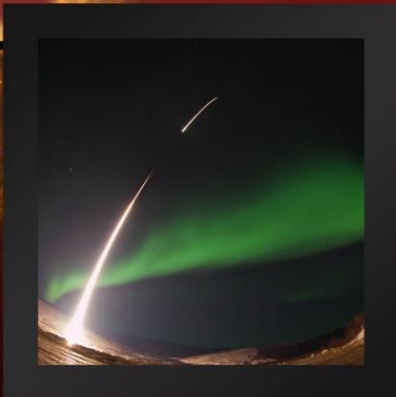
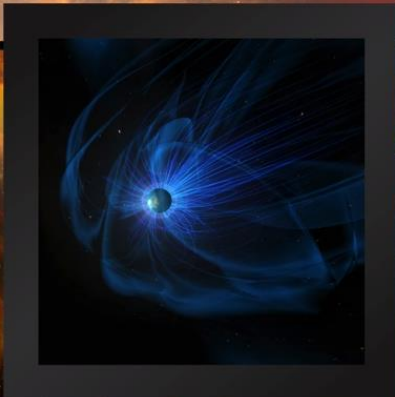


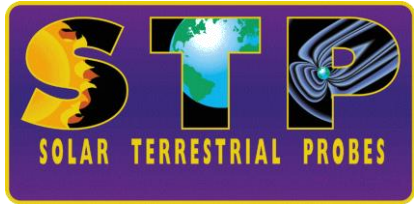
HELIOPHYSICS DIVISION



*Heliophysics Division Update
NAC Science Committee Meeting
July 28, 2015
Steven W. Clarke, Director*

HPD Objectives and Programs

Solar Terrestrial Probes



Strategic Mission
Flight Programs

Living With a Star



Strategic Mission
Flight Programs

Solve the fundamental physics mysteries of heliophysics: Explore and examine the physical processes in the space environment from the sun to the Earth and throughout the solar system.

Build the knowledge to forecast space weather throughout the heliosphere: Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Understand the nature of our home in space: Advance our understanding of the connections that link the sun, the Earth, planetary space environments, and the outer reaches of our solar system.

Explorers



Smaller flight programs,
competed science topics,
often PI-led

Research



Scientific research projects
utilizing existing data plus
theory and modeling

Heliophysics Program 2015-2024

7/21/15

Solar Terrestrial Probes

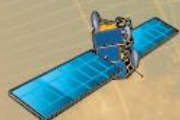


Magnetospheric Multiscale (MMS)
March 2015



STP #5
2023

Living With a Star



Space Environment Testbeds (SET)
October 2016



Solar Probe Plus
July 2018



Solar Orbiter Collaboration (with ESA)
October 2018

Explorers



Ionospheric Connection Explorer (ICON)
October 2017



Global-scale Observations of the Limb and Disk (GOLD)
April 2018



Heliophysics MO
2020



Heliophysics SMEX
2022



Heliophysics MO
2022



Heliophysics MIDEX
2024



Heliophysics MO
2024

Research Program



ROCKSAT-X - August 2015
Solar/Heliospheric - August 2015
Solar/Heliospheric - September 2015
UV/Optical Astrophysics - October 2015

UV/Optical Astrophysics - October 2015
Solar/Heliospheric - October 2015
UV/Optical Astrophysics - November 2015
Geospace - November 2015

Geospace - November 2015
High Energy Astrophysics - December 2015

Ongoing

Heliophysics Missions
Astrophysics Missions
Planetary Missions

2015

2016

2017

2018

2019

2020

2021

2022

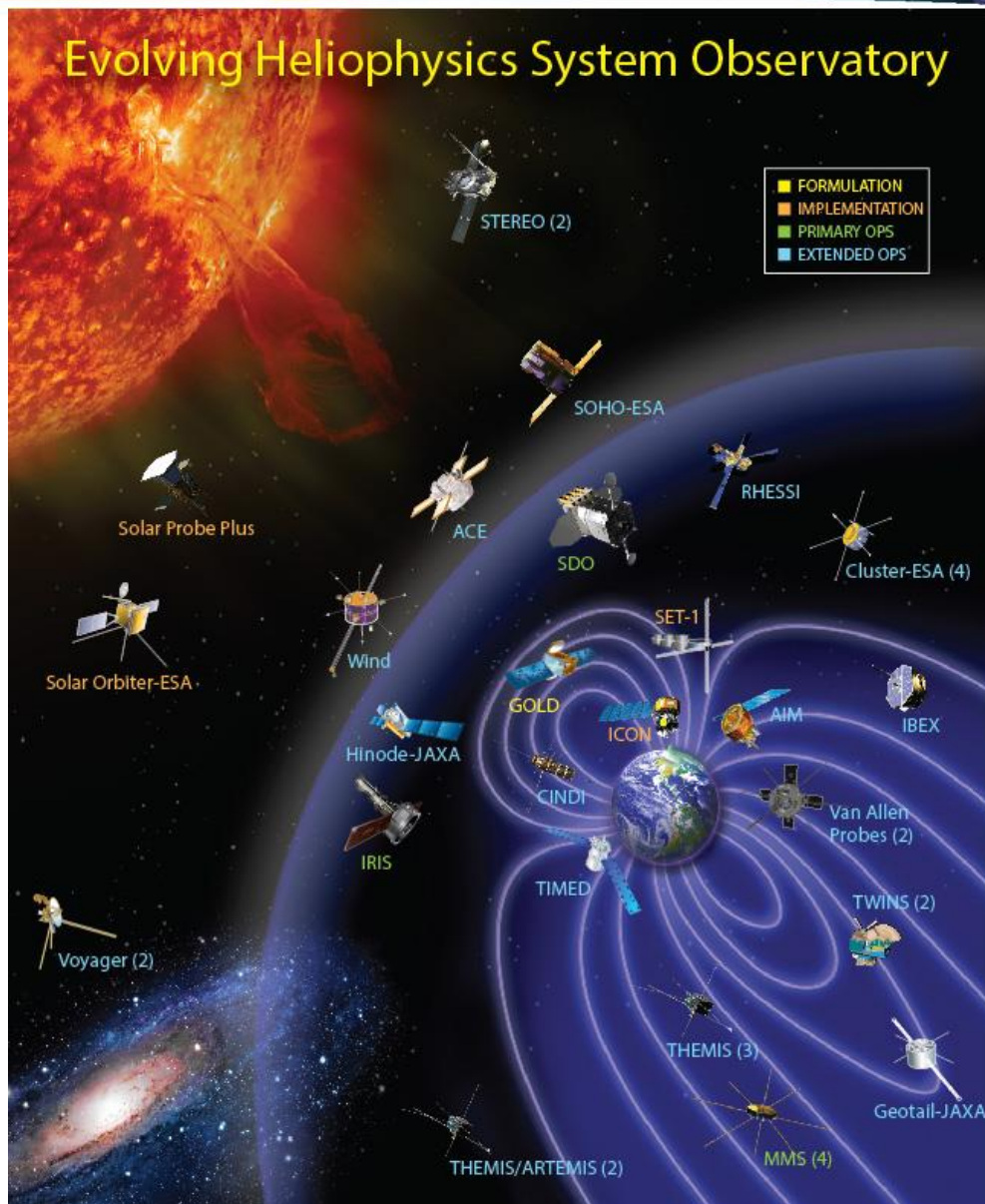
2023

2024

Heliophysics System Observatory

A coordinated and complementary fleet of spacecraft to understand the Sun and its interactions with Earth and the solar system, including space weather

Evolving Heliophysics System Observatory



- Heliophysics has 18 operating missions and 1 undergoing commissioning (on 33 spacecraft): Voyager, Geotail, Wind, **SOHO**, **ACE**, Cluster, TIMED, RHESSI, TWINS, Hinode, **STEREO**, THEMIS/ARTEMIS, AIM, CINDI, IBEX, **SDO**, **Van Allen Probes**, IRIS, **MMS**

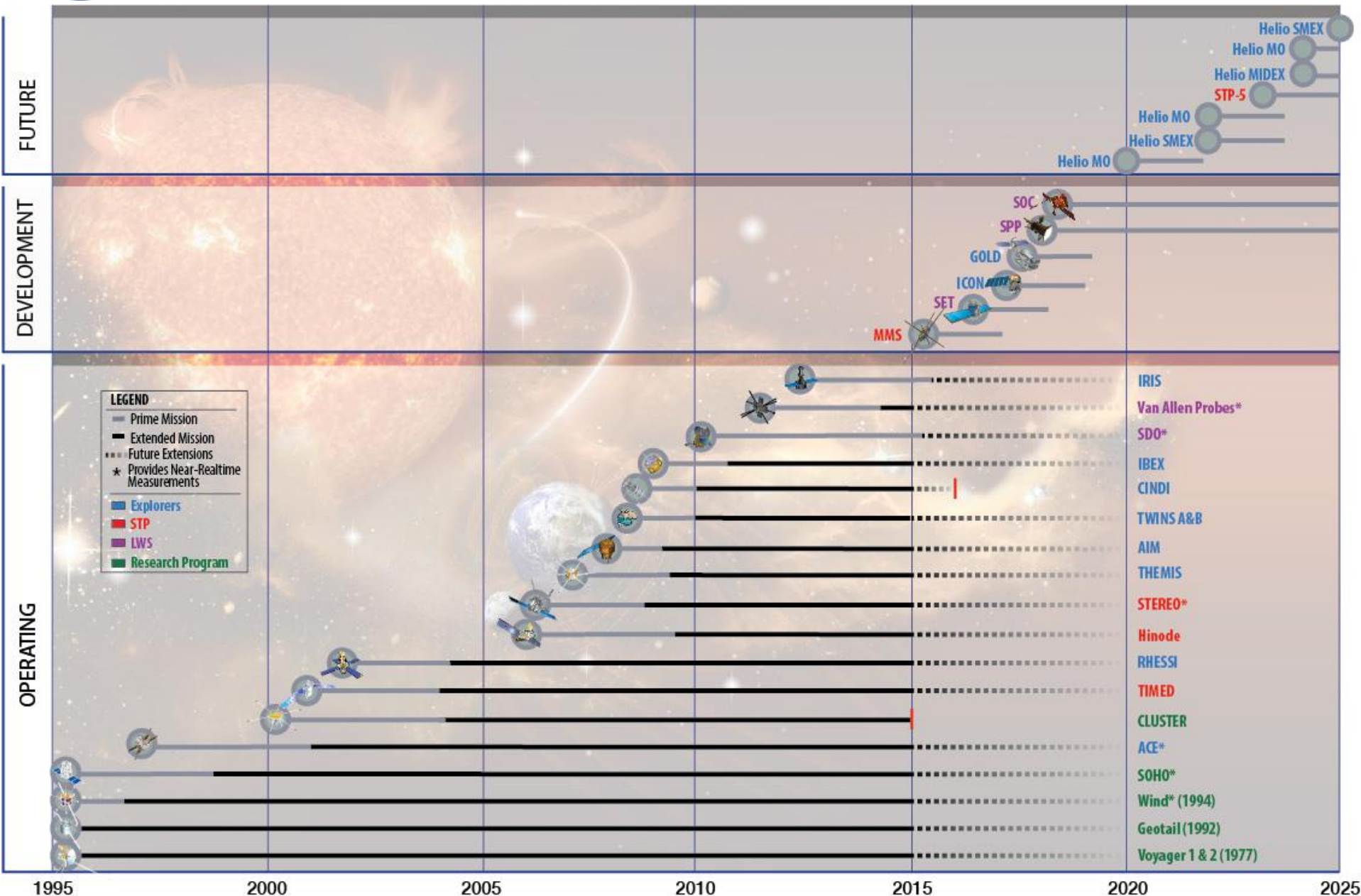
(Missions in red contribute to operational Space Weather in conjunction with the NOAA Space Weather Prediction Center)

- 5 missions are in development:

SET, ICON, GOLD, SPP, and SOC



Heliophysics Mission Timeline 1995-2025





Ops Mission Suite

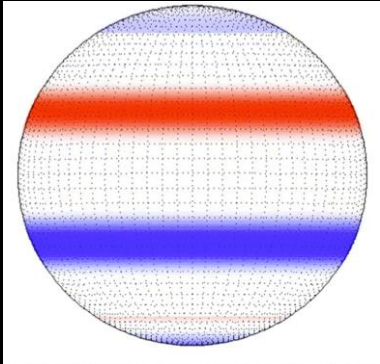


Mission	Launch	Phase	Extension to (*)	M-3	M-2	M-1	Cur. M.	Remarks
Geotail	7/24/92	Extended	12/31/2016	Green	Green	Green	Green	
STEREO	10/25/06	Extended	9/30/2018	Yellow	Yellow	Yellow	Yellow	STEREO-A in SciOps again! (as of 7/9)
THEMIS+Artemis	2/17/07	Extended	9/30/2018	Green	Green	Green	Green	Numerous resets during the month. Itemized in next chart.
AIM	4/25/07	Extended	9/30/2018	Green	Green	Green	Green	
Hinode	9/23/06	Extended	9/30/2018	Green	Green	Green	Green	Light leak on Ti_poly filter on XRT: minimal science impact.
Cluster	7/16/00	Extended	9/30/2015 (+)	Green	Green	Green	Black	Will cease to report after 10/1/2015
ACE	8/27/97	Extended	9/30/2018	Green	Green	Green	Green	
RHESSI	2/05/02	Extended	9/30/2018	Green	Green	Green	Green	
SOHO	12/02/95	Extended	9/30/2018	Green	Green	Green	Green	
TIMED	12/07/01	Extended	9/30/2018	Green	Green	Green	Green	
Voyager 1 + 2	8/20/77	Extended	9/30/2018	Green	Green	Green	Green	
TWINS A + B	6/06 & 3/08	Extended	9/30/2018	Green	Green	Green	Green	
CINDI:C/NOFS	4/16/08	Extended	12/31/2015	Green	Green	Green	Green	Reentry of C/NOFS due late CY2015
IBEX	10/19/08	Extended	9/30/2018	Green	Green	Green	Green	
Wind	11/01/94	Extended	9/30/2018	Green	Green	Green	Green	SEU on 6/14: recovered same day.
SDO	2/11/10	Extended	9/30/2018	Green	Green	Green	Green	
Van Allen	8/30/12	Extended	9/30/2018	Green	Green	Green	Green	
IRIS	6/27/2013	Extended	9/30/2018	Green	Green	Green	Green	16.5 hr lost on 6/23 due to Sun Point mode error.

Mission proceeding to meet science requirements

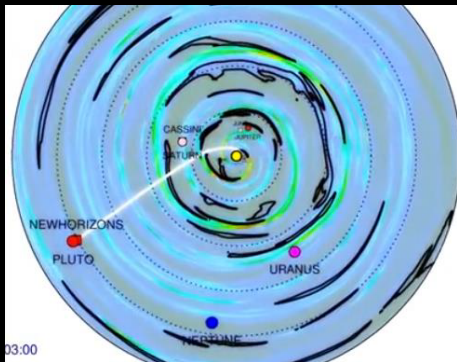
Area of concern - possible reduction in capability

Heliophysics Science Highlights



Seasonal Year-Long Cycles Seen on the Sun: The solar activity cycle peaks approximately every 11 years. Research shows evidence of a shorter time cycle as well, with activity waxing and waning over the course of ~ 330 days. These quasi-annual variations in solar storms are driven by changes in bands of strong magnetic field located in each solar hemisphere.

NASA's BARREL and Van Allen Probes Study How Plasma Waves Cause Particle Precipitation: Researchers show for the first time that plasma waves buffeting the planet's radiation belts are responsible for scattering charged particles into the atmosphere. BARREL researchers used Van Allen Probes data to simultaneously measure ion cyclotron waves and used the observations to validate this wave-particle interaction theory for the first time.



Heliophysicists Simulate the Space Environment During New Horizons Flyby: Scientists have modeled what temperature, density and wind speed could be expected around Pluto in mid-July 2015 to support the New Horizons flyby. Comparing this first outer solar system space environment model to measurements from New Horizons will help make future models more sophisticated.

NASA's THEMIS Reveals Breaking Waves Perturb Earth's Magnetic Field: Researchers recently discovered that Kelvin-Helmholtz waves actually occur 20 percent of the time at the magnetopause and can change the energy levels of our planet's radiation belts. These changing energy levels can have impacts on how the radiation belts impact spacecraft and Earth-based technologies.

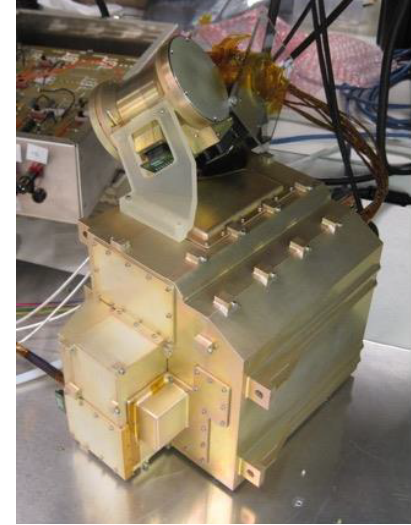




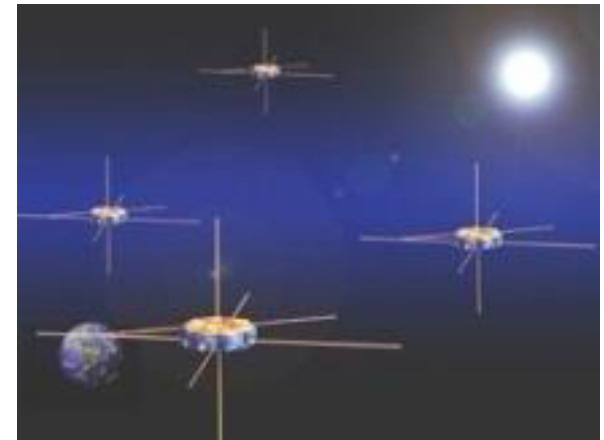
Significant Accomplishments

- ✓ **MMS** – Data collection to date successful. Initial tetrahedral science formation achieved (7/16)
- ✓ **SPP** – Mission CDR completed (Mar 2015). Conducted JHU/APL EVMS Compliance Review (May 2015). SWEAP passed CDR Part 2 (6/3). Conducted ULA/Orbital Delta IV Heavy Launch Vehicle Kickoff Meeting (6/17). ATK completed delivery of all WISPR QM parts to NRL.
- ✓ **Sounding Rockets** - Milner launched (7/7). Koehler RockOn! (student) Launched (6/25). Woods launched (5/21) but had to be cut down, payload recovered. McEntaffer (5/1). Koehler Rocksat (4/17).
- ✓ **Black Brant** - First Black Brant MK4 motor cast tested successfully despite perforation misalignment; second motor casted.
- ✓ **GOLD** – Pre-CDR engineering peer reviews complete, with exception of FPGA awaiting SW algorithm. Signed LASP and SES-GS contract for spacecraft accommodations (Apr 2015), SES-14 accommodation workshop conducted (May 2015). Completed aperture door life testing completed, spacecraft TIM2 (Jun 2015), and life testing for EM GYM, Slit, & Door mechanisms.

SPP ISIS EPI-Hi
Integrated EM Testing

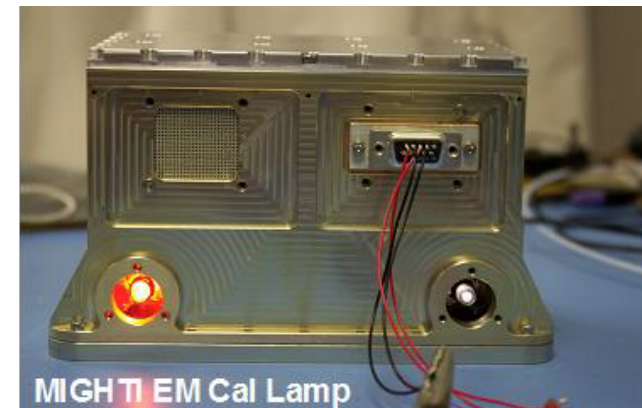


MMS Achieves Initial Science
Formation



Significant Accomplishments

- ✓ **ICON** – Completed Mission CDR (4/9), Mission Ops Peer Review (May 2015), FUV primary optics, Spacecraft structure fabrication, Harness mock-up, solar array substrates, ICP EM vibration testing, ICON Mission Avionics Unit, MIGHTI EM and FUV flight optics coatings. S/C structure load testing successful. Solar arrays and all Spacecraft components under contract (Apr 2015).
- ✓ **SOC** – CDR board meeting held (6/17). Completed HIS Electrical Model (ELM) testing with the suite level Data Processing Unit (DPU) ELM. HIS Detector Section electronics hardware configuration deemed acceptable to overcome discharge issue (high metallization).
- ✓ **SET** - All flight hardware has been delivered.





Additional Status and Accomplishments



Upcoming Milestones:

- **Sounding Rockets** - Koehler RockSAT-X (8/11).
Kankelborg (8/25).
- **Explorers AO** – 2016
- **MMS** - Post Launch Assessment Review (PLAR) (8/25).
Begin Prime Phase Operations (9/1).
- **STP 5 AO** - 2017



RockOn! Student Payload Jun 25

Recent Accomplishments:

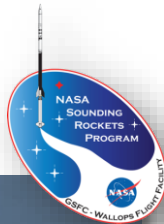
- ✓ **Senior Review** – Conducted Apr 21 – 24. Report released 6/30.
- ✓ **2015 SOAR** – Heliophysics recommended for noteworthy progress

Watch Items/Concerns:

- **Range:** Australian range sounding rocket campaign delayed until at least 2017.
- **Peregrine Motor Development:** Evaluating funding and options.
- **STEREO** – Reduced science data through 2016: AHEAD is back to normal operations on the 2nd side. All instruments except for In-situ Measurements of Particles and CME Transients IMPACT, SWEA, & STE are powered on and providing science data. The SWEA and STE instruments will be powered on in the December timeframe when the spacecraft will be operating on the primary lobe of the High Gain Antenna. Stereo B not communicating; STEREO-B is still in solar superior conjunction and will not reemerge until 11/24 when regular searches to reestablish contact will resume.

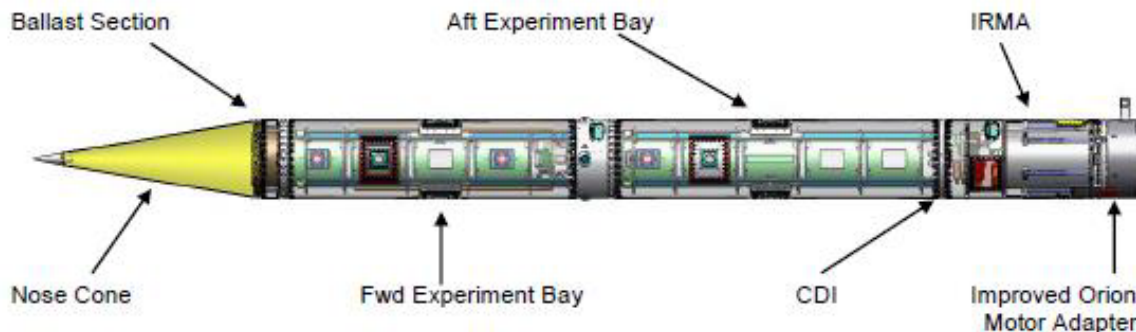
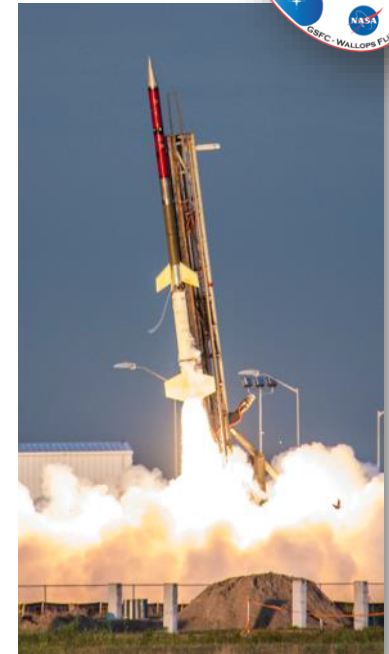


Sounding Rockets – Significant Progress



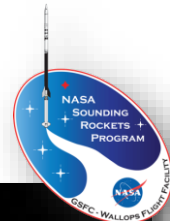
41.113/Koehler – RockOn! Workshop

- An introductory flight opportunity to provide exposure to, and spark interest in, space based science missions
- 150 total Rock-On participants onsite for the workshop this year
 - 72 RockOn! kit built experiment team members
 - 78 RockSat-C custom built experiment team members
- 80 additional “Cubes in Space” experiments from all 50 states
 - Estimated 1,600+ middle school students participated in this activity
- Launched on June 25, 2015 – Another very successful workshop



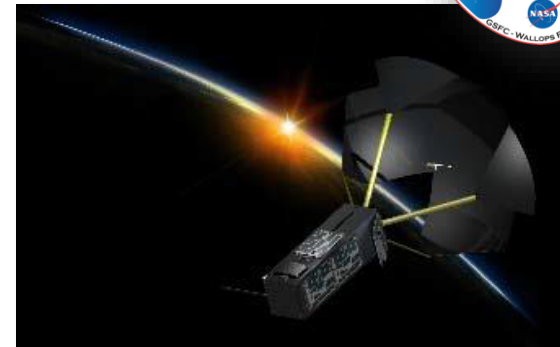


Sounding Rockets – Significant Progress



36.313/Milliner (STMD Experiment Flight)

- Flight supported NASA Space Technology Mission Directorate experiments
 - NASA GLENN Research Center Radial Core Heat Spreader
 - Method of thermal energy conversion, for use with space power
 - Perform thermal management before, during, and after launch scenarios
 - NASA AMES Research Center SOAREX-8
 - Exo-Brake Flight Test
 - A passive means of de-orbiting an object
 - ISS-compatible de-orbit system
- Provided additional flight data to characterize the Black Brant Mk1 motor
- The mission was launched from Wallops Island early in the morning of July 7, 2015
- The Radial Core Heat Spreader experiment performed nominally
- The SOAREX-8 experiment experienced a deployment anomaly however the decelerator did deploy and good data was obtained from four of the five telemetry channels
 - The Principal Investigator is assessing the results



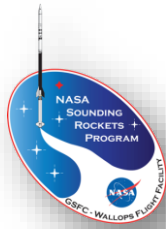
SOAREX-8 Experiment



Radial Core Heat Spreader Experiment



Sounding Rockets – Significant Progress



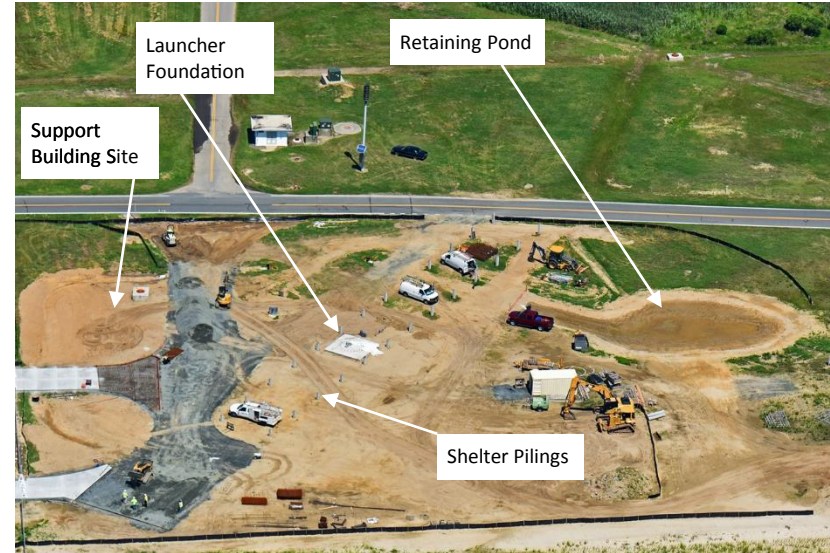
WRATS – Engineers teaching teachers... Interns teaching teachers... Teachers teaching teachers... Teachers go home and teach our future...

- **50K Launcher Relocation and Refurbishment Progress:**

- Foundation piles complete
- Concrete pad for launcher base complete
- Expanded duct bank at pad 2 complete
- Launcher stool sandblasting and painting complete
- Site work continues on pad 2 aprons with tie in to existing pad area
- Structure sandblasting and painting underway
- Azimuth bearing being reconditioned
- Elevation drive being reconditioned
- Launcher re-assembly on pad 2 scheduled to begin August 3

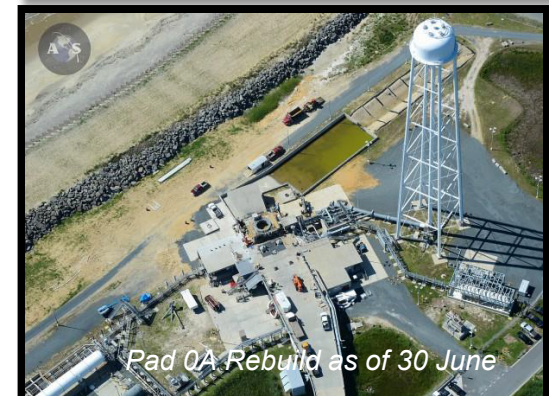
- **Mobile Radar:**

- Mobile Radar 2 is undergoing preparation and testing to support upcoming Orb-5 launch
- Radar 8 is being integrated with a 12ft dish to increase capability and in preparation for Bermuda site improvements solution



Radar 8 Testing

- **RockON-15 Sounding Rocket**
 - All instrumentation systems performed nominally in support of the Terrier-Improved Orion launch which lifted-off on June 25 at 0600L
 - Successful payload recovery 36 miles off the coast of Wallops Island
- **Milliner Sounding Rocket**
 - All instrumentation systems performed nominally in support of the Terrier MK70 Black Brant Mk1 launch which lifted-off on July 7 at 0615L
- **Antares**
 - Received first funding allotment for the Facilities & Ground Processing Annex #2.
 - Delivery of first two flight engines to Wallops in mid-July
 - Pad 0A rebuild completion and readiness for Roll-Out is scheduled for September 2015
 - Static stage test planned on Pad 0A January 2016
 - Orb-5 Initial Launch Capability (ILC) in March 2016



ROSES 2015 Update

The information below is now available through NSPIRES.

- **Two-Step Process**
 - All Heliophysics ROSES Solicitations Will Continue Utilizing the Two-Step Process
 - Encourage/Discourage Process Successful in ROSES14 H-GI, H-SR
 - **H-GI, H-SR: Encourage/Discourage in Step 1.** Three-Page Step-1 Proposals Required
 - **H-LWS, H-TIDeS and H-IDEE Step-1:** Single-Page, Team Fixed, **Compliance Check Only**
- **Duplicate Proposals: Risk Noncompliance**

ROSES 2015 Program Elements

- **Guest Investigator (H-GI)**
 - Open- primary emphasis is the analysis of data from currently-operating missions of the Heliophysics System Observatory (HSO)
- **Supporting Research (H-SR)**
 - Highest priority will be proposals that use data from current or historical NASA spacecraft together with theory and/or numerical simulation to address Heliophysics Decadal Survey goals
- **Living With a Star (H-LWS)**
 - Strategic Capabilities not competed
 - Cross-disciplinary proposals
 - Focus Topics, VarSITI,
- **Technology and Instrument Development for Science (H-TIDeS)**
 - Low Cost Access to Space
 - Instrument and Technology Development
 - Laboratory Nuclear, Atomic, and Plasma Physics
- **Grand Challenge Research (H-GCR)**
 - Currently Fully Subscribed. Not Competed in ROSES15.
- **Infrastructure and Data Environment Enhancements (H-IDEE)**
 - Only Data Environment Enhancements, no infrastructure. Heliophysics Data Services CAN: Solicited Outside ROSES



2015 ROSES Heliophysics Elements

ELEMENT	STEP 1 PROPOSALS	STEP 2 PROPOSALS	AWARDS (ESTIMATED)	YEAR 1 (\$M) (ESTIMATED)
HGI	204	(due 7/31/15)	20 - 25	4.0
HIDEE	15	(due 7/24/15)	10 - 12	0.5
LWS	103	92	25	3.5
HSR	345	(due 9/11/15)	22 - 30	4.0
HTIDeS	100	(due 8/28/15)	12	4.5 – 5.0
TOTALS	767	–	89 - 104	16.5 – 17.0

Heliophysics President's Budget FY16 Overview

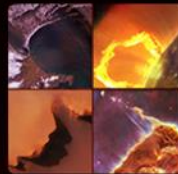
Favorable Budget: Showing first real growth in a Decade

(\$M)	2016	2017	2018	2019	2020
Heliophysics	\$651	\$685	\$698	\$708	\$722

- Meets our requirements - No surprises
- Augmentation fully implements DRIVE wedge
- Provides requested resources for current programs

FY16 Appropriation Status

		05/14/15	05/20/15	06/03/15		06/10/15	06/11/15				
FY16 All Values (\$M)	Pres Req (PBR)	HAPP Subc Markup	HAPP Comm Markup	House Floor	Delta from PBR	SAPP Subc Markup	SAPP Comm Markup	Delta from PBR	Delta from House	Senate Floor	Conference Bill
Science	5288.6	5237.5	5237.5	5237.5	-51.1	5295.0	5295.0	6.4	57.5		
Earth Science	1947.3	1682.9	1682.9	1682.9	-264.4	1931.6	1931.6	-15.7	248.7		
Planetary Science	1361.2	1557.0	1557.0	1557.0	195.8	1321.0	1321.0	-40.2	-236.0		
Astrophysics	709.1	735.6	735.6	735.6	26.5	730.6	730.6	21.5	-5.0		
JWST	620.0	620.0	620.0	620.0	0.0	620.0	620.0	0.0	0.0		
Heliophysics	651.0	642.0	642.0	642.0	-9.0	649.8	649.8	-1.2	7.8		
Education						42.0	42.0	42.0	42.0		
Aeronautics	571.4	600.0	600.0	600.0	28.6	524.7	524.7	-46.7	-75.3		
Space Technology	724.8	625.0	625.0	625.0	-99.8	600.0	600.0	-124.8	-25.0		
Exploration	4505.9	4759.3	4759.3	4759.3	253.4	3831.2	4731.2	225.3	-28.1		
Space Ops	4003.7	3957.3	3957.3	3957.3	-46.4	4756.4	3856.4	-147.3	-100.9		
Education	88.9	119.0	119.0	119.0	30.1	108.0	108.0	19.1	-11.0		
Safety, Security and Mission Services	2843.1	2768.6	2768.6	2768.6	-74.5	2784.0	2784.0	-59.1	15.4		
Construction & Environmental	465.3	425.0	425.0	425.0	-40.3	352.8	352.8	-112.5	-72.2		
Inspector General	37.4	37.4	37.4	37.4	0.0	37.4	37.4	0.0	0.0		
NASA Total	18529.1	18529.1	18529.1	18529.1	0.0	18289.5	18289.5	-239.6	-239.6		



Where is the Heliophysics Division Going?

Primary Focus

➤ *Ensure a more balanced Heliophysics portfolio and enable a continuing robust and long-term Heliophysics System Observatory and research programs.*

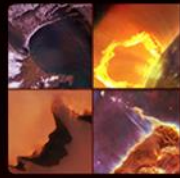
✓ **Assessing Division Resource Needs**

✓ **Re-Balancing Staff Work-Load**

✓ **Participating in OSTP-led Space Weather Operations, Research and Mitigation (SWORM) Task Force activities**

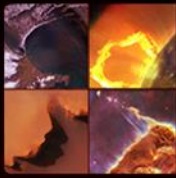
• **Develop and Implement Long-Term Strategy for a Balanced Portfolio**

- **Plan for more frequent, lower-cost missions by expanding Explorers and Missions of Opportunity**
- **Commence development of the highest priority Strategic Program (STP, LWS) science targets, consistent with the budget and with Research and Explorer priorities**
- **Work towards enhancing research programs (DRIVE) as recommended by the Decadal Survey**



Where is the Heliophysics Division Going?

- **Develop Division Technology Investment Focus**
- **Enhance Inter-Agency and International Partnerships**
- **Engage the Heliophysics Community**



Previous Science Committee Topic

Book-keeping non-HPD funds in HPD

- Suggestion was made by Committee to use JASD for book-keeping funds for non-HPD items
- JASD does not have it's own budget. It manages NOAA reimbursable funds only.
- Every SMD Theme (except JWST) carries some "bookkeeping" Projects that don't actually belong to the Theme
 - Earth carries Directorate Support (~\$50M/year) and manages the Airborne program
 - Planetary carries the OCS Science Innovation Fund (\$5-6M/year)
 - Astro carries STEM Education, CAAS/Audit Services (total \$35-57M/year) and the Balloon program
- Starting in FY16, Directed R&T funds will be allocated across all 4 Themes