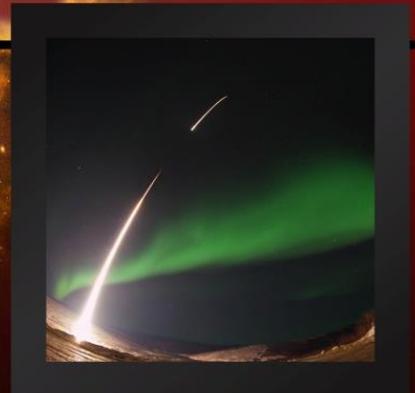
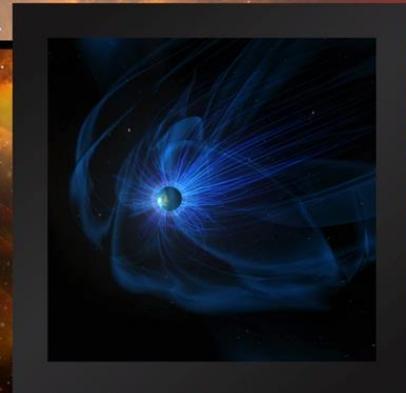




HELIOPHYSICS DIVISION



*Heliophysics Overview
Heliophysics Subcommittee Meeting
June 30, 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

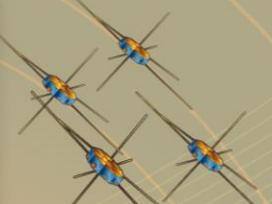
Research



Scientific research projects
utilizing existing data plus
theory and modeling

Heliophysics Program 2015-2024

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

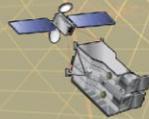


Solar Orbiter Collaboration (with ESA)
October 2018

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



ROCKON- June 2015
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
Geospace - November 2015

Geospace - November 2015
UV/Optical Astrophysics - November 2015
High Energy Astrophysics - December 2015

Ongoing

Heliophysics Missions
Astrophysics Missions
Planetary Missions

2015

2016

2017

2018

2019

2020

2021

2022

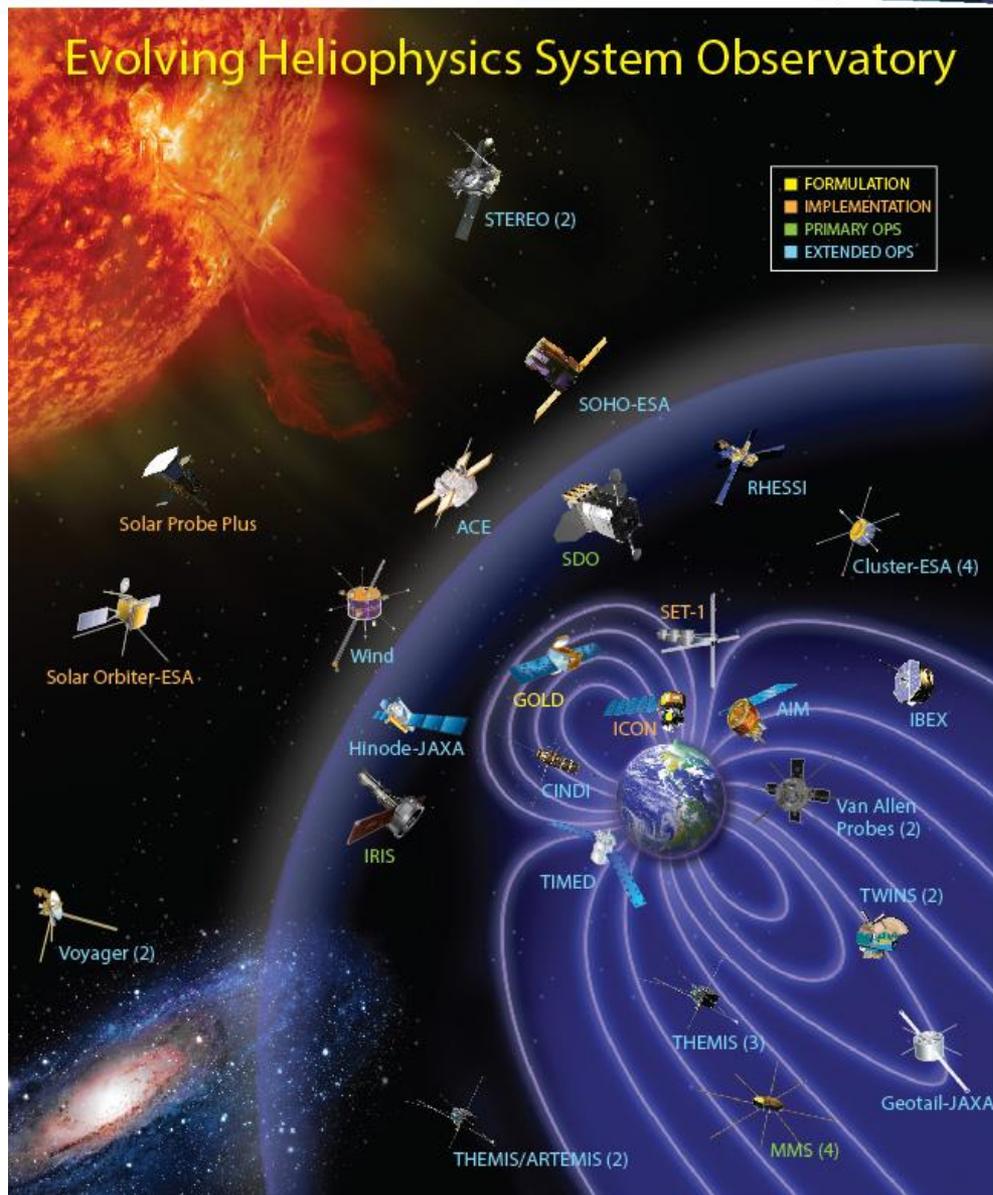
2023

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



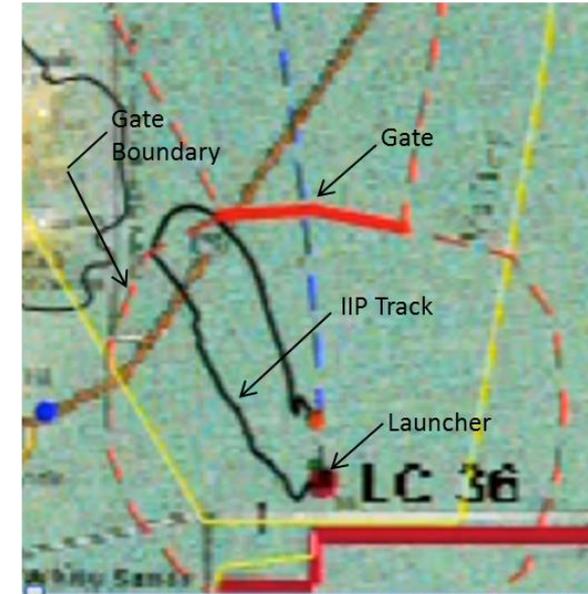
Heliophysics Flight Program Highlights

Significant Accomplishments

- **Senior Review** – Report released for SMD review.
- **MMS** – Commissioning ongoing, S/C coming out of eclipse on June 21.
- **SPP** – SWEAP passed CDR Part 2 on June 3.
- **Sounding Rockets** - Biannual Sounding Rockets Working Group Meeting held on 6/3. Woods successfully launched on May 21 but had to be cut down, payload recovered; Koehler (student) successfully launched on June 25
- **Black Brant** - first Black Brant MK4 motor was cast on 6/3/15.
- **GOLD** - SES-14 accommodation workshop held May 6-7; S/C TIM2 conducted June 2–4; life testing completed for EM GYM, Slit, & Door mechanisms.
- **ICON** - Spacecraft structure fabrication, harness mock-up and Solar array substrates completed; MRRs conducted for Antenna, Star Trackers, Battery, Transponder, IMAU, GPS, SADA & RWAs.
- **SOC** – Completed Mission CDR June 17

Upcoming Key Events

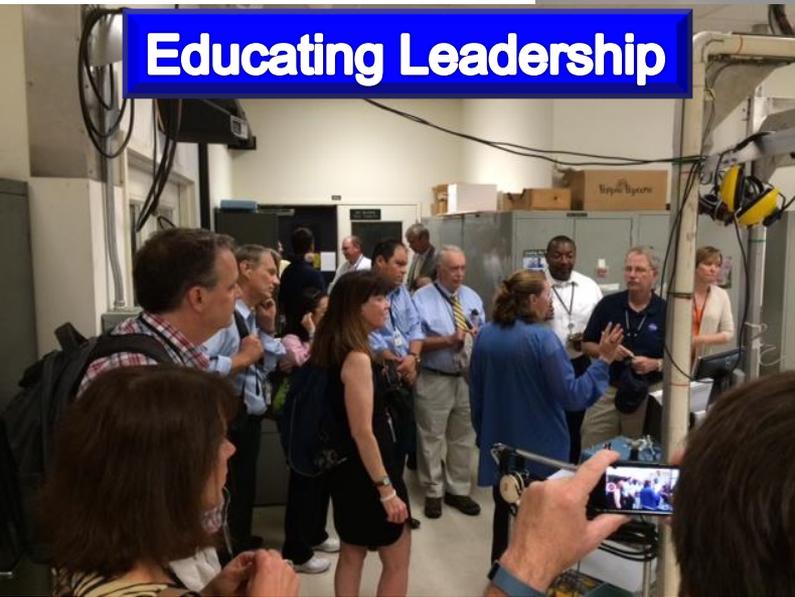
- **Sounding Rockets** – Milliner (Special Projects) Jul 7
- **MMS** – Commissioning completion on August 31



Terrier Booster

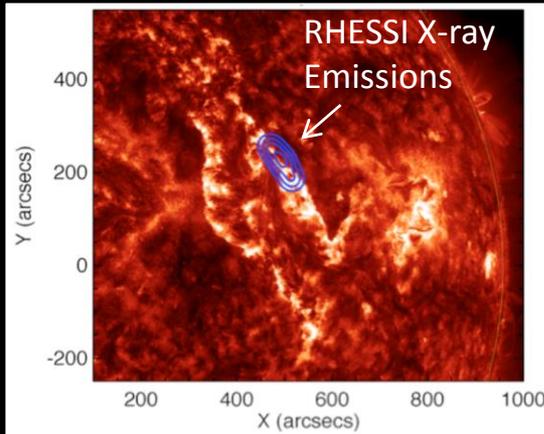


- Public Engagement - WFF Visit with the Sounding Rocket Program



Heliophysics Science Highlights

June 2015

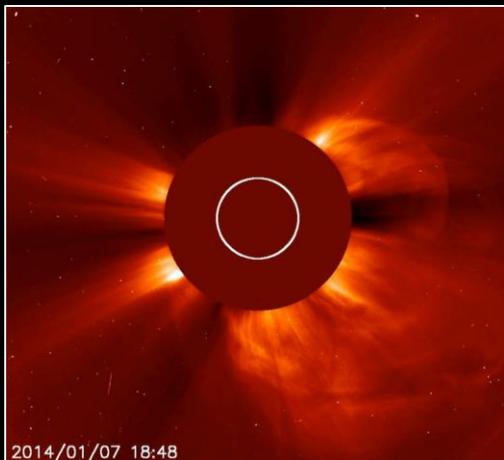


RHESSI Detects X-ray Emissions from a Quiet-Sun Filament Eruption:

RHESSI observed a high energy X-ray burst on the quiet sun at the location of an erupting filament rather than the nearby active region. Magnetic reconnection was likely the driver of the enhanced plasma heating observed by RHESSI. The connection between quiescent filament eruptions and flares, CMEs, and filament eruptions from active regions is important to improve our understanding of space weather events.

NASA's BARREL and Van Allen Probes Study How Plasma Waves Cause

Particle Precipitation: A new study has shed light on space weather's impact on Earth, 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.

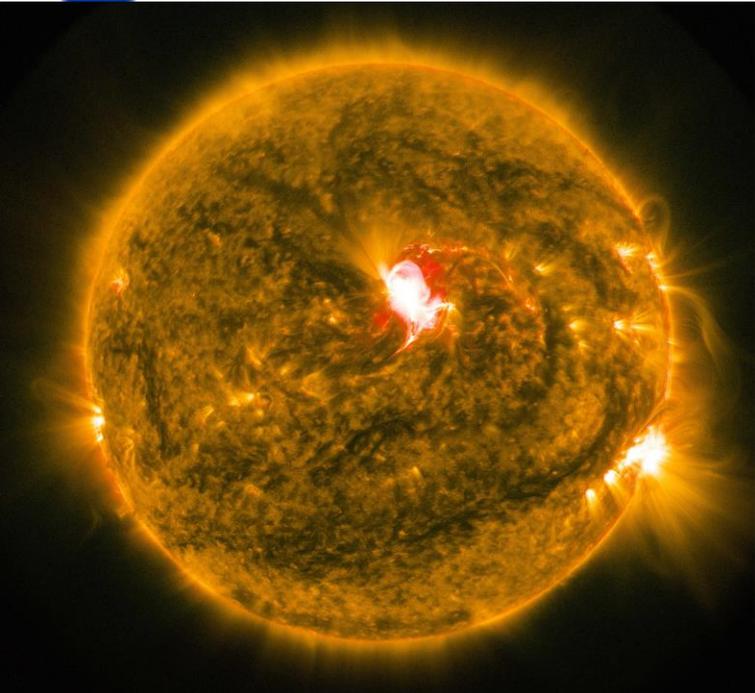


New Tool Could Track Space Weather Events 24 Hours Before

Reaching Earth: Magnetic fields contained in CMEs are measured as they pass by NASA's ACE satellite giving 30 to 60 minutes warning of the CMEs configuration before it impacts Earth's magnetosphere. Researchers are testing a new model that measures the magnetic field configuration up to 24-hours in advance. After more testing and validation, models such as these can be transitioned into operational forecasting.



Solar Dynamics Observatory



- Mid-level CME captured by SDO on June 20
- M6.6-Class Flare
- CME arrived at Earth at 1:59 PM EDT on June 22
- SWPC issued a G4 (Severe) Alert
- Aurora captured west of Philadelphia



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

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**

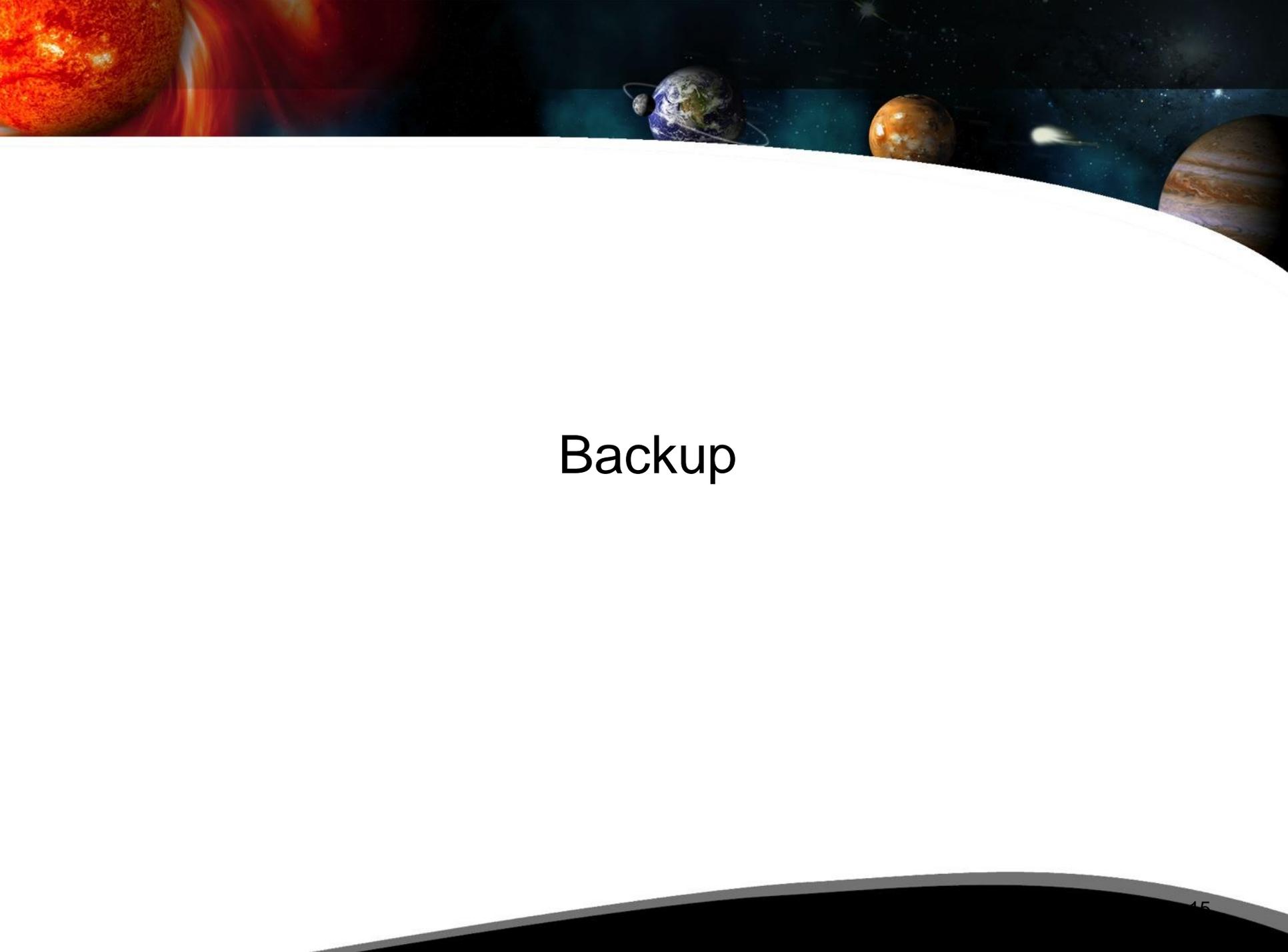
• **Develop and Implement Long-Term Strategy for a Balanced Portfolio**

- **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**



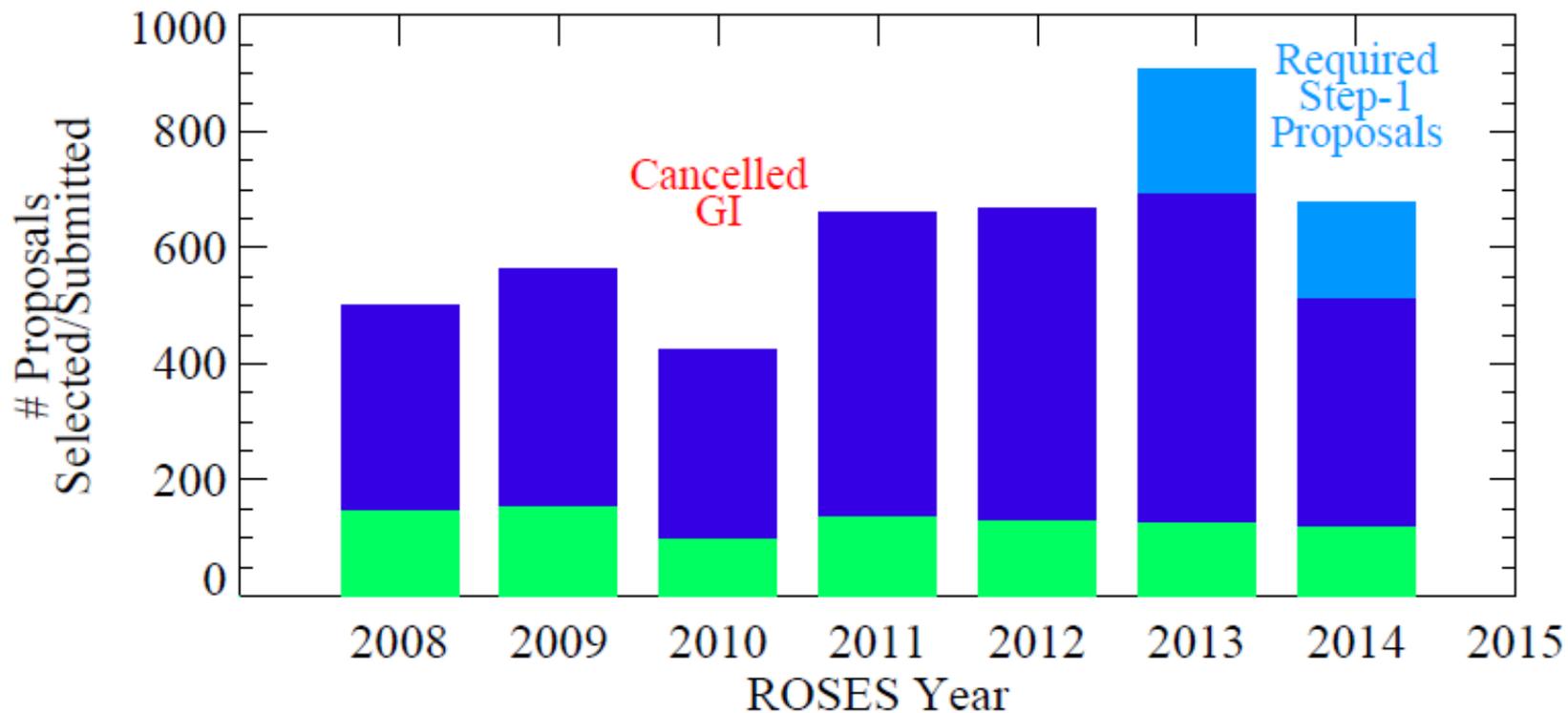
Where is the Heliophysics Division Going?

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

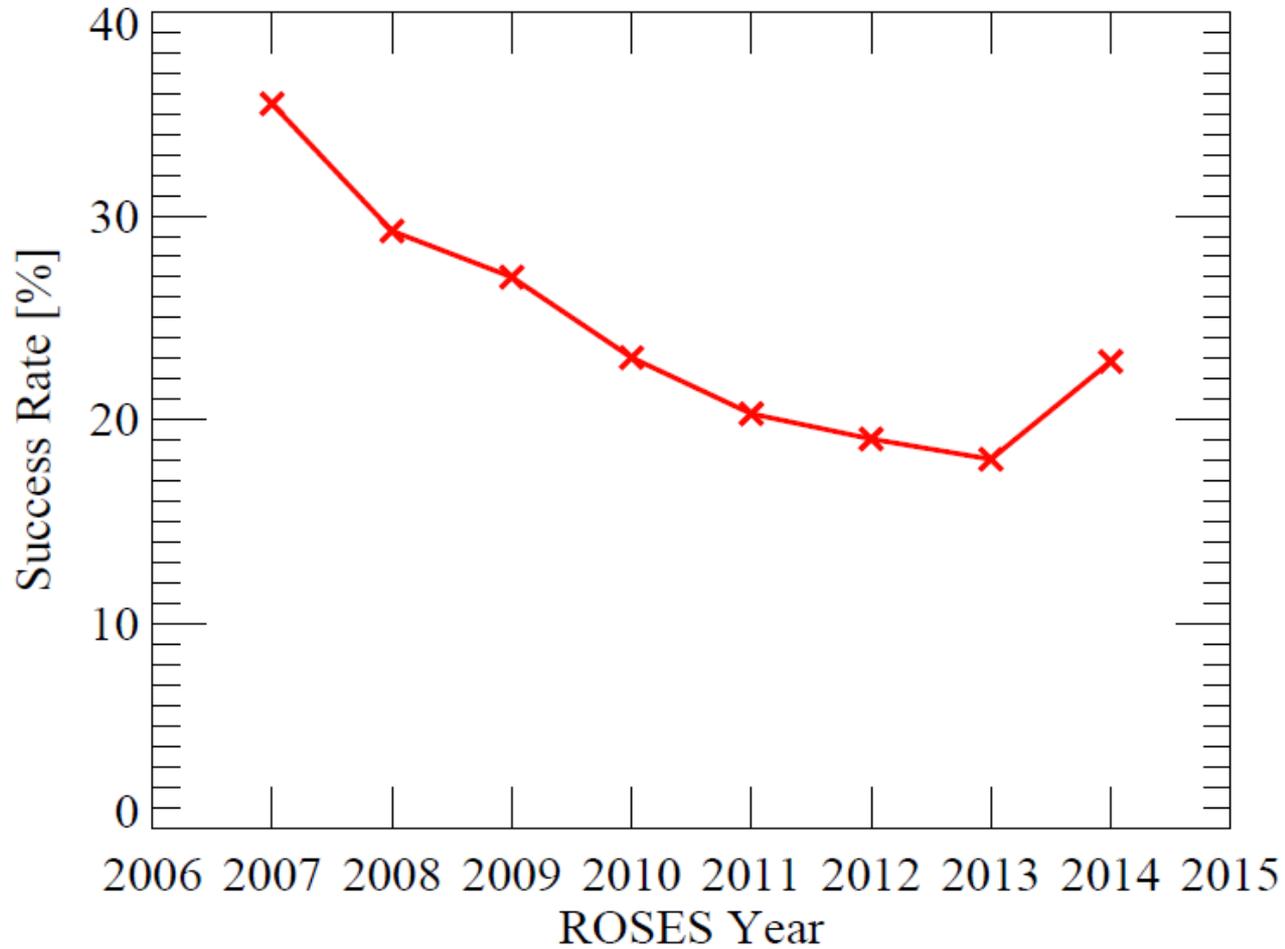
A space-themed background featuring a large, bright orange and red sun on the left, a blue and green Earth with a ringed planet in the distance, a brown and orange planet, and a comet streaking across the dark sky. The foreground is a large white curved shape.

Backup

ROSES: Research Proposal Submission Stats



Updated ROSES Proposal Success Rates



Heliophysics Presidents FY16 Budget

Budget Authority (in \$ millions)	Actual	Enacted	Request	Notional			
	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Heliophysics Research	185.1	--	158.5	168.5	202.1	207.6	208.4
Living with a Star	212.5	--	343.0	387.3	399.9	212.6	103.3
Solar Terrestrial Probes	143.3	--	50.5	37.6	41.8	133.3	189.2
Heliophysics Explorer Program	100.2	--	98.9	91.9	54.1	154.5	221.3
Total Budget	641.0	--	651.0	685.2	697.9	708.1	722.1

FY 2014 reflects funding amounts specified in the June 2014 Operating Plan per P.L. 113-76.

FY 2015 reflects only funding amounts specified in P.L. 113-235, the Consolidated and Further Continuing Appropriations Act, 2015.

★ Decrease only due to non-Heliophysics components, i.e. DR&T, SMD-wide activity

HELIOPHYSICS RESEARCH

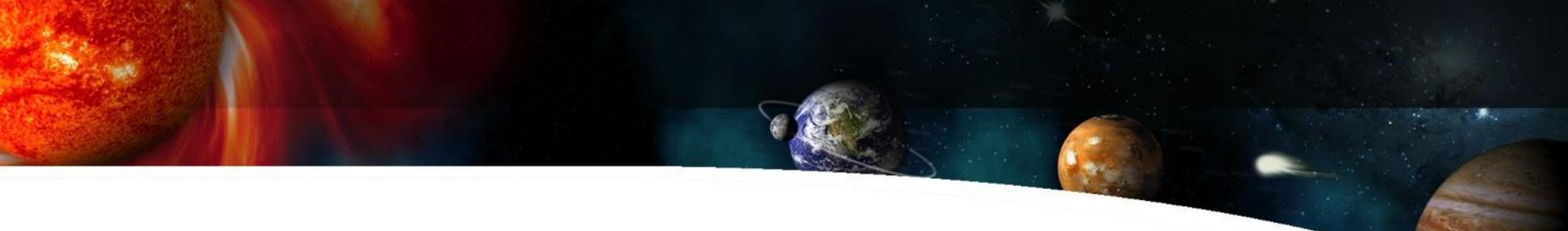
FY 2016 Budget

Budget Authority (in \$ millions)	Actual	Enacted	Request	FY 2017	Notional		
	FY 2014	FY 2015	FY 2016		FY 2018	FY 2019	FY 2020
Research Range	21.8	--	21.6	21.7	21.7	21.7	21.7
Sounding Rockets	53.4	--	48.3	53.3	59.0	61.1	63.1
Heliophysics Research and Analysis	33.5	--	34.0	33.9	48.9	53.9	53.9
Other Missions and Data Analysis	76.4	--	54.6★	59.6	72.5	71.0	69.7
Total Budget	185.1	--	158.5	168.5	202.1	207.6	208.4

FY 2014 reflects funding amounts specified in the June 2014 Operating Plan per P.L. 113-76.

FY 2015 reflects only funding amounts specified in P.L. 113-235, the Consolidated and Further Continuing Appropriations Act, 2015.

★ Decrease only due to non-Heliophysics components, i.e. DR&T, SMD-wide activity



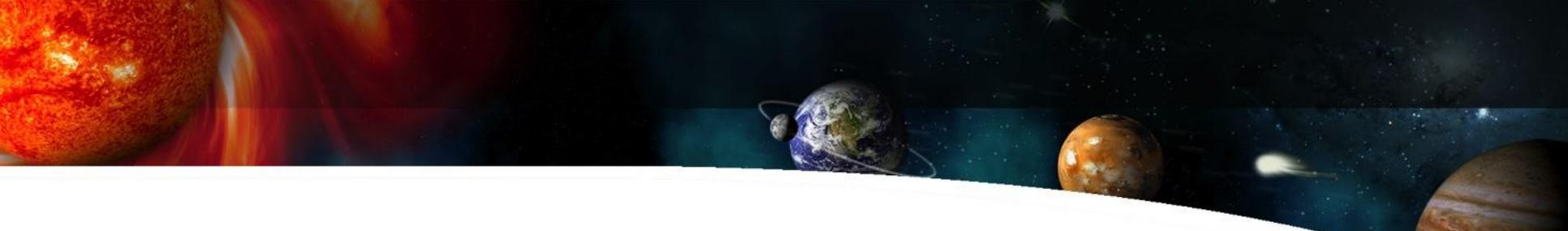
LIVING WITH A STAR

FY 2016 Budget

Budget Authority (in \$ millions)	Actual	Enacted	Request	Notional			
	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Solar Probe Plus	121.4	179.2	230.4	226.5	323.7	100.4	25.2
Solar Orbiter Collaboration	39.4	31.5	62.9	112.2	19.3	42.8	2.3
Other Missions and Data Analysis	51.7	--	49.7	48.7	56.9	69.4	75.9
Total Budget	212.5	--	343.0	387.3	399.9	212.6	103.3

FY 2014 reflects funding amounts specified in the June 2014 Operating Plan per P.L. 113-76.

FY 2015 reflects only funding amounts specified in P.L. 113-235, the Consolidated and Further Continuing Appropriations Act, 2015. For projects in development, NASA's tentatively planned FY 2015 funding level is shown. FY 2015 funding levels are subject to change pending finalization of the FY 2015 operating plan.



SOLAR TERRESTRIAL PROBES

FY 2016 Budget

Budget Authority (in \$ millions)	Actual	Enacted	Request	Notional			
	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Magnetospheric Multiscale (MMS)	120.9	52.4	30.1	17.5	10.8	0.0	0.0
Other Missions and Data Analysis	22.4	--	20.4	20.1	31.0	133.3	189.2
Total Budget	143.3	--	50.5	37.6	41.8	133.3	189.2

FY 2014 reflects funding amounts specified in the June 2014 Operating Plan per P.L. 113-76.

FY 2015 reflects only funding amounts specified in P.L. 113-235, the Consolidated and Further Continuing Appropriations Act, 2015. For projects in development, NASA's tentatively planned FY 2015 funding level is shown. FY 2015 funding levels are subject to change pending finalization of the FY 2015 operating plan.



HELIOPHYSICS EXPLORER PROGRAM

FY 2016 Budget

Budget Authority (in \$ millions)	Actual	Enacted	Request	Notional			
	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
ICON	59.8	61.0	49.8	48.0	9.0	4.5	1.3
Other Missions and Data Analysis	40.4	--	49.2	43.9	45.1	150.1	220.0
Total Budget	100.2	--	98.9	91.9	54.1	154.5	221.3

FY 2014 reflects funding amounts specified in the June 2014 Operating Plan per P.L. 113-76.

FY 2015 reflects only funding amounts specified in P.L. 113-235, the Consolidated and Further Continuing Appropriations Act, 2015. For projects in development, NASA's tentatively planned FY 2015 funding level is shown. FY 2015 funding levels are subject to change pending finalization of the FY 2015 operating plan.

Heliophysics President's FY16 Budget

	Op Plan	Enacted	Notional				
	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Heliophysics	641.0		651.0	685.2	697.9	708.1	722.1
<u>Heliophysics Research</u>	<u>185.1</u>		<u>158.5</u>	<u>168.5</u>	<u>202.1</u>	<u>207.6</u>	<u>208.4</u>
Heliophysics Research and Analysis	33.5		34.0	33.9	48.9	53.9	53.9
Sounding Rockets	53.4		48.3	53.3	59.0	61.1	63.1
Research Range	21.8		21.6	21.7	21.7	21.7	21.7
<u>Other Missions and Data Analysis</u>	<u>76.4</u>		<u>54.6</u>	<u>59.6</u>	<u>72.5</u>	<u>71.0</u>	<u>69.7</u>
CubeSat	5.0		5.0	5.0	5.0	5.0	5.0
Voyager	5.4		5.7	5.6	5.6	5.6	5.5
SOHO	2.2		2.2	2.2	2.2	2.2	2.2
WIND	2.2		2.2	2.2	2.2	2.0	2.0
Geotail	0.5		0.2	0.2	0.2	0.2	0.2
CLUSTER-II	0.6						
Space Science Mission Ops Services	10.9		11.5	11.5	11.5	11.6	11.9
Solar Data Center	1.0		1.0	1.0	1.0	1.0	1.0
Data & Modeling Services	3.1		2.8	2.8	2.8	3.0	3.0
Community Coordinated Modeling Center	2.0		2.0	2.0	2.0	2.1	2.1
Space Physics Data Archive	2.0		2.0	2.0	2.0	2.0	2.0
Guest Investigator Program	8.1		10.5	10.3	19.2	24.3	22.7
Science Planning and Research Support	6.3		6.6	6.7	6.8	6.8	6.8
Heliophysics Directed R&T	27.2		2.9	8.0	11.9	5.3	5.3

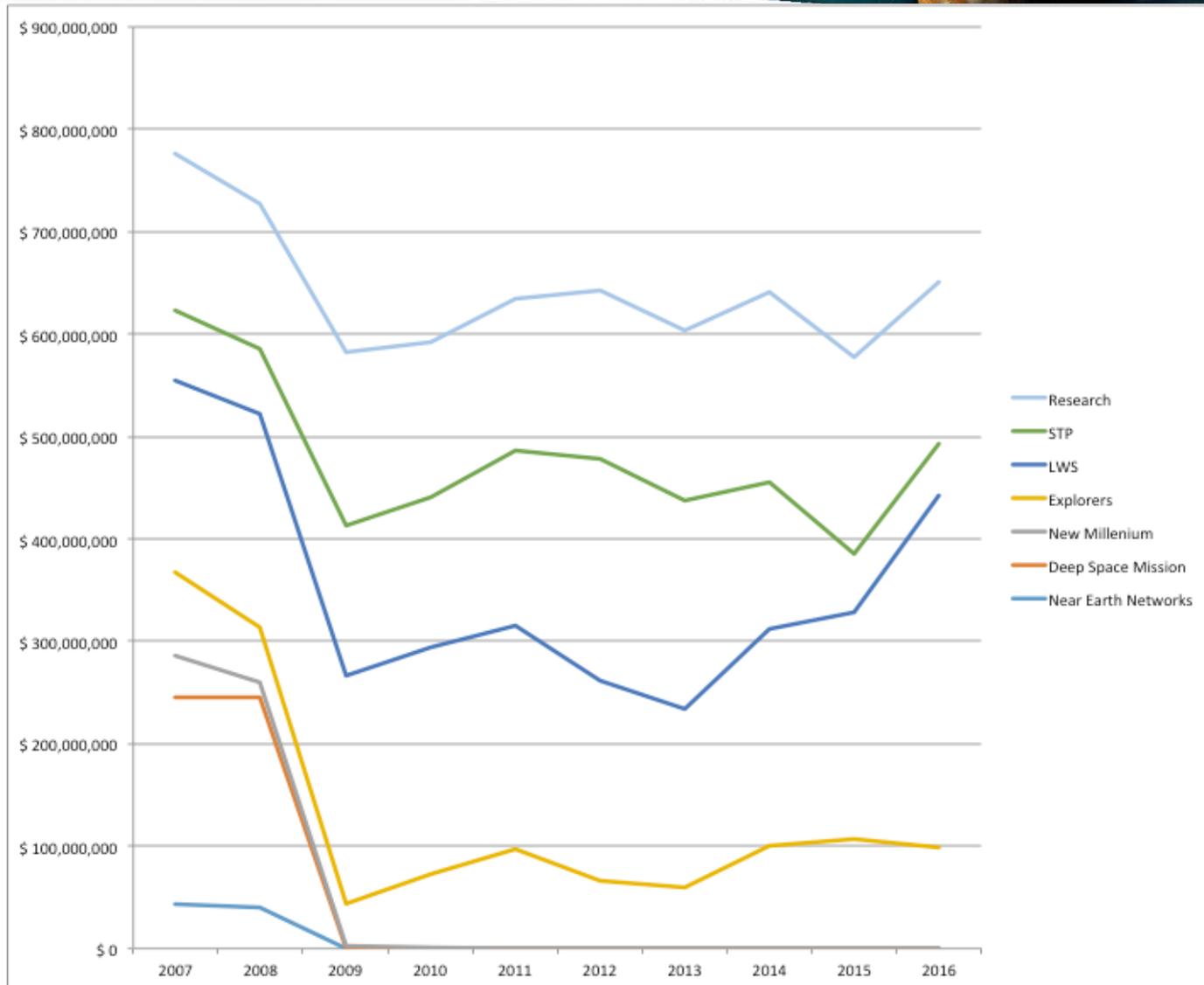
Heliophysics President's FY16 Budget (cont'd)

	Op Plan	Enacted	Notional				
	FY14	FY15	FY16	FY17	FY18	FY19	FY20
<u>Living with a Star</u>	<u>212.5</u>		<u>343.0</u>	<u>387.3</u>	<u>399.9</u>	<u>212.6</u>	<u>103.3</u>
Solar Probe Plus	121.4	179.2	230.4	226.5	323.7	100.4	25.2
Solar Orbiter Collaboration	39.4	31.5	62.9	112.2	19.3	42.8	2.3
<u>Other Missions and Data Analysis</u>	<u>51.7</u>		<u>49.7</u>	<u>48.7</u>	<u>56.9</u>	<u>69.4</u>	<u>75.9</u>
Van Allen Probes (RBSP)	10.8		15.5	14.3	14.0	14.0	10.0
Solar Dynamics Observatory (SDO)	14.8		9.5	9.5	9.5	9.5	9.5
LWS Space Environment Testbeds	0.6		0.4	0.4			
BARREL	1.5						
LWS Science	18.2		17.5	17.5	25.5	30.5	29.5
Program Management and Future Missions	5.9		6.7	6.9	7.8	15.3	26.8
<u>Solar Terrestrial Probes</u>	<u>143.3</u>		<u>50.5</u>	<u>37.6</u>	<u>41.8</u>	<u>133.3</u>	<u>189.2</u>
Magnetospheric Multiscale (MMS)	120.9	52.4	30.1	17.5	10.8		
<u>Other Missions and Data Analysis</u>	<u>22.4</u>		<u>20.4</u>	<u>20.1</u>	<u>31.0</u>	<u>133.3</u>	<u>189.2</u>
STEREO	9.5		9.5	9.5	9.5	9.5	9.5
Hinode (Solar B)	8.0		7.3	7.0	7.0	7.0	7.0
TIMED	2.9		2.7	2.6	2.5	2.5	2.5
Program Management and Future Missions	2.0		1.0	1.0	12.0	114.4	170.2

Heliophysics President's FY16 Budget (cont'd)

	Op Plan	Enacted	Notional				
	FY14	FY15	FY16	FY17	FY18	FY19	FY20
<u>Heliophysics Explorer Program</u>	<u>100.2</u>		<u>98.9</u>	<u>91.9</u>	<u>54.1</u>	<u>154.5</u>	<u>221.3</u>
ICON	59.8	61.0	49.8	48.0	9.0	4.5	1.3
<u>Other Missions and Data Analysis</u>	<u>40.4</u>		<u>49.2</u>	<u>43.9</u>	<u>45.1</u>	<u>150.1</u>	<u>220.0</u>
GOLD	9.4		17.5	14.8	8.6	2.8	0.7
IRIS	8.6		7.7	7.7	7.0	7.0	6.5
THEMIS	5.4		4.6	4.5	4.5	4.5	4.5
Interstellar Boundary Explorer (IBEX)	3.6		3.4	3.4	3.4	3.4	3.4
Aeronomy of Ice in Mesosphere	3.0		3.0	3.0	3.0	3.0	3.0
ACE	3.0		3.0	3.0	3.0	3.0	3.0
RHESSI	2.1		1.9	1.9	1.9	1.9	1.9
TWINS	0.6		0.6	0.6	0.6	0.6	0.6
CINDI	0.9		0.6	0.3	0.2		
Heliophysics Explorer Future Missions					4.0	115.2	187.2
Heliophysics Explorer Program Management	3.8		6.8	4.7	8.9	8.7	9.1

Long Term Budget



Heliophysics FY16 Budget Top Level

FY16 Budget provides resources to allow for:

	<u>NS Recommendation</u>
Funds currently operating missions per upcoming April 2015 Senior Review	0.0
Fund Missions in development (~\$3.5B investment):	0.0
• Proceed with MMS for an LRD of Mar 2015 ✓	
• Proceed with SOC for LRD Oct 2018	
• Proceed with SPP development for LRD Jul 2018	
• Proceed with ICON development for LRD Oct 2017	
• Proceed with GOLD development for LRD Sep 2017	
Fund missions entering extended operations (Van Allen, IRIS, SDO)	0.0
Competed PI research award program, current (~\$63M) + DRIVE augmentation (~\$40M) + program growth	1.0
Maintain viable sounding rocket/Wallops research range program for the benefit of SMD	1.0
Utilize mission wedge for future missions	2.0, 3.0

Heliophysics Research Program

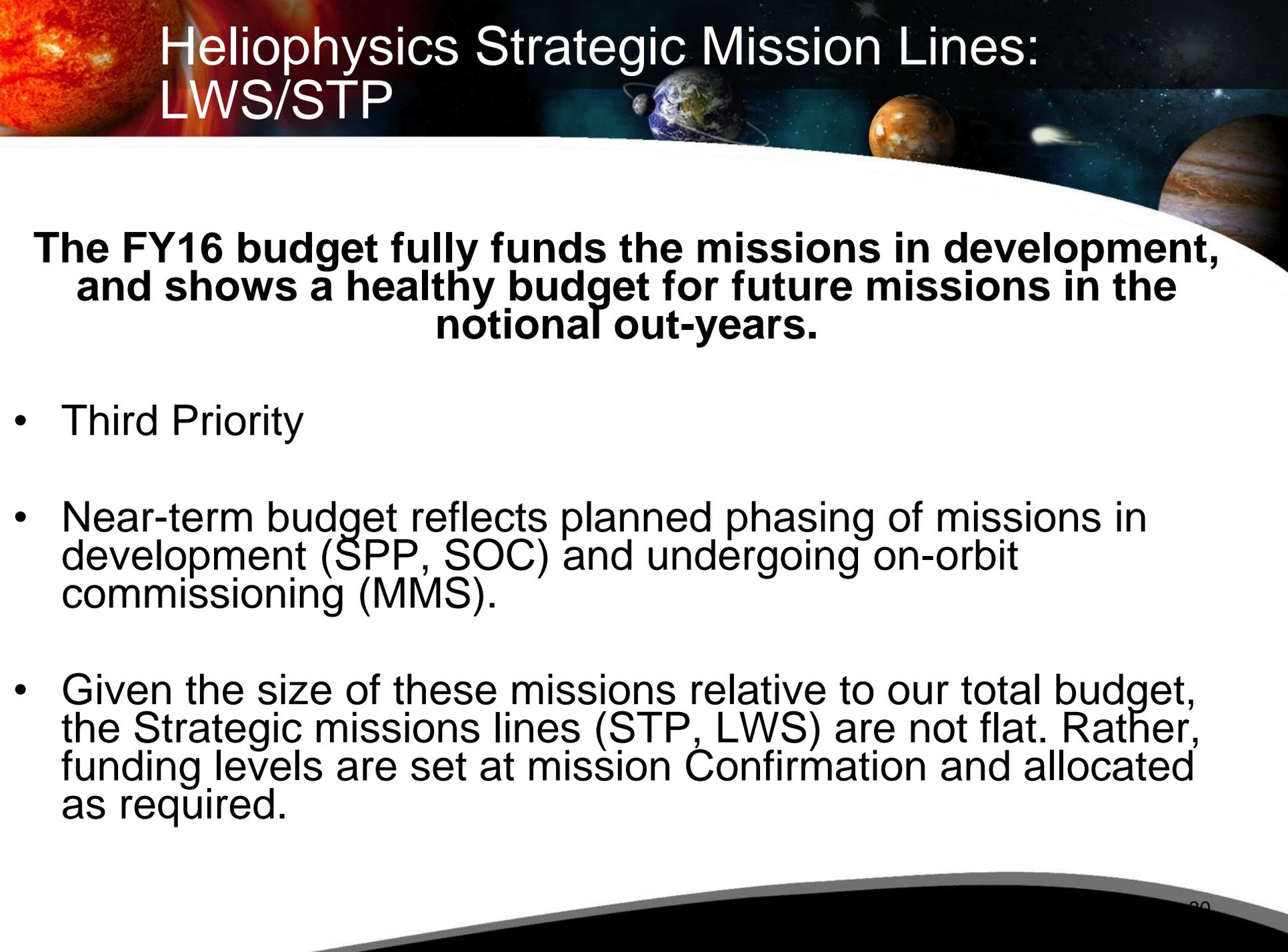
Research Program has strong growth in all of its elements beginning in FY16 and in notional future budgets.

- Highest priority: Significant funding wedge for DRIVE implementation
 - Growth in Research & Analysis (includes LCAS, Instrument & Technology Development, Theory, etc.), Guest Investigator, LWS Targeted Research & Technology
- As in the past, Research Program contains elements that are Science Mission Directorate (SMD) pass-throughs, i.e. bookkeeping for non-Heliophysics funds. These include “Science Planning and Research Support” and “Directed Research and Technology.” The latter had a significant decrease, but no decrease to “Heliophysics” research budget since these are funds for other SMD activities.
- Sounding Rocket Program Office budget had no decrease. This budget line funds the infrastructure part of the program, changes reflect planned multi-year phasing of budget allocations, i.e., shifting from FY16 to FY15 of some funds to meet procurement needs.

Heliophysics Explorer Program

A space-themed background featuring a large orange and red sun on the left, a blue and green Earth in the center, and a brown and orange planet on the right. The background is filled with stars and a dark blue space.

- Second priority
- Budget reflects strong growth in notional out-year budgets.
- Notional budget in future years projects funding for the launch of ICON and GOLD, as well as the beginning development of new Explorer missions.



Heliophysics Strategic Mission Lines: LWS/STP

The FY16 budget fully funds the missions in development, and shows a healthy budget for future missions in the notional out-years.

- Third Priority
- Near-term budget reflects planned phasing of missions in development (SPP, SOC) and undergoing on-orbit commissioning (MMS).
- Given the size of these missions relative to our total budget, the Strategic missions lines (STP, LWS) are not flat. Rather, funding levels are set at mission Confirmation and allocated as required.