	2.4
Space Science Mission Ops Services (385616)	11.3	11.5	11.5	11.5	11.6	11.9	11.9
<u>Solar Terrestrial Probes</u>	<u>70.6</u>	<u>50.5</u>	<u>39.8</u>	<u>38.8</u>	<u>127.3</u>	<u>179.4</u>	<u>198.4</u>
Magnetospheric Multiscale (MMS) (943396)	52.4	30.1	17.4	14.6	11.0	11.0	4.0
STP Program Management and Future Missions (617871)	0.4	1.0	3.4	5.7	97.4	149.4	175.4
Solar Terrestrial Relations Observatory (STEREO) (619595)	7.5	9.5	9.5	9.3	9.5	9.5	9.5
Hinode (Solar B) (511432)	7.5	7.3	7.0	6.8	7.0	7.0	7.0
TIMED (370544)	2.8	2.7	2.6	2.4	2.5	2.5	2.5



FY17 Heliophysics President's Budget



	Op Plan FY15	Request FY16	FY17	FY18	FY19	FY20	FY21
<u>Living with a Star</u>	<u>263.5</u>	<u>343.0</u>	<u>374.2</u>	<u>398.7</u>	<u>244.6</u>	<u>135.8</u>	<u>127.3</u>
Solar Probe Plus (388443)	193.7	230.4	232.5	289.7	100.4	30.6	22.1
Solar Orbiter Collaboration (996805)	20.5	62.9	80.7	51.4	66.3	2.3	2.4
Balloon Array for Radiation-Belt Relativ (296527)	0.2						
Van Allen Probes (RBSP) (605745)	13.0	15.5	13.3	13.0	13.0	9.0	
LWS Space Environment Testbeds (499999)	0.4	0.4	0.4				
LWS Science (936723)	17.4	17.5	27.5	24.0	30.5	30.3	30.3
LWS Program Management and Future Missions (937818)	5.3	6.7	7.8	8.9	22.3	51.7	60.5
Solar Dynamics Observatory (SDO) (939252)	13.1	9.5	12.0	11.8	12.0	12.0	12.0
<u>Heliophysics Explorer Program</u>	<u>110.0</u>	<u>98.9</u>	<u>104.6</u>	<u>54.5</u>	<u>116.3</u>	<u>183.8</u>	<u>184.0</u>
Ionospheric Connection Explorer (581067)	61.0	49.8	49.4	9.0	4.5	1.3	
Global-scale Observations of the Limb an (496787)	13.9	17.5	16.3	8.6	4.6	2.0	
Interface Region Imaging Spectogr (IRIS) (649056)	8.2	7.7	7.7	6.8	7.0	6.5	6.5
Heliophysics Explorer Future Missions (516741)			3.3	8.5	74.5	149.3	156.1
Interstellar Boundary Explorer (IBEX) (576706)	3.4	3.4	3.4	3.3	3.4	3.4	3.4
TWINS (953004)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
CINDI (953212)	1.2	0.6	0.3	0.2			
Aeronomy of Ice in Mesosphere (SMEX-9) (956269)	3.0	3.0	3.0	2.9	3.0	3.0	3.0
Time History of Events and Macroscale In (960804)	5.4	4.6	5.4	5.0	5.1	4.5	4.5
Heliophysics Explorer Program Management (062285)	8.5	6.8	10.4	4.8	8.8	8.3	5.0
ACE (910989)	3.0	3.0	3.0	2.9	3.0	3.0	3.0
RHESSI (667339)	1.8	1.9	1.9	1.9	1.9	1.9	1.9



Next Steps



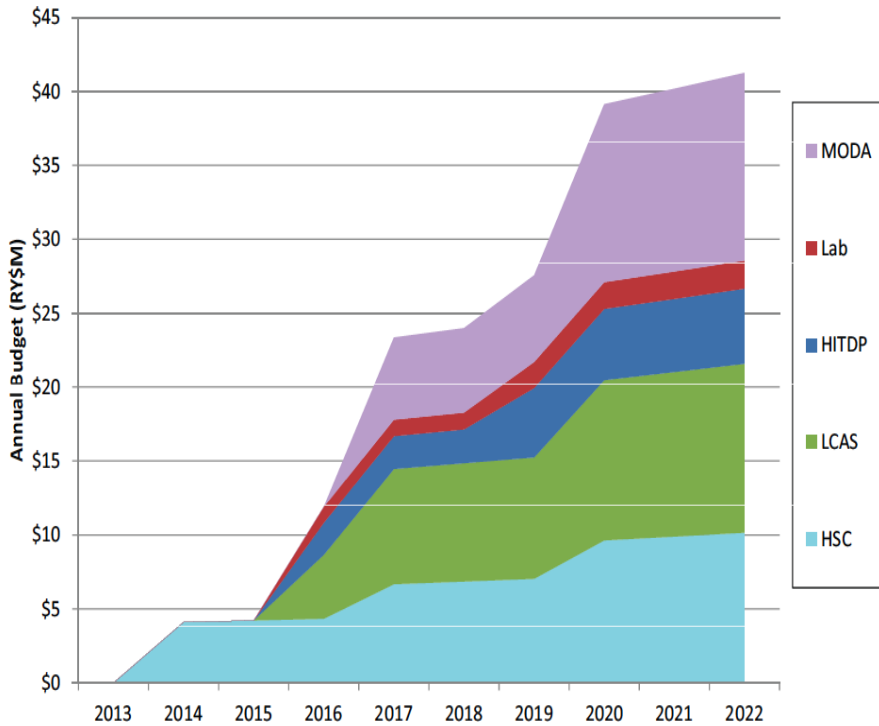
- Plan for growth in ROSES competitions, implement DRIVE
- Plan for AOs
 - Explorers (+MO) highest priority
 - Develop near term strategy for STP-5 (+MO)
 - Begin planning for LWS-7 (+MO)



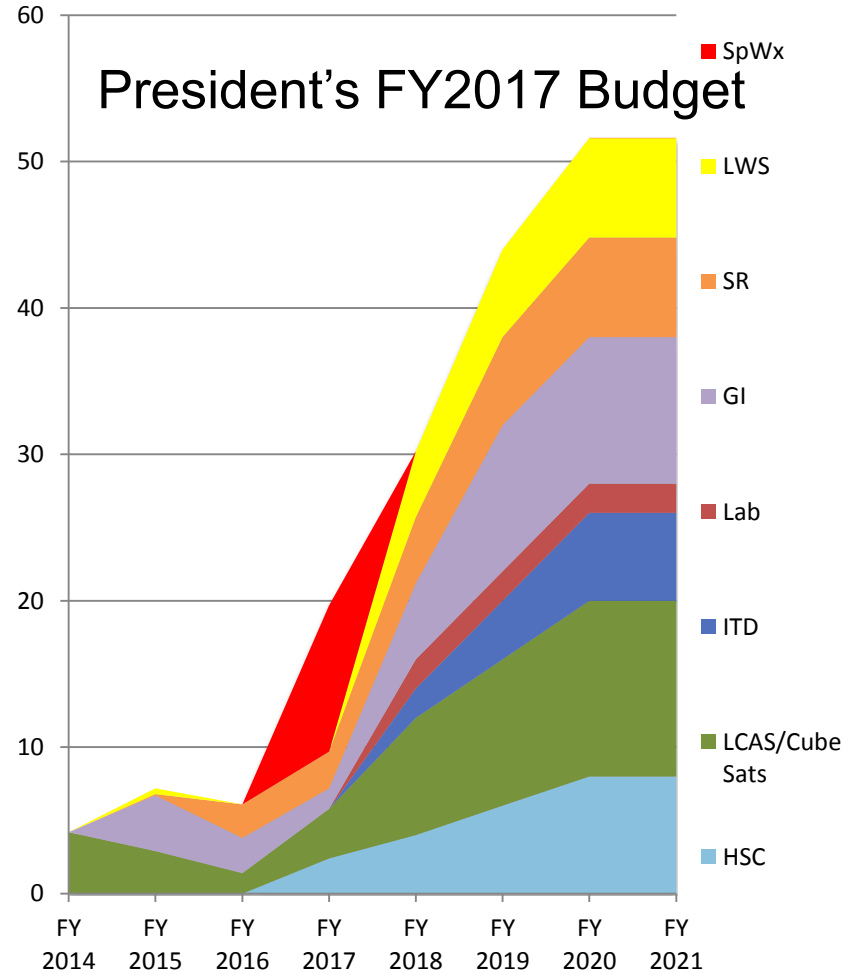
Decadal Survey – Implement Drive



Decadal Survey



President's FY2017 Budget

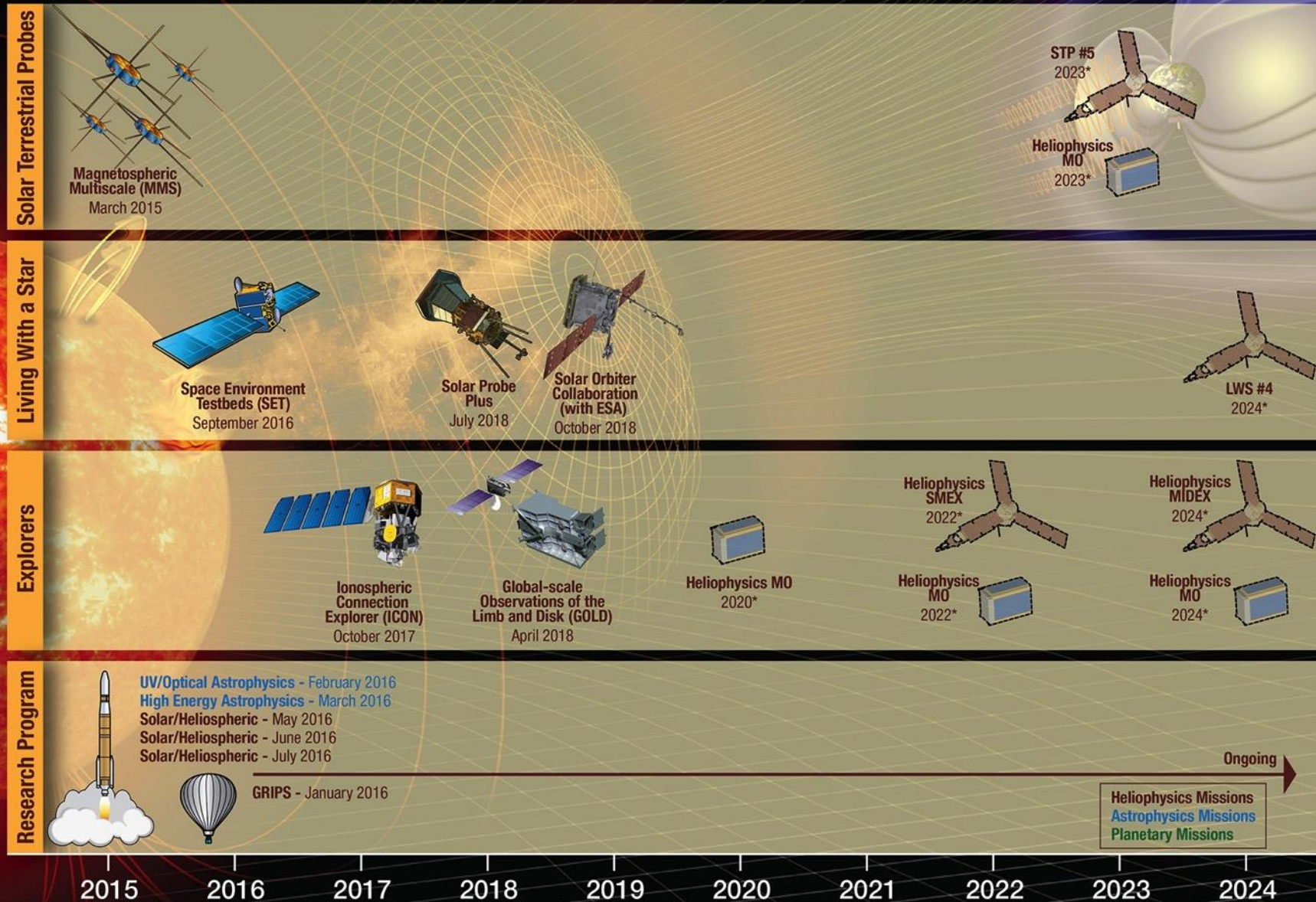


Solar and Space Physics: A Science for a Technological Society



Mission Update

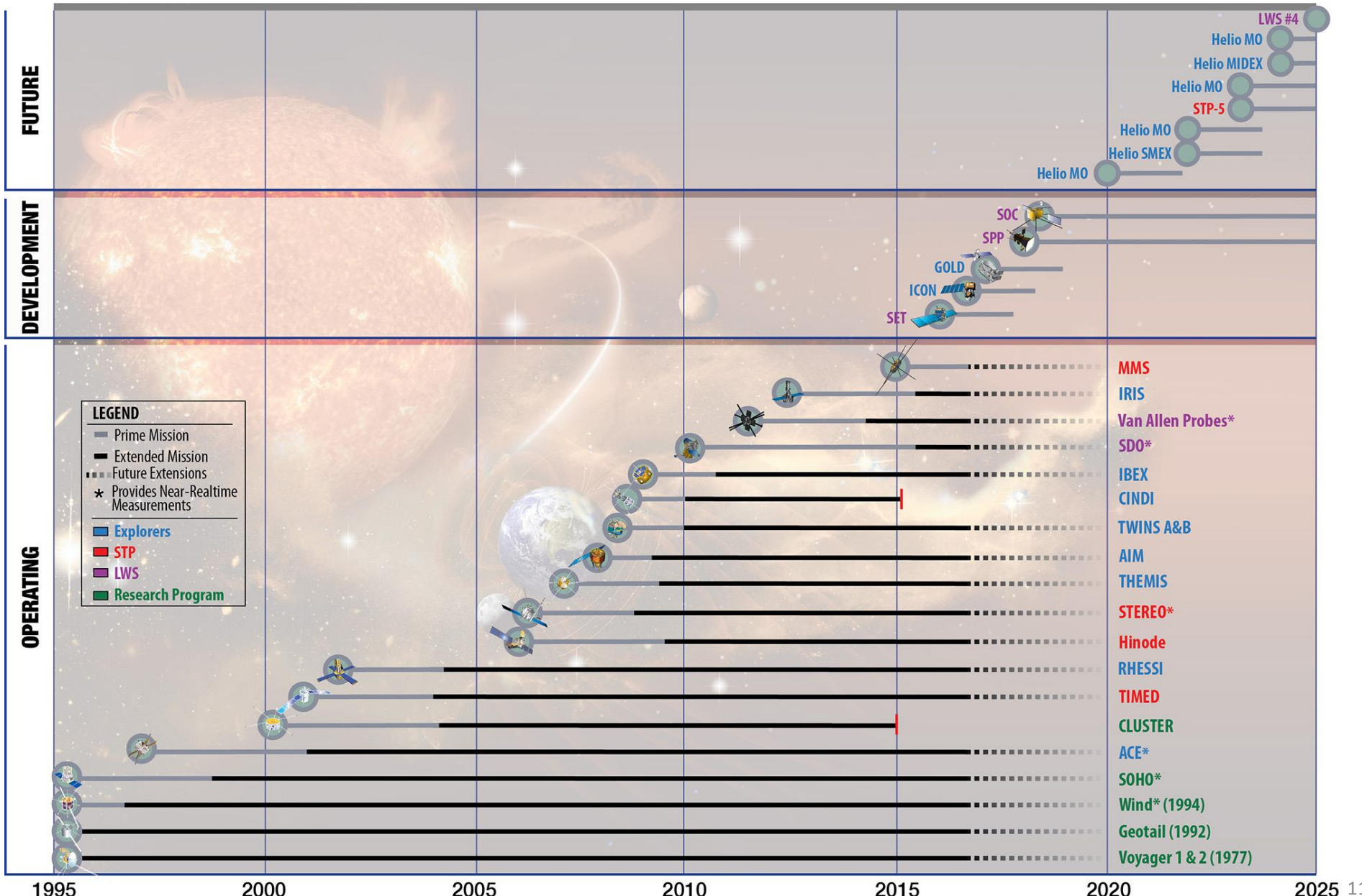
Heliophysics Program 2015-2024



*Notional

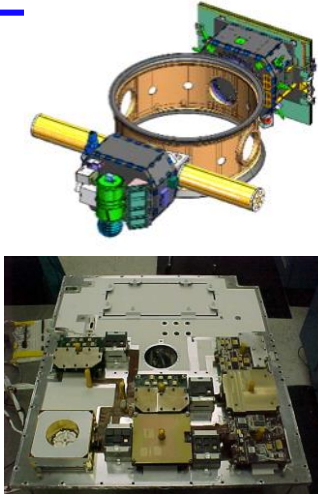


Heliophysics Mission Timeline 1995-2025





LWS Space Environment Testbeds (SET)-1



Launch Information:

- **Spacecraft:** AFRL Deployable Structures Experiment (DSX)
- **Launch Vehicle:** SpaceX Falcon Heavy
- **Date:** March 2017
- **Site:** Cape Canaveral
- **Orbit:** 6000 x 12,000 km, 45 degree inclination MEO

Description:

Space Environment Testbeds (SET) improves the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design and operations by: 1) collecting data in space to develop a physics-based understanding of response of spacecraft materials, components, & sensors/detectors to space environments; 2) collecting data in space to validate new & existing ground test protocols for the effects of solar variability on emerging technologies; and 3) developing & validating engineering environment models, tools, & databases for spacecraft design & operations.

Accomplishments:

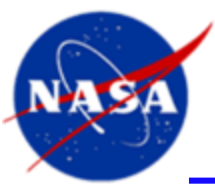
- All flight hardware has been delivered, including the separation system for the DSX secondary payload.
- EMI / EMC tests are complete and showed no problems.
- Vibe tests completed for payload module.

Upcoming Milestones:

- TVAC tests planned for March-April 2016.
- Activities scheduled for FY16 include work with the separation system, mission readiness review (MRR), and 4 mission rehearsals.

Watch Items/Concerns:

- Launch date delays



Ionospheric Connection Explorer (ICON)



Description: ICON will explore the boundary between Earth and space to understand the physical connection between our world and our space environment. ICON will launch on a Pegasus XL launching from Kwaj in October 2017. The spacecraft will be placed in a LEO Orbit at 575 km with a 24° inclination. The payload consists of four instruments, MIGHTI (NRL) – neutral wind measurements; IVM (UT Dallas) – in situ ion velocities; and FUV & EUV imaging UV spectrographs (UC Berkeley) – O/N₂, O⁺ ion density

Recent Accomplishments:

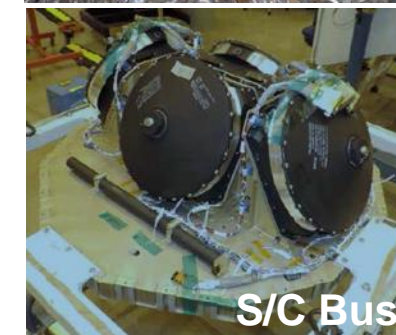
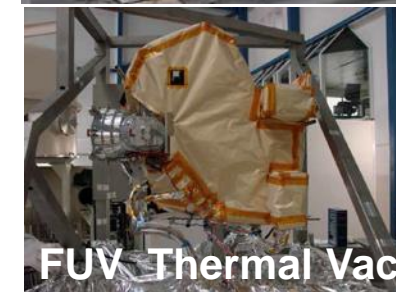
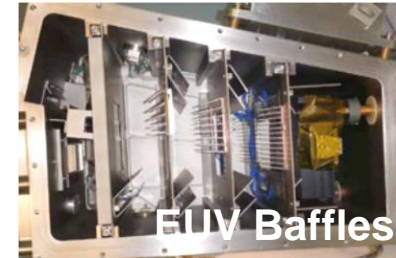
- MIGHTI: Integration onto the Payload Interface Plate (PIP) in work
- FUV: Delivered for integration
- EUV: Stray light baffle modifications successful
- IVM: IVM-A delivered for integration to the PIP. IVM-B is in final performance testing.
- ICP: Flight boards integrated and vibration testing is scheduled to start this week.

Upcoming Milestones/Events:

- SIR – June 2016
- KDP-D – July 2016
- PER – August 2016
- LRD – October 2017

Issues/Concerns:

- IMAU: Failure to power up after integration; LVPS instability was identified as the cause of the improper power ramp. A parts stress analysis was completed with two additional boards requiring parts replacement. Investigating a design modification and the use of the Engineering MAU for interface verification testing.





GOLD

GOLD

- Global Observations of the Limb And Disk -

Description: GOLD is an Explorer Program Mission of Opportunity that will provide the first simultaneous measurements of temperatures and composition in Earth's thermosphere and ionosphere on a global scale. GOLD will fly a UV imaging spectrograph as a hosted payload on a commercial communications spacecraft in geostationary orbit.

Recent Accomplishments:

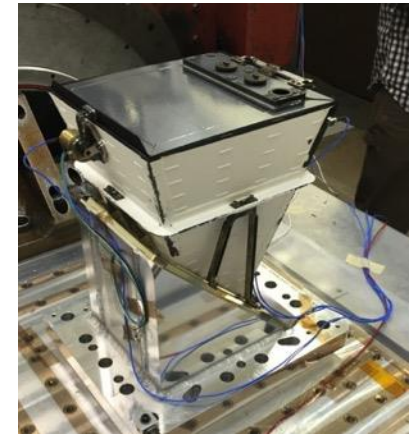
- Collimator mirror assemblies have been successfully installed into both instrument channel housings and alignments are in work.
- All electronics boards have successfully completed bench testing and fit checked in the GOLD electronics housing.
- Lightshade assembly complete and ready for integration
- FM1 and FM2 detector vibration has been successfully completed; FM2 is under going stand alone testing at LASP.

Upcoming Milestones/Events:

- PER - May 2016
- PSR - October 2016
- LRD – April 2018

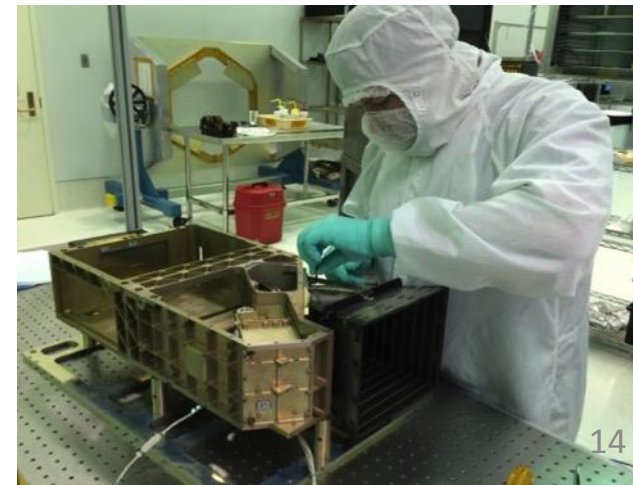
Issues/Concerns:

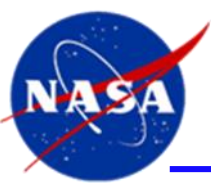
- Quantum efficiency of the detector on FM1 was reduced by 25% after its first scrub; investigating to determine if there is a problem with the scrub procedure or an issue with the detector.



Aperture cover mechanism

Channel 1 Assembly





Solar Probe Plus (SPP)



Description

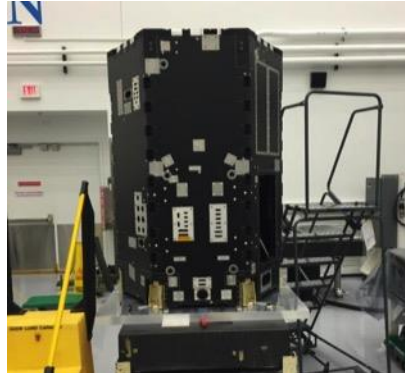
Spacecraft in a highly eccentric elliptical orbit with a minimum perihelion of 9.9 Solar Radii (~4.3 million miles). Employs a combination of in-situ measurements and imaging to achieve the mission's primary scientific goal: to understand how the Sun's corona is heated and how the solar wind is accelerated.

Upcoming Milestones

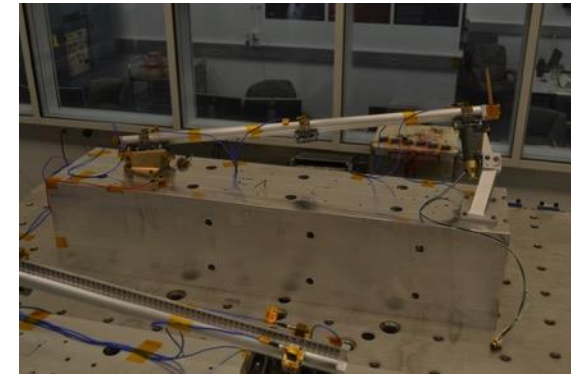
- System Integration Review – May 2016
- Pre-Environmental Review – October 2017
- Pre-Ship Review – March 2018
- LRD – July 2018

Recent Accomplishments

- Mission Operations Review – Nov 2015
- Launch Vehicle: Successfully completed the Mission Specific Requirements Review
- Cooling System: Completed top and bottom manifold assembly (welding) and inspection
- Mag Boom: Successfully completed EM boom thermal vacuum pop-n-catch test
- G&C: Completed fabrication and inspection of IMU electronic boards at Northrop Grumman
- Mechanical: Completed testing of the re-designed propulsion tanks struts
- Propulsion: Completed manufacture and qualification testing of propellant tank brackets



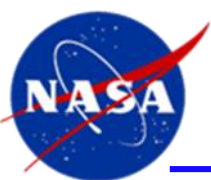
Flight Spacecraft Structure



FIELDS Clamshell Testing

Watch Items/Concerns

- FIELDS whip antenna: Testing and analysis of EM antenna and clam shell complete by end of February.
- Late delivery of first solar array platen, could impact schedule reserve.
- Truss Structure Assembly (TSA) developed a weld crack during vibe test; FRB initiated; new joint design developed and analyzed.



Solar Orbiter Collaboration (SOC)



Description: Will use a unique combination of measurements: *In situ* measurements will be used alongside remote sensing, close to the sun (~ 0.3 AU), to relate these measurements back to their source regions and structures on the sun's surface. Operates both in and out of the ecliptic plane. Measures solar wind plasma, fields, waves and energetic particles close enough to the Sun to ensure that they are still relatively pristine.

Recent Accomplishments:

- Heavy Ion Sensor (HIS) instrument Post Acceleration (PAC) isolator completed peer review, fabrication and testing beginning.
- Solar Orbiter Heliospheric Imager (SoloHI):
 - Thermal correlation successfully completed; no requirement for additional heaters or heater resizing.
 - Straylight testing complete; results indicate science requirements should be met.

Upcoming Milestones:

- | | |
|----------------------------------|----------------|
| • Mission CDR Kick-Off/Close-Out | Mar/June 2016 |
| • SoloHI PER | April 2016 |
| • HIS PER | May 2016 |
| • SoloHI PSR | June 2016 |
| • HIS PSR | September 2016 |
| • LRD | October 2018 |

HIS Heat Shield Assembly - Completed



Watch Items/Concerns:

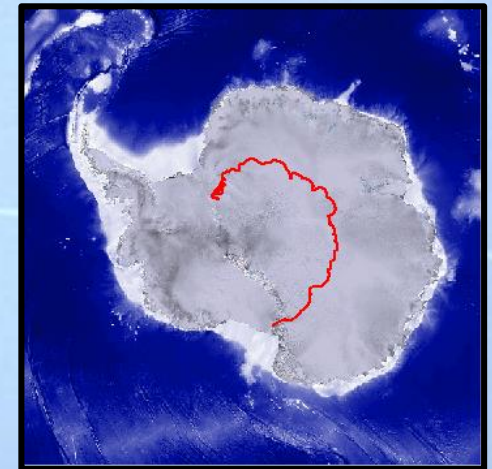
- Schedule risk (spacecraft) to LRD
- Completion of IRAP High Voltage Power Supply delayed at IRAP, impacting the HIS delivery.

Gamma Ray Imager/Polarimeter for Solar flares (GRIPS)

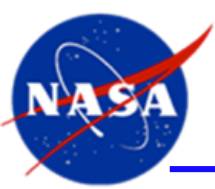


Balloon Missions - Gamma-Ray Imager/Polarimeter for Solar flares (GRIPS)

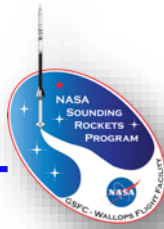
- PI: Pascal Saint-Hilaire, UCB/SSL
- Designed to observe flare gamma-ray/hard X-ray emission with an unparalleled angular resolution at gamma-ray energies (12.5 arcsec)
- Launched: 19 January 2016 from McMurdo Station, Antarctica



- Flight lasted 11 days, 19 hours, 50 minutes; Mission (Flight 668N) was successfully terminated over East Antarctica to expedite recovery of high priority items.
- 21 C-class flares occurred, with the largest at C9.6, with concurrent RHESSI observations
- Radiation-belt precipitation was observed
- Data vaults successfully recovered



Recent Sounding Rocket Launches



- **Lessard Mission: Successful launch from Andøya Space Center on 13 December 2015**

- A University of New Hampshire investigation, Rocket Experiment for Neutral Upwelling II (RENU) was designed to transit the magnetospheric cusp region during a neutral upwelling event. The Black Brant XII-A rocket was equipped with a suite of instruments that build on previous observations of neutral upwelling in the thermosphere.



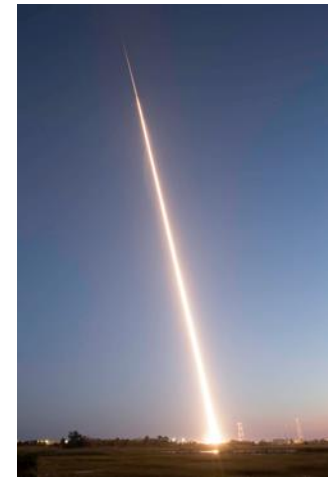
Andøya Rocket Range, Norway

- **CHESS-2: Studying the Birthplace of Stars and Planets**

- The Colorado High-resolution Echelle Stellar Spectrograph or CHESS-2 was successfully launched 22 Feb 2016 at 11:15 p.m. EST on a NASA Black Brant IX suborbital sounding rocket from the White Sands Missile Range in New Mexico. The 1,108 pound CHESS-2 payload flew to an altitude of 191 miles. Preliminary analysis shows that the science team acquired all of its targets and received data.

- **MUSIC: The Multiple User Suborbital Instrument Carrier**

- The MUSIC payload was successfully launched on 1 March 2016 at 9:50 a.m. EST from NASA's Wallops Flight Facility on a Terrier-Improved Malemute suborbital sounding rocket. MUSIC carried a set of engineering development projects and student experiments from West Virginia University, Morgantown, through the NASA Undergraduate Student Instrument Project.



Wallops Island, VA



Sounding Rockets Schedule



NSRP Mission Manifest Dec 2015 Nov 2016

Updated: Feb 12, 2016

Flag Fields	Mission Title	Launch Date	Month													
			Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
.....BB	GALEAZZI DXL-2 WS	Fri 12/4/15	★													
.....BB	LESSARD RENU 2 NOR	Sun 12/13/15	★													
.....BB	MCCANDLISS FORTIS WS	Mon 12/14/15	★													
.....BB	FRANCE CHESS-2 WS	Sun 2/21/16			★											
.....	MILLINER MUSIC WI	Mon 2/22/16 →			★											
.....	DELEON WI	Mon 3/7/16			▲											
R.....	CHRISLEY ZOMBIE WS	Tue 5/10/16							▲							
.....BB	WOODS SDO EVE WS	Fri 5/27/16							▲							
.....BB	TUN BELTRAN HERSCHEL WS	Wed 6/8/16							▲							
.S.....	KOEHLER ROCKON - RockSAT-C WI	Thu 6/23/16							▲							
.....BB	CIRTAIN HiC WS	Mon 7/18/16							▲							
R.....	CLARK SHARPIE WI	Mon 8/1/16							▲							
.S.....	KOEHLER RockSAT-X WI	Mon 8/8/16							▲							
.....BB	HASSLER RAISE WS	Tue 8/23/16							▲							
.....	MILLINER WI	Mon 9/5/16							▲							
R.....	CLARK SHARPIE TBD	Thu 9/29/16							▲							
.....BB	FIGUEROA MICRO-X WS	Tue 11/1/16							▲							
.....BB	HESH SUBTEC 7 WI	Sat 11/5/16							▲							



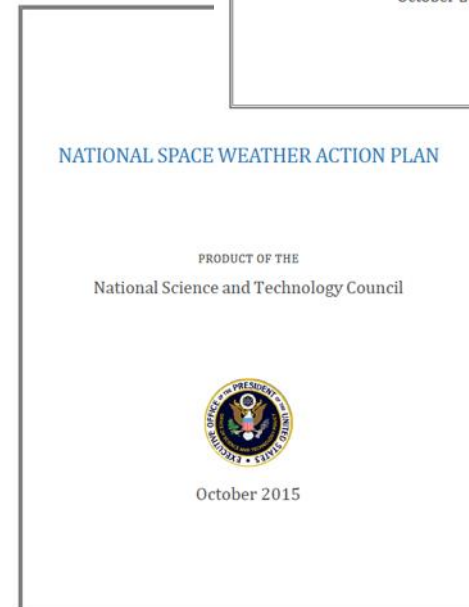
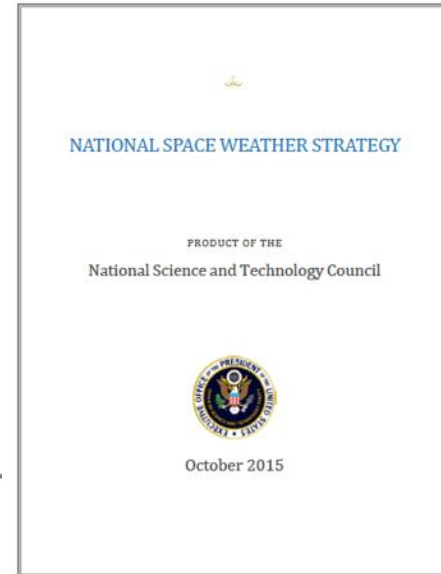
National Space Weather Strategy



National Space Weather Strategy Update



- National Space Weather Strategy and Space Weather Action Plan were officially released on 29 October 2015.
 - www.whitehouse.gov/sites/default/files/microsites/ostp/fin_al_nationalspaceweatherstrategy_20151028.pdf
 - www.whitehouse.gov/sites/default/files/microsites/ostp/fin_al_nationalspaceweatheractionplan_20151028.pdf
- Subcommittee on Space Weather Operations, Research, and Mitigation (SWORM) established for Space Weather Action Plan follow-through.
- Establishment of working groups underway
- Process for reporting working group progress to Subcommittee being finalized





Subcommittee on Space Weather



Committee on Environment, Natural Resources, and Sustainability (CENRS)

CENRS Co-Chairs:

Tamara Dickinson - OSTP
 Kathryn Sullivan - NOAA
 Thomas Burke - EPA

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL (NSTC)

COMMITTEE ON ENVIRONMENT, NATURAL RESOURCES, AND SUSTAINABILITY (CENRS) <small>Tamara Dickinson (OSTP), Kathryn Sullivan (NOAA), Glenn Paulson (EPA)</small>		
AQRS: Air Quality Research (SC)		SOST: Ocean Science & Technology (SC)
CSMSC: Critical & Strategic Mineral Supply Chains (SC)	SDR: Disaster Reduction (SC)	SWAQ: Water Availability & Quality (SC)
IARPC: Interagency Arctic Research Policy Committee (IWG)	SES: Ecological Services (SC)	T&R: Toxics & Risk (SC)
ISTS: Integration of Science and Technology for Sustainability (TF)	SGCR: Global Change Research (SC)	USGEO: U.S. Group on Earth Observations (SC)

COMMITTEE ON HOMELAND & NATIONAL SECURITY (CHNS) <small>Patricia Falcone (OTSP), Alan Shaffer (DoD), Tara O'Toole (DHS)</small>		
BDRD: Biological Defense Research & Development (SC)	ISC: Infrastructure (SC)	SOS-CBRNE Standards (SC)
CDRD: Chemical Defense Research and Development (SC)	NDRD: Nuclear Defense Research & Development (SC)	TISTI: Topics in International Science, Technology and Innovation (SC)
D-IED: Domestic IEDs (SC)	FSLFI: Federal Security Laboratory Facilities and Infrastructure (IWG)	

COMMITTEE ON SCIENCE (CoS) <small>Francis Collins (NIH), Phillip Rubin (OSTP), Cora Marrett (NSF)</small>		
IWGN: Neuroscience (IWG)*	PSSC: Physical Science (SC)	LSSC: Life Science (SC)*
Social, Behavioral, and Economic Science (SC)		

COMMITTEE ON STEM EDUCATION (CoSTEM)* <small>John Holdren (OSTP), Cora Marrett (NSF)</small>	
FC-STEM: Federal Coordination in STEM Education (TF)	

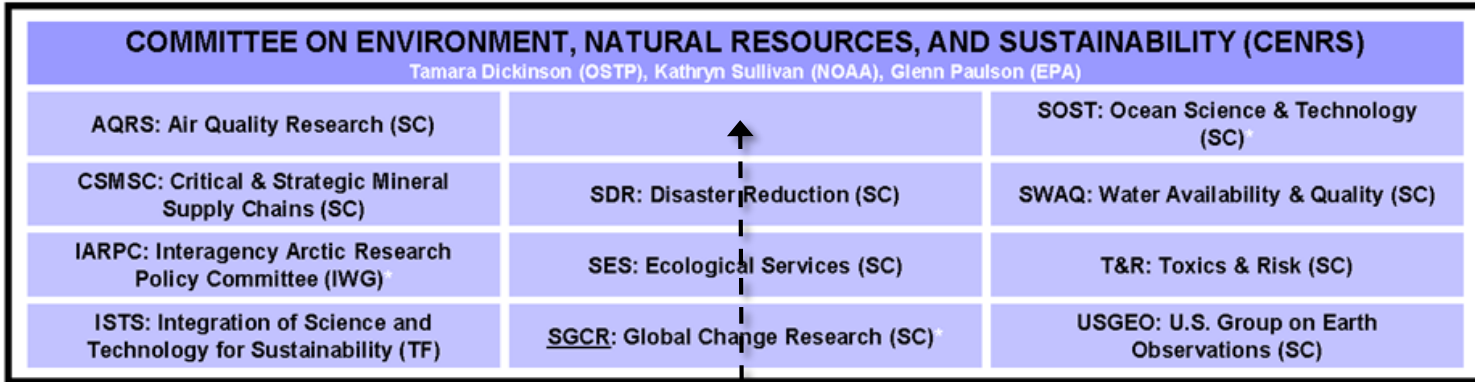
COMMITTEE ON TECHNOLOGY (CoT) <small>Thomas Kalil (OSTP)</small>		
ASTS: Aeronautics Science & Technology (SC)	AMS: Advanced Manufacturing (SC)*	SG: Smart Grid (SC)
BidM: Biometrics & Identity Management (SC)	DGT: Digital Game Technologies (IWG)	SMGI: Material Genome Initiative (SC)
P2I: Privacy (SC)	NITRD: Network and Information Technology R&D (SC)*	SoS: Standards (SC)
GIG: Global Internet Governance (SC)	NSET: Nanoscale Science Engineering & Technology (SC)*	
H2FC: Hydrogen & Fuel Cells (IWG)		



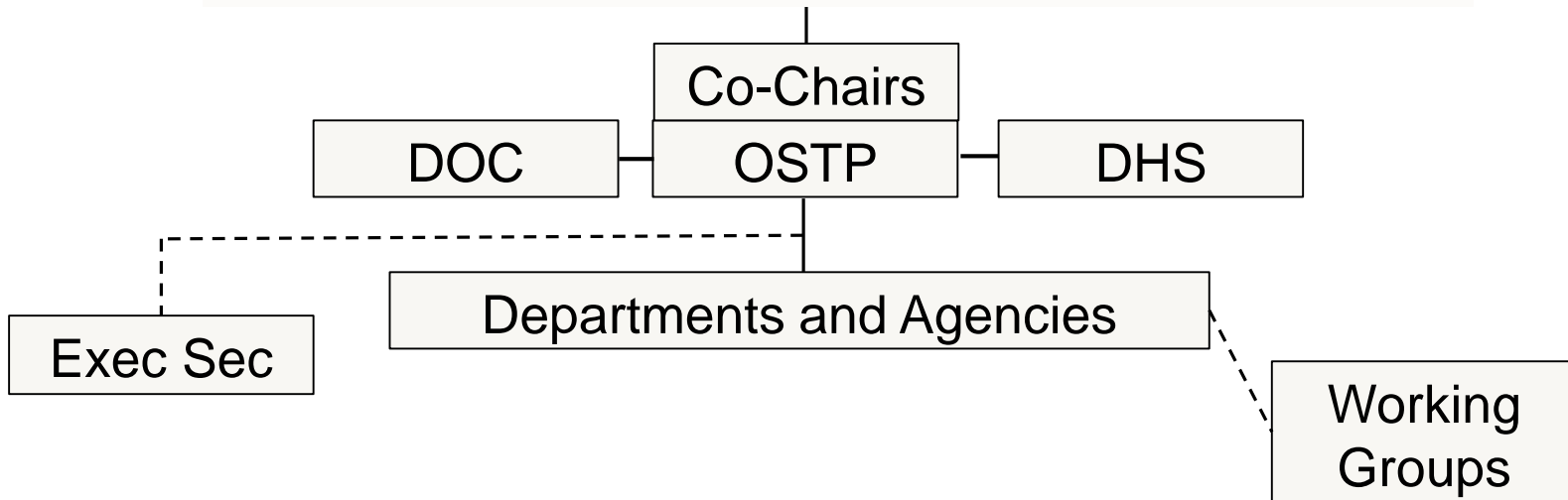
Subcommittee on Space Weather



NATIONAL SCIENCE AND TECHNOLOGY COUNCIL (NSTC)



Subcommittee on Space Weather Operations, Research, and Mitigation (SWORM)





SWORM Subcommittee



- **Co-Chairs**
 - OSTP (policy), DHS (preparedness), and NOAA (science)
- **Executive Secretary**
 - Administrative functions (compiles documents, scheduling, meeting minutes, etc.)
- **Subcommittee**
 - Meets quarterly to discuss progress, next steps, and to resolve issues associated with implementation
- **(sub-)Working Groups**
 - Six groups
 - Meet monthly, or as necessary, to track progress across all actions within each of the six-goals



SWORM Subcommittee



- Interagency body to coordinate the Federal Government departments and agencies to meet the goals and objectives specified in the *National Space Weather Strategy* and the complete the activities defined in the *National Space Weather Action Plan*
- SWORM will also provide space-weather focused input into the National Planning Frameworks called for by the Presidential Policy Directive 8 (PPD-8): *National Preparedness* (2011) and National critical infrastructure resilience initiatives outlined in PPD-21: *Critical Infrastructure Security and Resilience* (2013)



SWORM Subcommittee



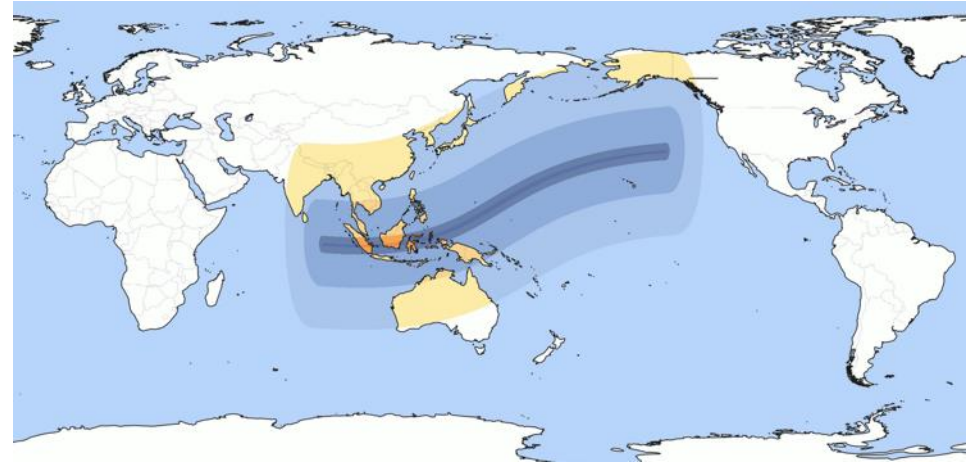
- Coordinate and oversee the implementation of the activities, timelines, and milestones identified in the Action Plan.
- The SWORM Co-chairs, in coordination with OMB and SWORM-participating departments and agencies, shall develop annual multi-agency investment strategies and priorities that advance the implementation of the Strategy and Action Plan.
- Coordinate agency efforts to establish Federal and non-Federal stakeholder collaborations to enhance understanding, observing systems and networks, and data management activities related to space weather.
- Work with other NSTC bodies to coordinate international cooperation in space weather, including strategic communications; the exchange of data, information, models, and research personnel; joint research, planning, and exercises.
- Provide scientific and technical information to senior policymakers to enhance preparedness before, during, and after space weather events.
- SWORM may establish additional working groups, as necessary, to carry out these functions.



Outreach

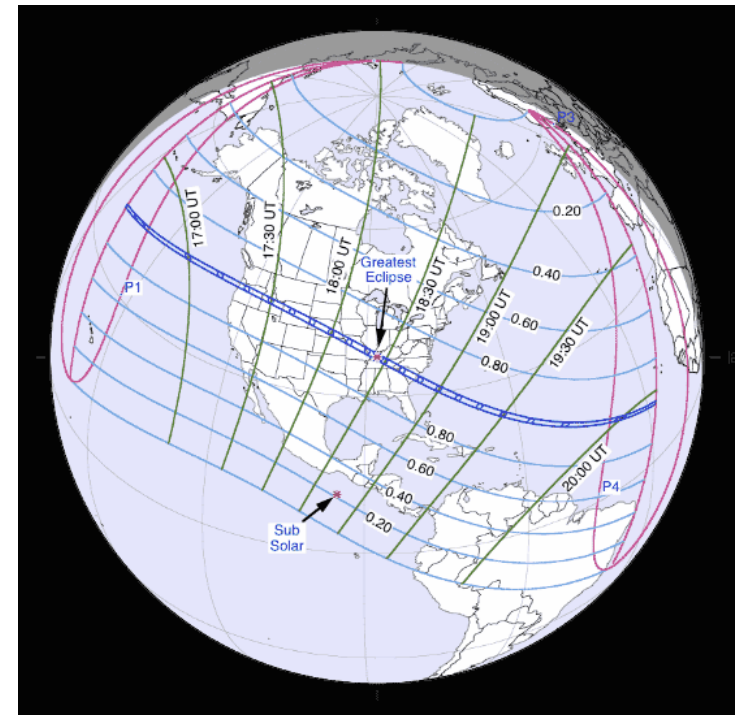
Indonesian Total Eclipse 2016

- A NASA team, consisting of scientists and public outreach specialists, will be in Indonesia to cover the March 8-9 total eclipse.



United States Total Eclipse 2017

- Lessons learned from covering the Indonesian event will be leveraged for the total eclipse event in August 2017





Outreach Activities



- NC State University @ Raleigh, NC
- SAO Atmospheric Imaging Assembly (AIA) Live Feed at James B. Hunt Library



SDO Celebrates its 6th Year Anniversary!

See “SDO: Year 6” at <https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=12144>

The Solar Dynamics Observatory (SDO), our first Living with a Star mission, launched in February of 2010 to help us understand where the Sun's energy comes from, how the inside of the Sun works, and how energy is stored and released in the Sun's atmosphere.

- ✓ SDO discovered a new class of solar flares with possible implications on changes in the Earth's atmosphere.
- ✓ SDO data and science results have appeared in almost 2500 refereed publications.
- ✓ Each day, about 1.5 TB flows into the Joint Satellite Operations Center (JSOC) from SDO and 7.5 TB in science data flows out to users around the world.
- ✓ During the extended mission we continue to add about 50 publications a month.

The images and data from SDO capture the public's attention in compelling ways. Goddard released a beautiful video showing the entire 6th year on YouTube which received more than 640,000 plays by the end of its first week, **becoming Goddard's most popular video over the last 3 months!**

Superlative-laden news coverage came from **Gizmodo/Sploid, Gizmag, Discovery News, Discover Magazine** and others, including a quote from VOX news saying,

“SDO might be the space agency's most beautiful mission.”

The three powerful and technologically innovative instruments on SDO:

Helioseismic and Magnetic Imager (HMI) makes high resolution full disk maps of the solar magnetic fields and peers beneath the sun's opaque surface using a technique called helioseismology. A key goal of this experiment is to decipher the physics of the Sun's magnetic dynamo.

Atmospheric Imaging Assembly (AIA) provides continuous full-disk observations of the sun's surface and atmosphere using a battery of 4 telescopes, with filters that cover 10 different wavelength bands, or colors, selected to reveal key aspects of solar activity, spanning a temperature range from approximately 20,000 Kelvin to above 20 million Kelvin.

Extreme Ultraviolet Variability Experiment (EVE) measures fluctuations in the Sun's extreme ultraviolet output with unprecedented accuracy and timing. EUV radiation from the sun has a direct and powerful effect on Earth's upper atmosphere, heating it, puffing it up, and breaking apart atoms and molecules.