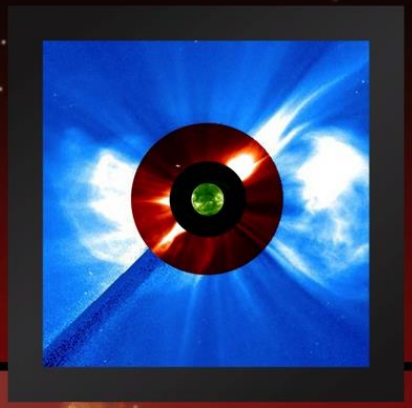
National Aeronautics and Space Administration



# HELIOPHYSICS DIVISION

## Heliophysics Overview
## CSSP
## March 2015
## Jeffrey Newmark

# *Topics for discussion*

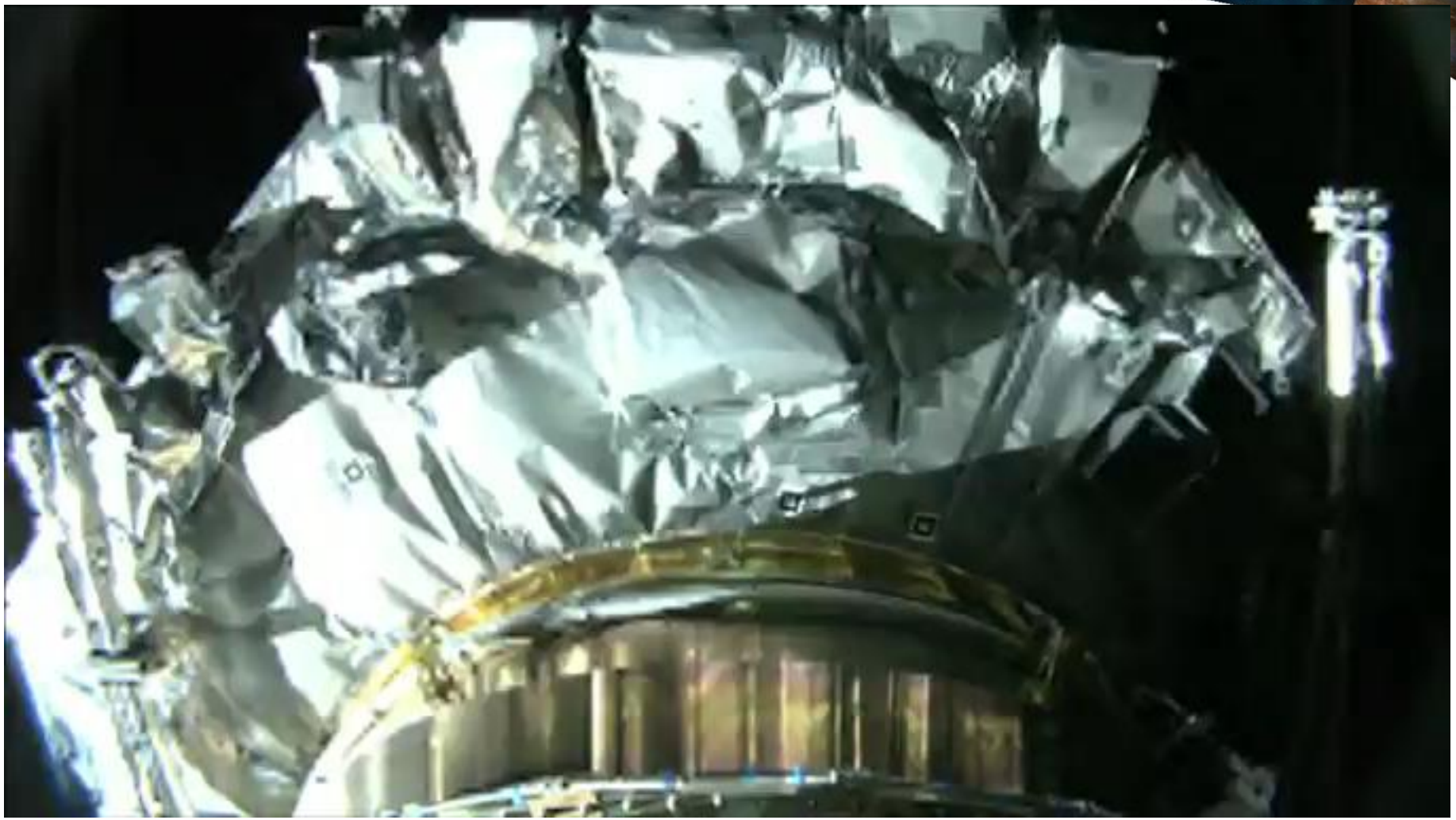
- **Recent Accomplishments**
- **NASA's Heliophysics Division Objectives and Science**
- **Program Status**
- **Research Program Updates**
- **Science Mission Directorate**
- **Future**

# MMS Launch March 12, 2015 at KSC



# MMS Launch

# MMS Deployment



# MMS Launch News Highlights

POPULAR SCIENCE

SPACE

## SPACE PROBE QUARTET AIMS TO FLY THROUGH MAGNETIC EXPLOSIONS

THEY'L… UNCH THIS WEEK TO STUDY EARTH'S MAGN…

By Lore…

U.S.News & World Report NEWS

News Opinion National Issues Special Reports Cartoons Photos Videos Quizz… News,

## NASA launching 4 spacecraft to solve magnetic mystery ; quartet will fly in pyramid formation

LATIN POST

Home US&World P… OZ…

## News: Four Satellites Launched t… Magnetic Reconnection

0 Comments

By Andre F. Puglie (staff@latinpost.com)

UNIVERSE TODAY

## NASA's MMS Satellite Constellation Blasts to Orbit to Study Explosive Magnetic Reconnection

by KEN KREMER on MARCH 13, 2015

The Washington Post

Speaking of Science

## NASA launches four spacecraft to study a phenomenon called magnetic reconnection

TECH SPACE HUMAN EARTH HISTORY ANIMALS ADVENTURE VIDEO

NEWS

SPACE

## NASA to Launch Satellites into Powerful Magnetic Explosions

CBS News / CBS Evening News / CBS This Morning / 48 Hours / 60 Minutes / Sunday Morning / Face The Natio…

CBSNEWS Video US World Politics Entertainment Health MoneyWat…

## NASA to study Earth and sun's explosive interplay

The four satellites making up NASA's $1.1 billion Magnetospheric Multiscale mission, or MMS, are stacked for launch Thursday in the nose of an Atlas 5 rocket. The satellites will work in concert to study the underlying physics of explosive interactions between the sun's magnetic field and Earth's. / NASA

CNN

U.S. Edition

News Video TV Opinions More…

U.S. World Politics Tech Health Entertainment Living Travel Money Sports

## NASA launches satellites to study magnetic mystery

USA TODAY

A GANNETT COMPANY

NEWS SPORTS LIFE MONEY TECH TRAVEL OPINION 52° CROSSWORDS MORE

## Atlas V rocket on pad for Thursday night launch

James Dean, Florida Today 7:10 a.m. EDT March 12, 2015

# National Air and Space Museum Debuts Must-See Sun Video Wall

- Unveiled on March 18th, the 7 by 6 ft. Video Wall streams data from NASA's Solar Dynamics Observatory, or SDO.

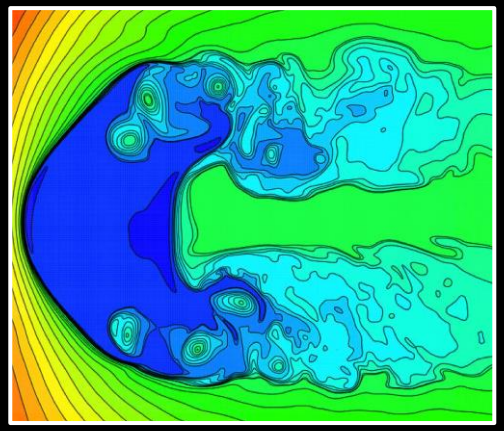
- SDO takes ten images of the differing layers of the Sun's atmosphere every 12 seconds with an image size of 4096 x 4096 pixels. By comparison, a high-definition TV can only display 1920 x 1080 pixels.

- Tremendous computing power is required to visualize the data from SDO. This data is improving our understanding of the Sun's ever-changing magnetism.

- The Video Wall is located at the base of the Skylab exhibit in the Space Race Gallery.

# Heliophysics Science Highlights

## March 2015

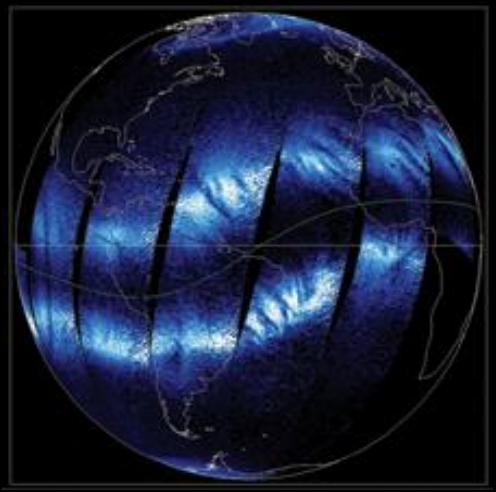


### NASA-Funded Study Finds Two Solar Wind Jets in the Heliosphere:

New research suggests the heliosphere is actually dominated by two giant jets of material shooting backwards over the north and south poles of the sun, which are confined by the interaction of the sun's magnetic field with the interstellar magnetic field. These curve around in two—relatively short – tails toward the back. The end result is a heliosphere that looks a lot more like a crescent moon than a comet.

### NASA's SDO Celebrates 5th Anniversary:

February 11, 2015 marked five years in space for NASA's Solar Dynamics Observatory or SDO, which provides incredibly detailed images of the Earth-facing side of the sun 24 hours a day. SDO has provided an unprecedentedly clear picture of how massive explosions on the sun grow and erupt ever since its launch and recently returned its 100-millionth image.

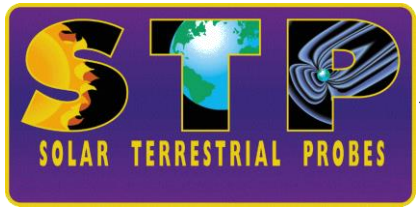


### **Study of Ionospheric 'Froth' May Improve GPS Communications:**

A new study on irregularities in the ionosphere compares turbulence in the auroral region to that at higher latitudes, and provides insights that could have implications for the mitigation of this disturbance. The size of the irregularities in the plasma gives researchers clues about their cause, more turbulence means larger disturbances to radio signals.

# HPD Objectives and Programs

## Solar Terrestrial Probes




Strategic Mission Flight Programs

## Living With a Star


Strategic Mission Flight Programs

*Solve the <u>fundamental physics</u> 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

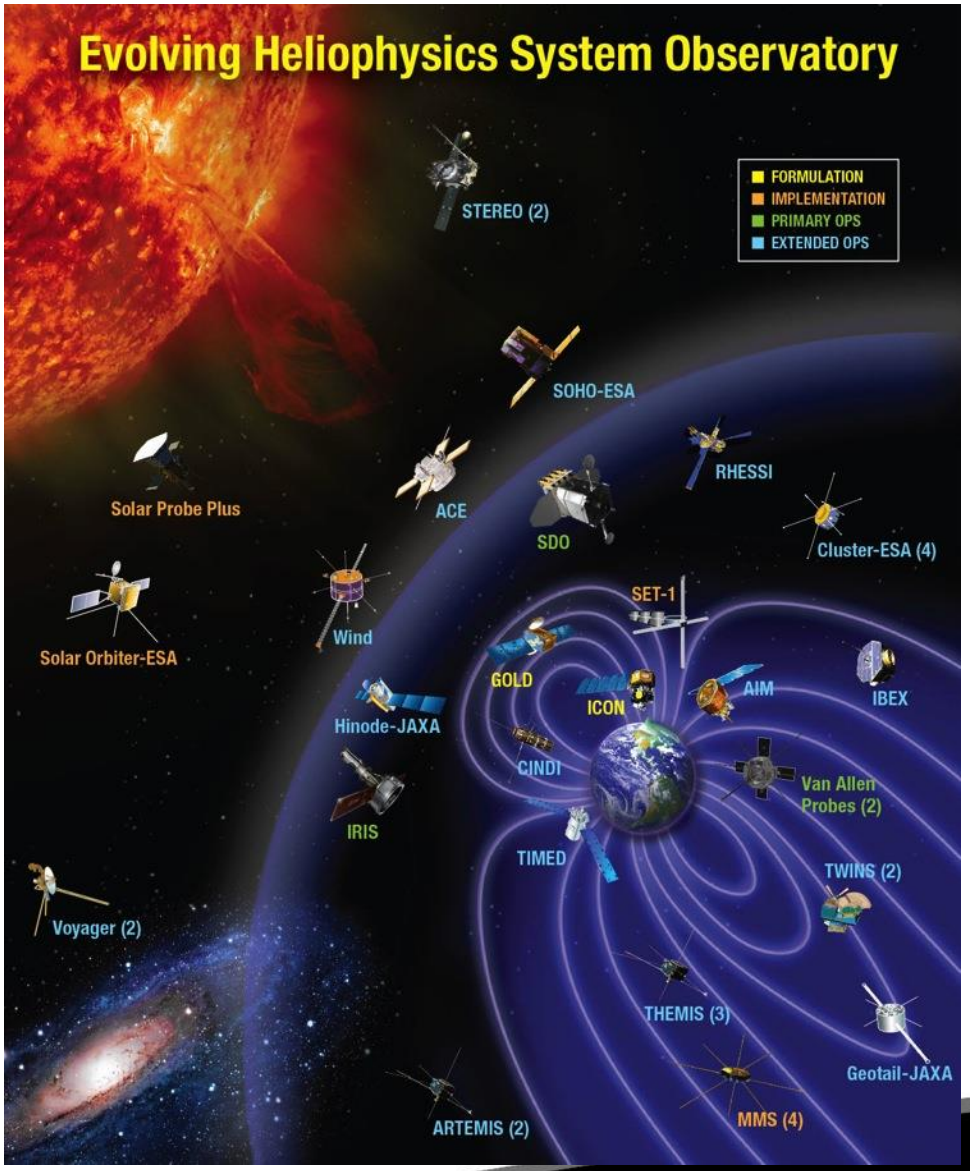

Smaller flight programs, competed science topics, often PI-led

## Research


Scientific research projects utilizing existing data plus theory and modeling

# Heliophysics 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




- **Heliophysics has 18 operating missions (on 29 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.)**
- **5 missions are in development: SET, SOC, SPP, ICON, and GOLD**

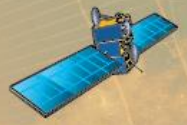
# Heliophysics Program 2015-2024

## Solar Terrestrial Probes

Magnetospheric Multiscale (MMS)
March 2015

STP #5
2023

## Living With a Star



Space Environment Testbeds (SET)
Mid-2016

Solar Probe Plus
July 2018

Solar Orbiter Collaboration (with ESA)
October 2018

## Explorers

Global-scale Observations of the Limb and Disk (GOLD)
September 2017

Ionospheric Connection Explorer (ICON)
October 2017

Heliophysics MO
2020

Heliophysics SMEX
2022

Heliophysics MO
2022

Heliophysics MIDEX
2024

Heliophysics MO
2024

## Research Program

ROCKSAT-X - March 2015
High Energy Astro - May 2015
Geospace - May 2015

ROCKSAT-On - June 2015
Solar/Heliospheric - August 2015
ROCKSAT-X - August 2015

Solar/Heliospheric - August 2015
Solar/Heliospheric - August 2015
UV/Optical Astro - August 2015

Ongoing

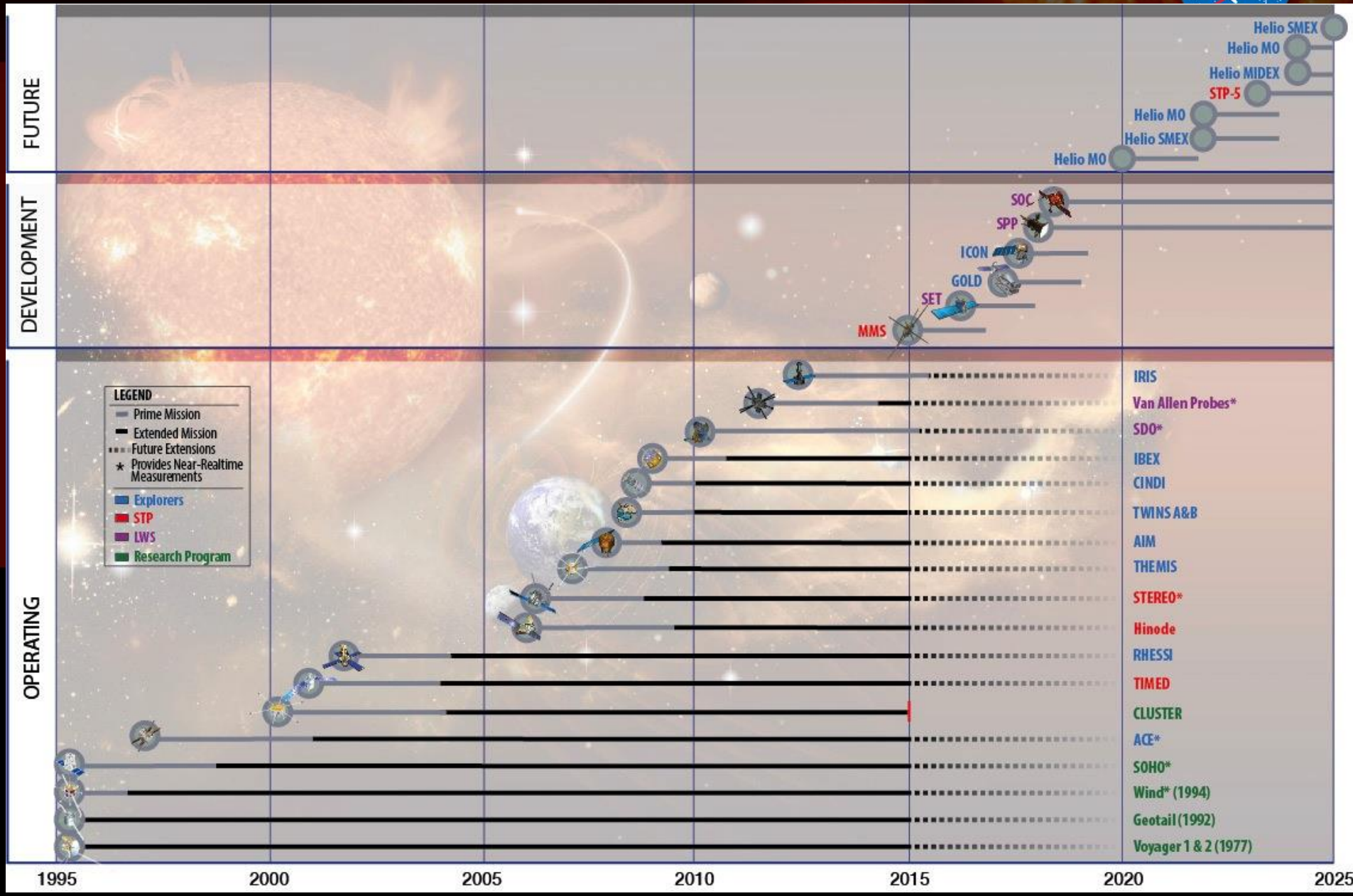
Wanaka: SPB

Heliophysics Missions
Astrophysics Missions
Planetary Missions

2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

# Heliophysics Mission Timeline 1995-2025

National Aeronautics and Space Administration



# Heliophysics Budget Features

**What's changed:**

- Implement the DRIVE (Diversify, Realize, Integrate, Venture, Educate) initiative, resulting in an increase of the competed research program from 10 percent to about 15 percent of the budget request. The FY 2016 budget supports a gradual increase with a goal of fully implementing DRIVE by the end of the decade.
- ESA-NASA **SOC** LRD October 2018**.**
- **SPP** budget profile reflects the requirements approved at the KDP-C in March 2014
- **MMS** Launched, funded for Phase E.
- **ICON, GOLD** budgets reflects the cost and schedule baseline approved at the KDP-C.
- **CLUSTER** Not supported after FY15.

**What's the same:**

- Continuation of the CubeSat Project to enable Heliophysics science from this platform
- Continuation of missions in operations:
  - Prime Ops: IRIS and SDO (both entering Extended Phase this year)
  - Extended Ops: Van Allen Probes, TWINS, CINDI, IBEX, THEMIS, AIM, Hinode, STEREO, RHESSI, TIMED, ACE, SOHO, WIND, Geotail, and Voyager

# Heliophysics FY15 and FY16 Planned Accomplishments

- NASA will launch, commission, and begin MMS mission operations in FY 2015. ✔
- GOLD will proceed into implementation phase during FY 2015.✔
- Complete ICON Critical Design Review (CDR) in FY 2015.
- NASA will continue to support the integration of the SOC HIS and SoloHI instruments into the spacecraft. The project will deliver the Electrical Model for SoloHI. Flight assets will be completed, tested and delivered.
- SPP will conduct peer level critical design reviews for system and subsystems, leading up to the mission level CDR. ✔After CDR, the build of flight hardware will be initiated and the launch vehicle procurement process will be completed. FY16 will mark the end of Phase C and the beginning of system assembly, integration and testing.
- The SDO mission will complete its prime mission phase in May 2015 and IRIS will complete its prime mission phase in July 2015, they will then enter extended operations. The 2015 Senior Review process will reevaluate both missions.
- Conduct Senior Review of Heliophysics Missions in FY15
- Launch up to 20 sounding rockets at Wallops Flight Facility, Poker Flats, White Sands, Woomera Range in Australia, and Andøya Rocket Range in Norway.

# Heliophysics Flight Program Summary Highlights

## Significant Accomplishments

- **PIR –** Successfully completed for LWS, STP, and Explorers (OCT 2014).
- **MMS** – Successful launch and separation on MAR 12, 2015.
- **SPP** – Completed Mission CDR (MAR 2015).
- **SOC –** NASA/ESA Agreement LRD to OCT 2018.
- **GOLD** – KDP-C – Successfully completed (MAR 2015).
- **ICON** – Conducting IBR (MAR 2015) , and ICP and Payload subsystem CDR (MAR 2015).
- **Sounding Rockets** - Successfully launched Hassler, Conde, Krucker, Pedersen, Collins, Swensen, & Larson

## Upcoming Key Events

- **Koehler** – Sounding Rocket, Wallops Island, MAR 27
- **Senior Review** – APR 21 - 24

MMS Mar 12, 2015

# MMS Significant Progress Highlights

**Description:** The Magnetospheric Multiscale (MMS) mission is a Solar Terrestrial Probes mission comprising four identically instrumented spacecraft that will use Earth's magnetosphere as a laboratory to study the microphysics of three fundamental plasma processes: magnetic reconnection, energetic particle acceleration, and turbulence.

**Recent Accomplishments:**

- **PSR –** Pre Ship Review completed October 22-24th, 2014
- **ORR/FOR –** Operations Readiness Review and Flight Operations Review – completed November 18-21st, 2014
- **KDP E** – KDP E completed on February 10, 2015.
- **HV801** accepted as a residual risk after all instruments screened for HV801 failures during FPI super suite testing, and with operational changes to limit on orbit thermal cycling of FPI instruments implemented.
- **LAUNCH - MMS launched on-time on March 12, 2015, at 10:44 pm EDT and was inserted with perfect accuracy and attitude into our initial orbit by the Atlas-Centaur AV-53.**

**Commissioning activities leading to start of prime operations:**

- **Mag Boom Deployments – completed**
- Perigee Burns – end of March
- DSP Deployments – end of April
- ADP Deployments – May
- MMS Formation achieved – July
- Start prime operations – September 1, 2015

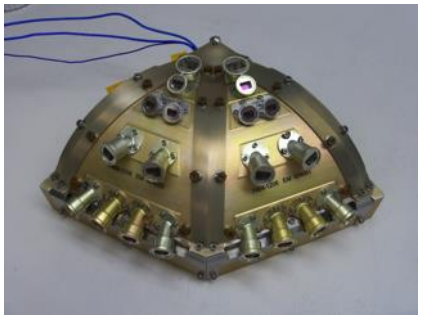
# Solar Probe Plus: First Voyage to a Star

**Description:**

Spacecraft in a highly eccentric elliptical orbit with a minimum perihelion of 9.9 Solar Radii (~4.3 million miles). Solar Probe Plus will employ 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.

**Milestones:**

- KDP-C March, 2014 – Confirmed
- Thermal Protection System reached TRL 6
- **CDR March, 2015 – Successful**
- SIR June, 2016
- LRD July, 2018

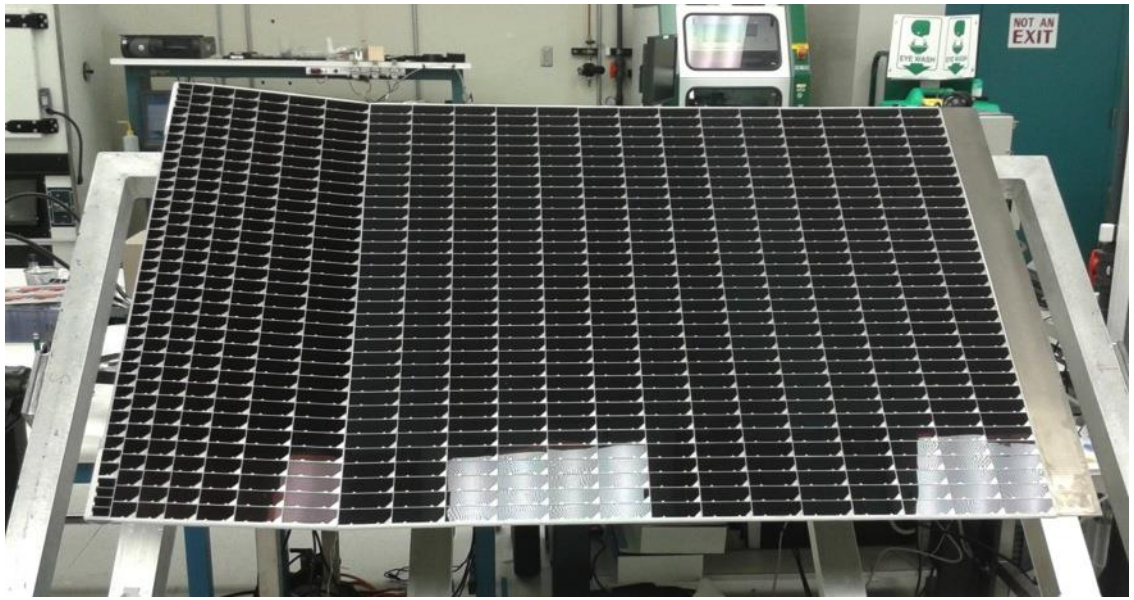


EPI-Lo Acoustic / Launch pressure profile test hardware

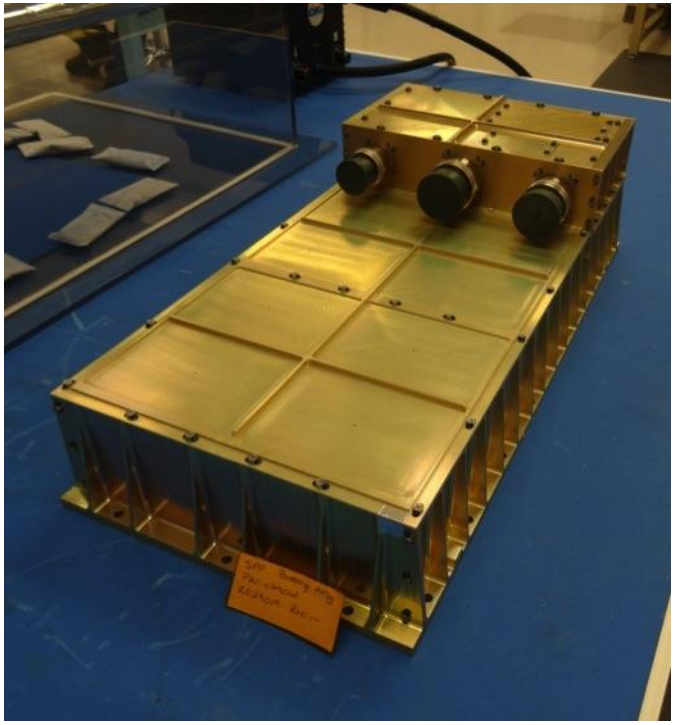
**Recent Accomplishments:**

- TPS: Completed Coupon Cold Cycle, Hot Cycle and Gradient tests.
- G&C: Completed initial stability analysis for attitude control using reaction wheels.
- Telecomm: Conducted Frontier Radio testing at the DSN test facility (DTF-21).
- Solar Array: Completed thermal vacuum cycle testing & survival irradiance exposure on Full Size Secondary #2 panel.
- Dust: White Sands hypervelocity testing completed for MLI-on-honeycomb coupons.
- **FIELDS: Completed First Run of Comprehensive Performance Test (CPT) for FIELDS Main Electronics Package (MEP) followed by environmental test.**
- **SWEAP: Engineering Model of SPAN B fully built and integrated.**
- WISPR: Completed screening and assembly of the EM optics and of the EM detectors in their mechanical package.
- ISIS: EPI-Lo EM vibration test of three fully operational sensor wedges and 5 mass simulators was successfully completed.

# SPP Qualification Wing and EM Battery




Solar Array Qualification Wing laydown is complete, awaiting application of Aluminized Kapton

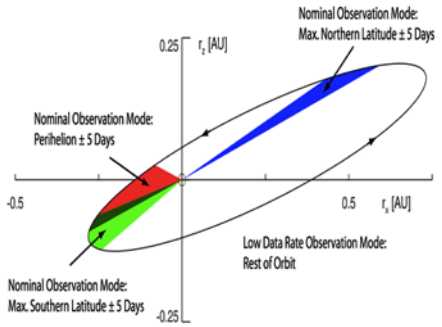


Completed Engineering Model Battery

# Solar Orbiter: The Sun Up Close, to Understand How the Sun Creates and Controls the Heliosphere

**Description:** Will use a unique combination of measurements:
*In situ* measurements will be used alongside remote sensing, close to the Sun (~.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.




**Milestones:**

- KDP-C March 2013 – For NASA-contributed instruments (HIS, SoloHI)
- **Mission CDR March-June 2015 – ESA-led, ongoing**
- LRD October 2018

**Recent Accomplishments:**

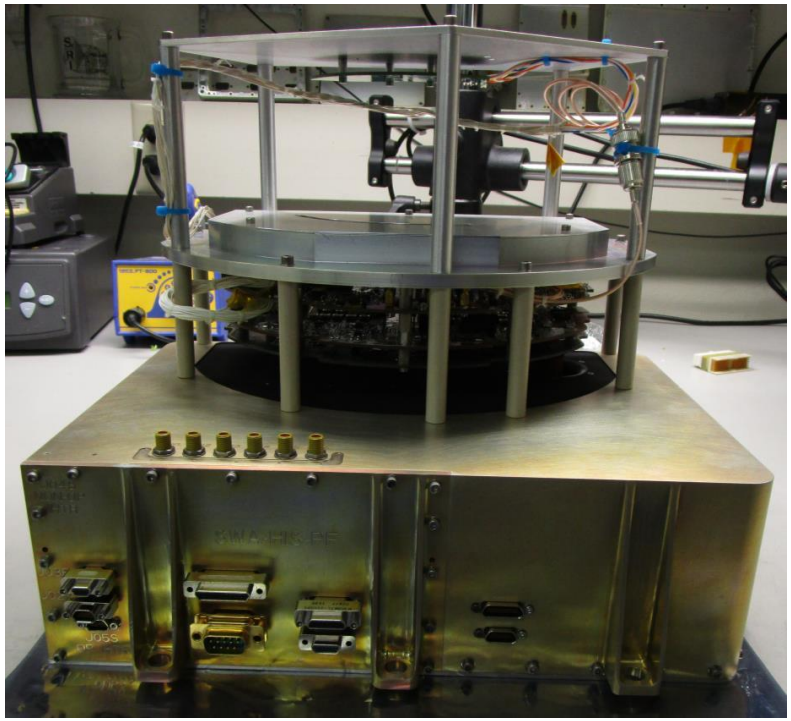
- **NASA/ESA set launch to October 2018**
- Heavy Ion Sensor:
  - Integration and Test Phase 1 Underway
  - Detector Section-Time Of Flight (DS-TOF) Integrated with Flight Model boards
    - First-Light Test conducted showing triple coincidence
- Solar Orbiter Heliospheric Imager (SoloHI):
  - Integration and Test Underway
  - Electrical Model Delivered and Integrated on ESA Solar Orbiter Electrical Test Bed (ETB)
    - *First SO Instrument to Successfully Send Data Through the ETB*

# Solar Orbiter Heavy Ion Sensor Integration & Test – Phase 1

Flight Model
Detector Section-Time Of Flight
(FM DS-TOF)

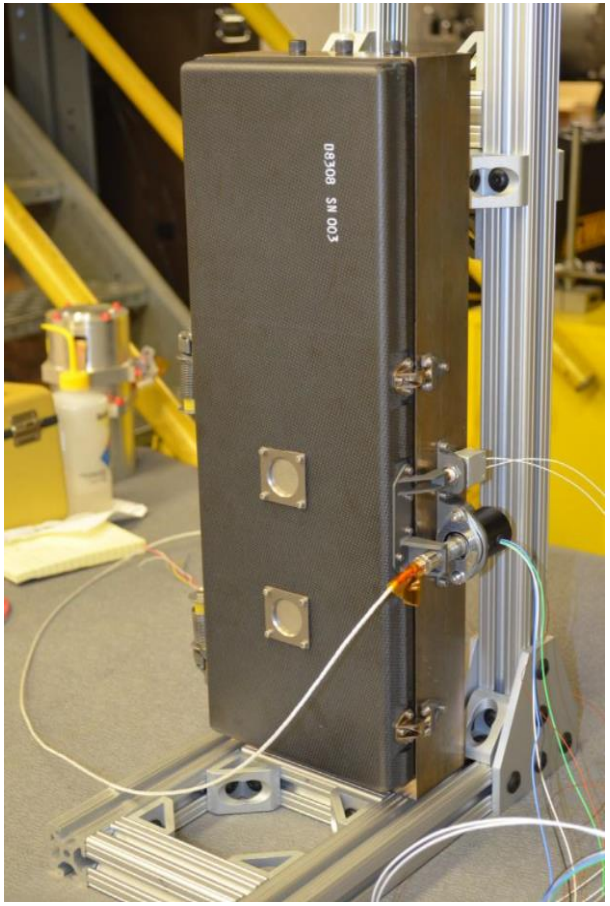
First-Light Test Conducted Showing Triple Coincidence

Flight Model
Main Electronic Board



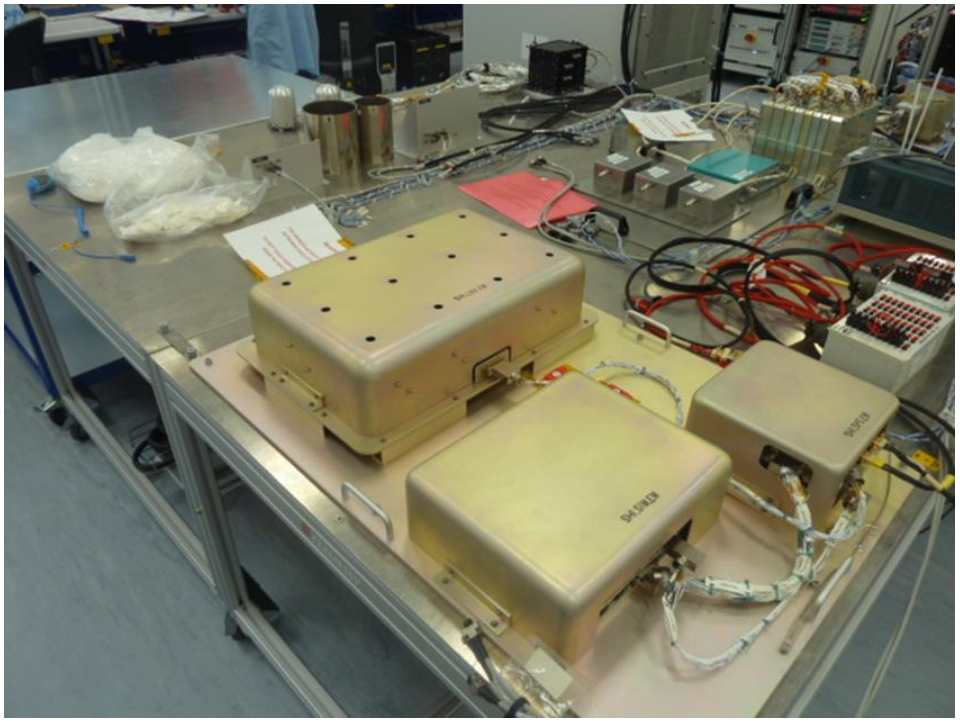
# Solar Orbiter Heliospheric Imager (SoloHI) Integration & Test

Door Mechanism



Flight Hardware
Acceptance Tested

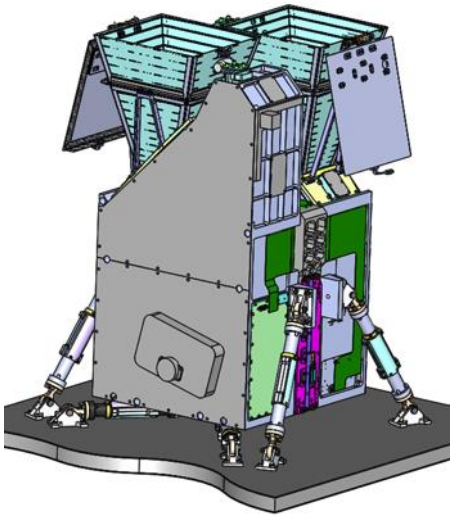
SoloHI Electrical Model (ELM)



Delivered and Tested
on
ESA Electrical Test Bed

# GOLD - Global Observations of the Limb And Disk

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



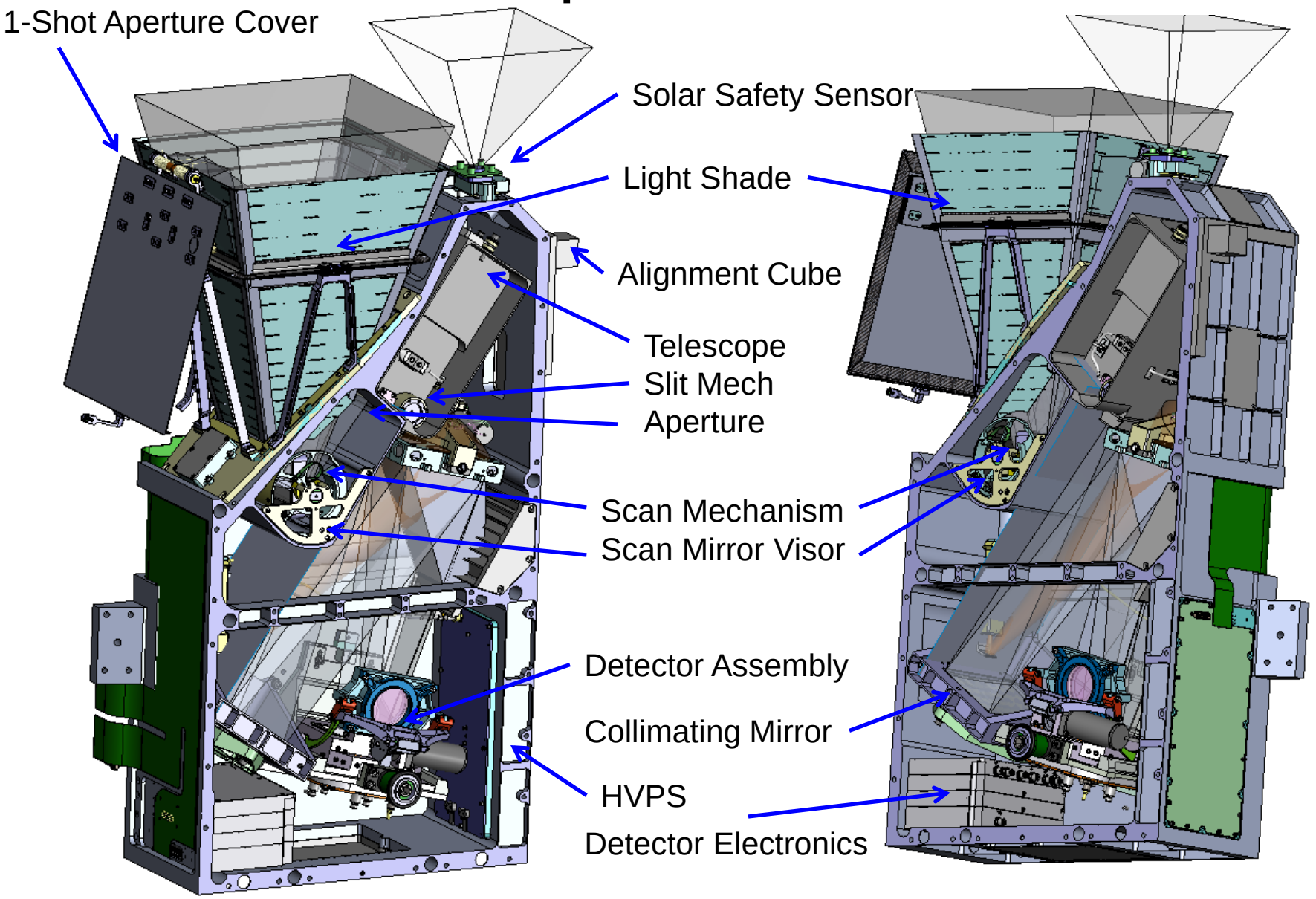
**Milestones:**

- 2011-2012 Phase A, culminating with the GOLD Concept Study Report
- GOLD Selected as a NASA MoO Mission MAY 2013
- **PDR – DEC 2014 – Successful**
- **KDP - C MAR 2015 – Confirmed**
- CDR - July 2015
- Pre-Environmental Review - MAR 2016
- Pre-Ship Review - SEP 2016
- Launch Readiness Date - APR 2018

**Recent Accomplishments:**

- **Preliminary Design Review – SRB characterized design maturity as close to CDR level.**
- **JAN 2015 AirBus selected as hosting spacecraft.** Accommodation contract with SES is in final negotiations.
- FEB 2015 SOC and SDC TIM to further define roles and coordination between LASP, CPI, UCF
- **KDP-C Confirmation Review – Highly Successful. No action items**.
- MAR 2015 - Successful manufacturing readiness review (MRR) for the detector electronics.
- MAR 2015 - Completed EM life testing: Grating Yaw Mechanism (GYM) Slit Mechanism
- MAR 24-25 - Kickoff Meeting and TIM held at AirBus for in Toulouse, France

# Instrument Layout Minimizes Mass and Provides a Simple S/C Interface




**Description:** ICON will explore the boundary between Earth and space to understand the physical connection between our world and our space environment. It is a Category 2, Risk Class C Mission Launch on a Pegasus XL launching from Kwaj in June 2017. The spacecraft will be placed in a LEO Orbit at 575 km with a 24° inclination. The spacecraft consist of four instruments, MIGHTI (NRL) – neutral wind measurements; IVM (UT Dallas) – in situ ion velocities; and FUV & EUV (UC Berkeley) – imaging UV spectrographs; $O/N_2$, $O^+$ ion density

**Milestones:**

- **KDP-C October, 2014 – Confirmed**
- Mission CDR, April 2015
- Spacecraft CDR, April 2015
- Mission Operation Engineering Peer Review, June 2015
- LRD June, 2017

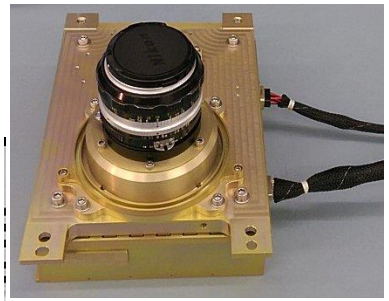
**Recent Accomplishments:**

**Instruments***:* **All instrument CDRs are complete** except the second portion of the MIGHTI instrument because of the inclement weather. The MIGHTI CDR completion is being scheduled.

**Spacecraft:** S-band antenna TVAC testing completed. The spacecraft thermal detailed design and analysis was completed.

The solar array and battery CDRs were completed

ICON
Ionospheric Connection Explorer

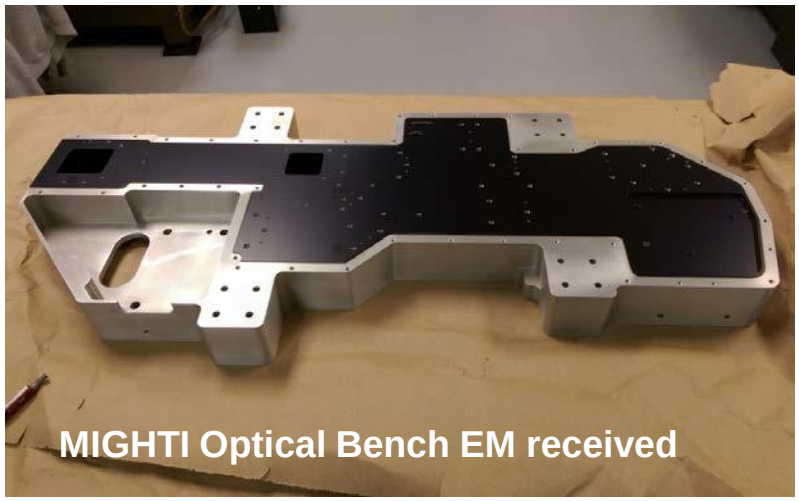


**FUV Camera is fully functional**

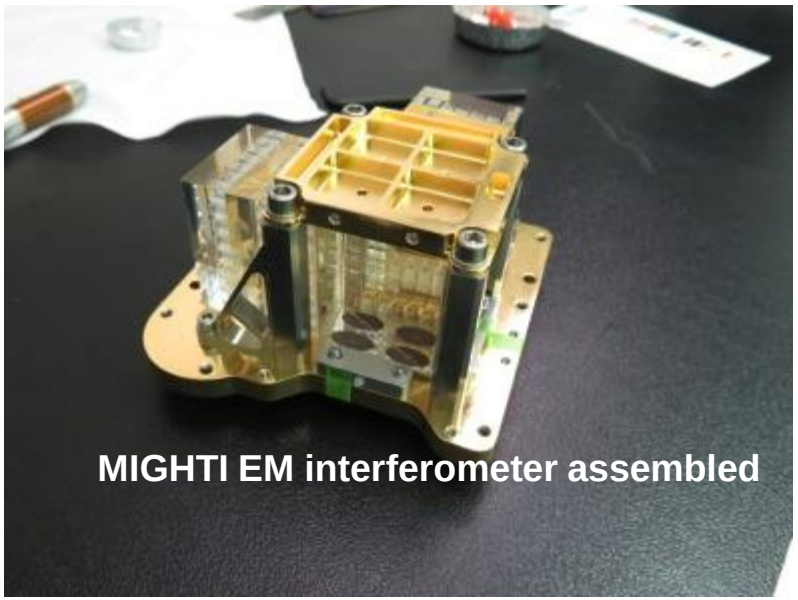
**Solar array panel fab commences**

EM ICP board assembly

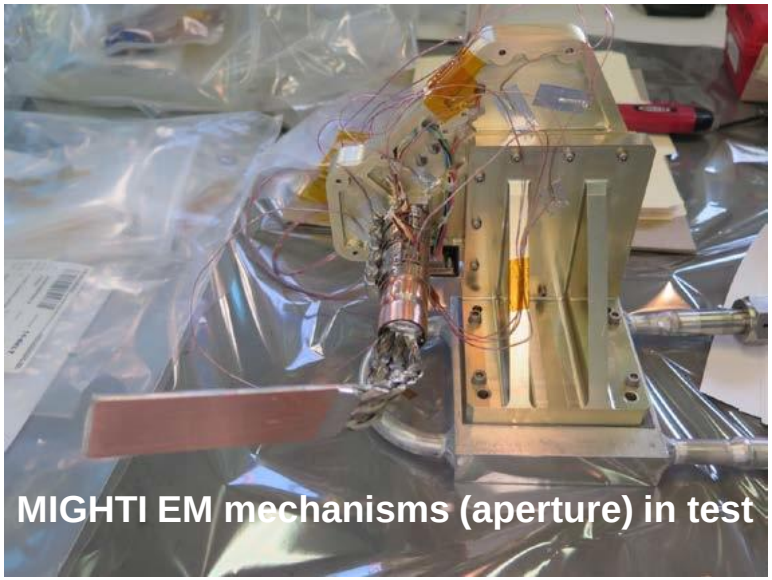
# ICON Significant Progress



MIGHTI Optical Bench EM received



MIGHTI EM interferometer assembled



MIGHTI EM mechanisms (aperture) in test

ICP simulator delivered to MIGHTI

# Heliophysics Science Missions in Formulation & Implementation – March 2015

| Project | Overall previous months | | | | This Month | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| | -4 | -3 | -2 | -1 | O | T | C | S | P | |
| **Implementation** | | | | | | | | | | |
| **EX-GOLD** Sept 2017 | Y | G | G | G | G | G | G | G | G | |
| **EX-ICON** Feb 2017 | G | G | G | G | G | G | G | G | G | EUV line Board coupon testing failure. EUV and FUV instruments Optics coating contamination. |
| | | | | | | | | | | |
| **LWS-SPP** July 2018 | G | G | G | G | G | Y | G | G | G | Technical: S/C magnetic fields on SWEAP Span A and B; Coupled loads analysis on FIELDS Whip antenna |
| **LWS-SOC** October 2018 | G | G | G | G | G | Y | G | G | G | HIS High-Voltage Opto-Diode (glass): passivation qualification underway. Overall Green: ABC - Oct 2018. |
| **LWS – SET** Mid 2016 | G | G | G | G | G | G | G | G | G | |
| **STP-MMS** Mar 2015 | G | G | G | G | G | G | G | G | G | Launched Mar 12! |

T: Technical, S: Schedule, P: Programmatic,
C: $ resources, O: overall

On plan, adequate Margin

Problems, working to resolve within planned Margin

Problems, not enough margin to recover

# Operating Mission Suite

| Mission | Launch | Phase | Extension to (*) | M-3 | M-2 | M-1 | Cur. M. | Remarks |
|---|---|---|---|---|---|---|---|---|
| Geotail | 7/24/92 | Extended | 12/31/2016 | | | | | |
| STEREO | 10/25/06 | Extended | 9/30/2016 | | | | | FRB report for B to be released 3/13. 3/24 is start of A blackout. |
| THEMIS+Artemis | 2/17/07 | Extended | 9/30/2016 | | | | | on 2/3, 2/9, 2/20 & 3/1 D BAU resets. 28 hrs lost. |
| AIM | 4/25/07 | Extended | 9/30/2016 | | | | | |
| Hinode | 9/23/06 | Extended | 9/30/2016 | | | | | |
| Cluster | 7/16/00 | Extended | *9/30/2015 (+)* | | | | | |
| ACE | 8/27/97 | Extended | 9/30/2016 | | | | | |
| RHESSI | 2/05/02 | Extended | 9/30/2016 | | | | | |
| SOHO | 12/02/95 | Extended | 9/30/2016 | | | | | |
| TIMED | 12/07/01 | Extended | 9/30/2016 | | | | | on 2/27 45 min lost due to APL 60ft issues. |
| Voyager 1 + 2 | 8/20/77 | Extended | 9/30/2016 | | | | | |
| TWINS A + B | 6/06 & 3/08 | Extended | 9/30/2016 | | | | | |
| CINDI:C/NOFS | 4/16/08 | Extended | 9/30/2016 | | | | | |
| IBEX | 10/19/08 | Extended | 9/30/2016 | | | | | |
| Wind | 11/01/94 | Extended | 9/30/2016 | | | | | |
| SDO | 2/11/10 | Prime | 2/11/15 | | | | | on 2/23 20 min lost due to HGA mismatch: RCC |
| Van Allen | 8/30/12 | Prime | 11/30/14 | | | | | |
| IRIS | 6/27/2013 | Prime | 7/26/2015 | | | | | |

Mission proceeding to meet science requirements

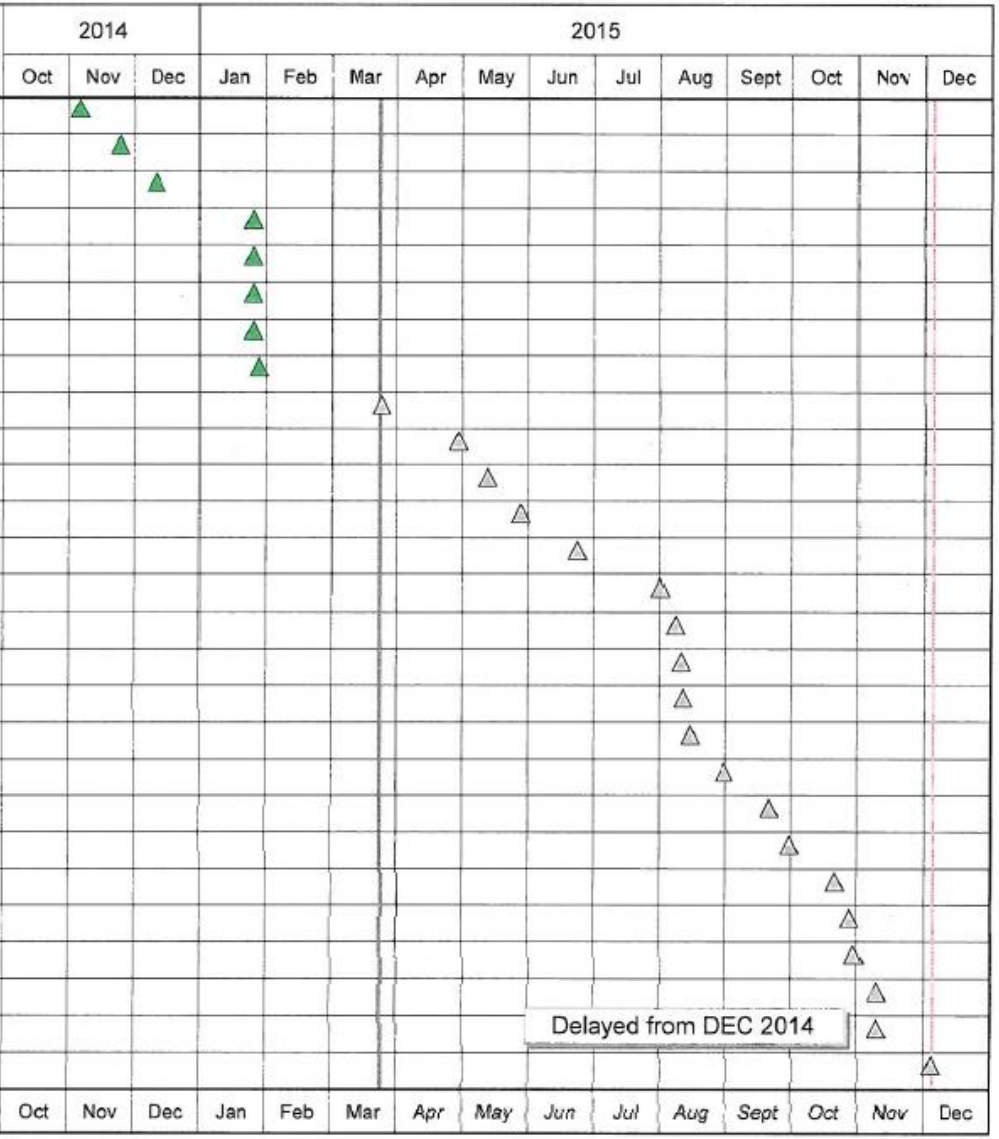
Area of concern - possible reduction in capability

Significant problem - possible or probable loss of mission

# Sounding Rocket Launches for FY 2015

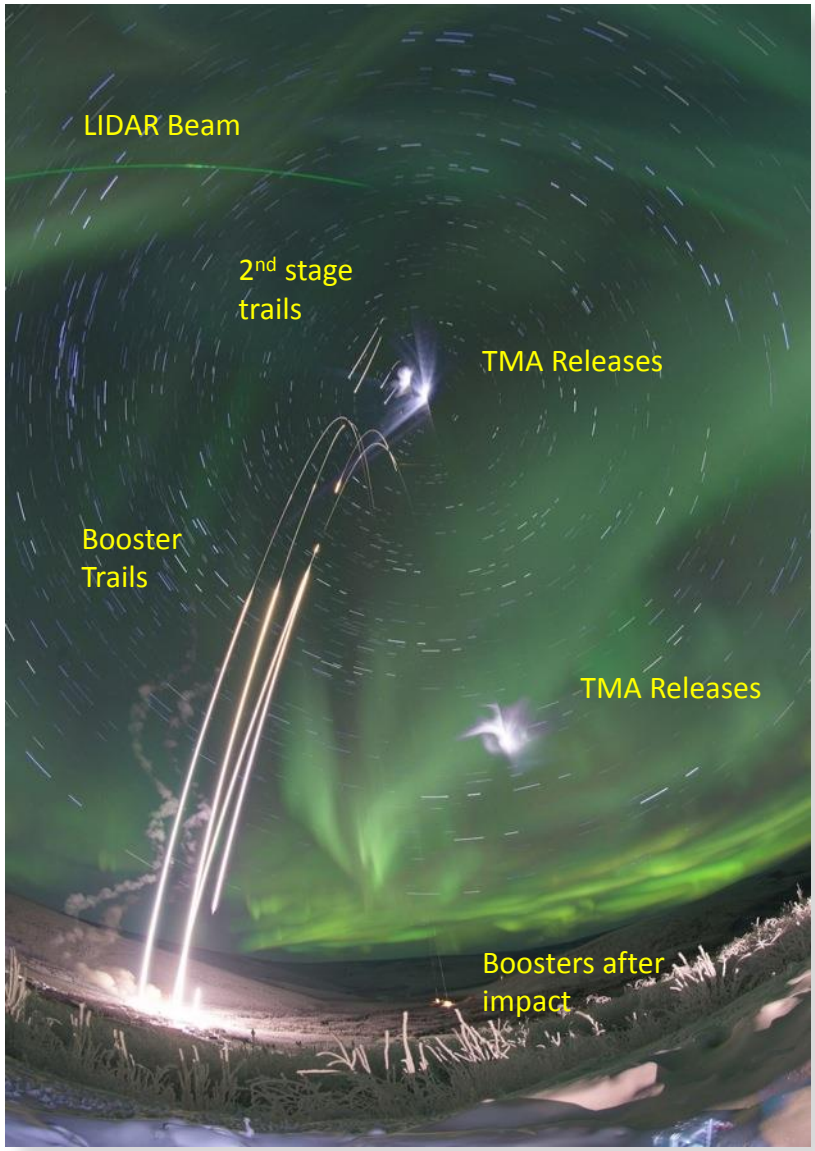


| | PI Name | PROJECT | SITE | Start Date | Finish Date |
|---|---|---|---|---|---|
| 1 | HASSLER | RAISE | WS | 11/6/14 | 11/6/14 |
| 2 | CONDE | C REX | NO | 11/24/14 | 11/24/14 |
| 3 | KRUCKER | FOXSI | WS | 12/11/14 | 12/11/14 |
| 4 | COLLINS | MTEX | FB | 1/26/15 | 1/26/15 |
| 5 | COLLINS | MTEX | FB | 1/26/15 | 1/26/15 |
| 6 | LARSEN | MIST | FB | 1/26/15 | 1/26/15 |
| 7 | LARSEN | MIST | FB | 1/26/15 | 1/26/15 |
| 8 | SWENSON | ASSP | FB | 1/28/15 | 1/28/15 |
| 9 | KOEHLER | ROCKSAT-X | WI | 3/25/15 | 3/25/15 |
| 10 | MCENTAFFER | OGRESS | WS | 4/29/15 | 4/29/15 |
| 11 | WOODS | EVE | WS | 5/13/15 | 5/13/15 |
| 12 | MILLINER | 0 | WI | 5/28/15 | 5/29/15 |
| 13 | KOEHLER | ROCKSAT-ON | WI | 6/23/15 | 6/23/15 |
| 14 | WINEBARGER | CLASP | WS | 7/31/15 | 8/3/15 |
| 15 | KOEHLER | ROCKSAT-X | WI | 8/7/15 | 8/10/15 |
| 16 | KANKELBORG | MOSES #2 | WS | 8/10/15 | 8/10/15 |
| 17 | MILLINER | MUSIC | WI | 8/11/15 | 8/11/15 |
| 18 | HASSLER | RAISE | WS | 8/14/15 | 8/17/15 |
| 19 | HESH | 0 | WI | 8/31/15 | 8/31/15 |
| 20 | FRANCE | CHESS-2 | WS | 9/21/15 | 9/21/15 |
| 21 | MCCANDLISS | FORTIS | WS | 9/30/15 | 9/30/15 |
| 22 | CHAKRABARTI | PICTURE | WS | 10/21/15 | 10/21/15 |
| 23 | MOSES | HERSCHEL | WS | 10/28/15 | 10/28/15 |
| 24 | FIGUEROA | MICRO-X | WS | 10/30/15 | 11/2/15 |
| 25 | LESSARD | RENU 2 | NOR | 11/9/15 | 11/9/15 |
| 26 | LABELLE | CAPER | NOR | 11/9/15 | 11/9/15 |
| 27 | GALEAZZI | DXL-2 | WS | 12/4/15 | 12/4/15 |



# 4 Rocket Salvo Mission Results

- Launch sequence of events
  - After 12 nights of counting the necessary combination science and weather conditions finally occurred and all four rockets were launched as planned
  - One each Collins and Larsen rockets were launched one minute apart
  - Approximately 33 minutes later the second pair of rockets launched one minute apart
- Mission Results
  - Success
  - All four rockets flew well with no anomalies
  - All four payloads (support systems & experiments) functioned as planned releasing visible TMA trails and collecting scientific data from the onboard instrumentation



# ROSES Elements

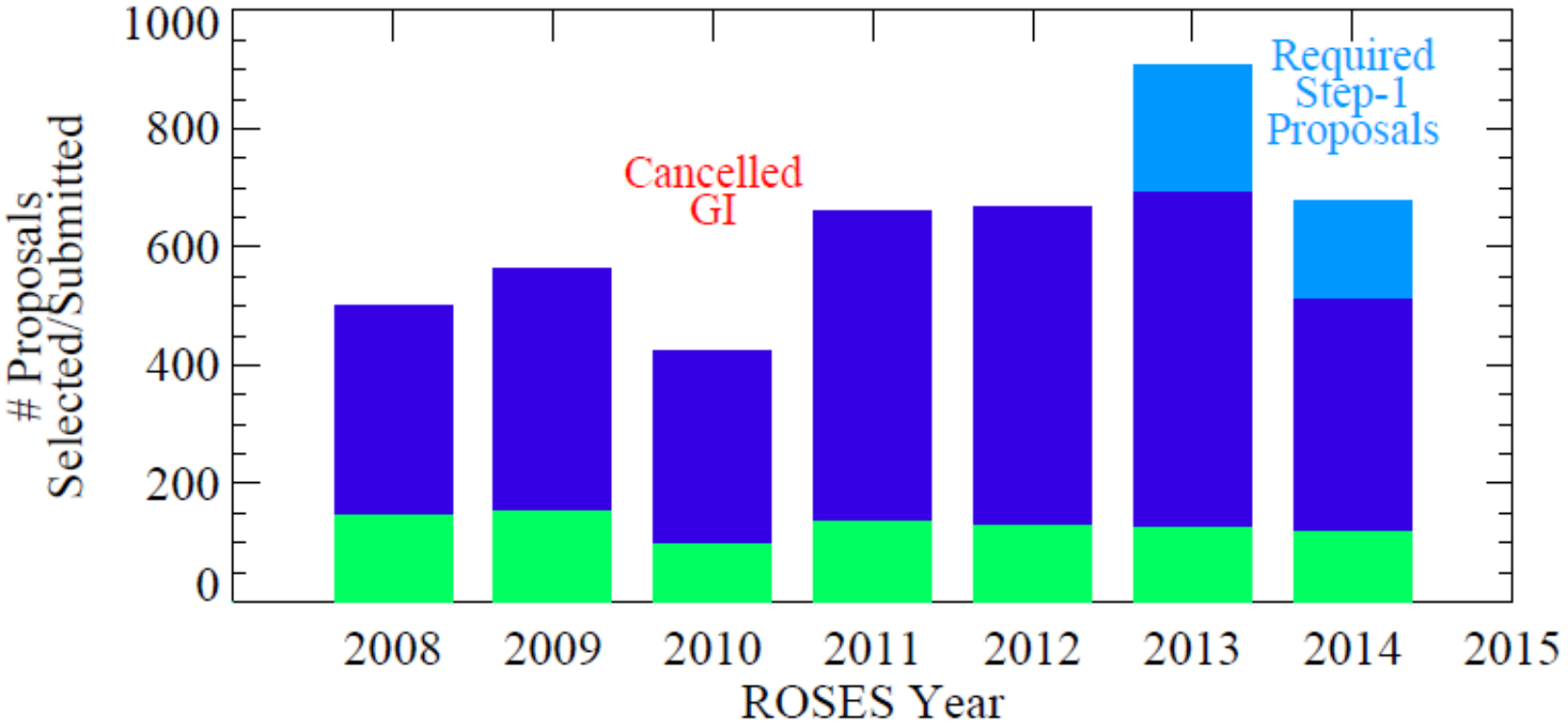
HPD engaged its Advisory groups on the Heliophysics Guest Investigator (H-GI) and Supporting Research (H-SR) programs and the underlying rationale for their potential merger into a single annual open competition for the 2015 ROSES announcement.

- Heliophysics Subcommittee – Recommended against merger
- HPD accepted recommendation and re-wrote ROSES elements to better differentiate the two programs.
- H-GI: The H-GI Open program is for investigations whose primary emphasis is the analysis of data from currently operating missions of the Heliophysics System Observatory (HSO). It provides support for analysis of observations from both extended missions and from missions in their prime phase (Phase E).
- H-SR: Heliophysics SR awards are focused individual research investigations that employ a variety of techniques, including theory, numerical simulation, modeling, analysis, and interpretation of space data. The investigations that will be of highest priority to the program will be those that a) use data from current or historical NASA spacecraft b) together, with theory and/or numerical simulation to address, c)one of the Four Heliophysics Decadal Survey goals.

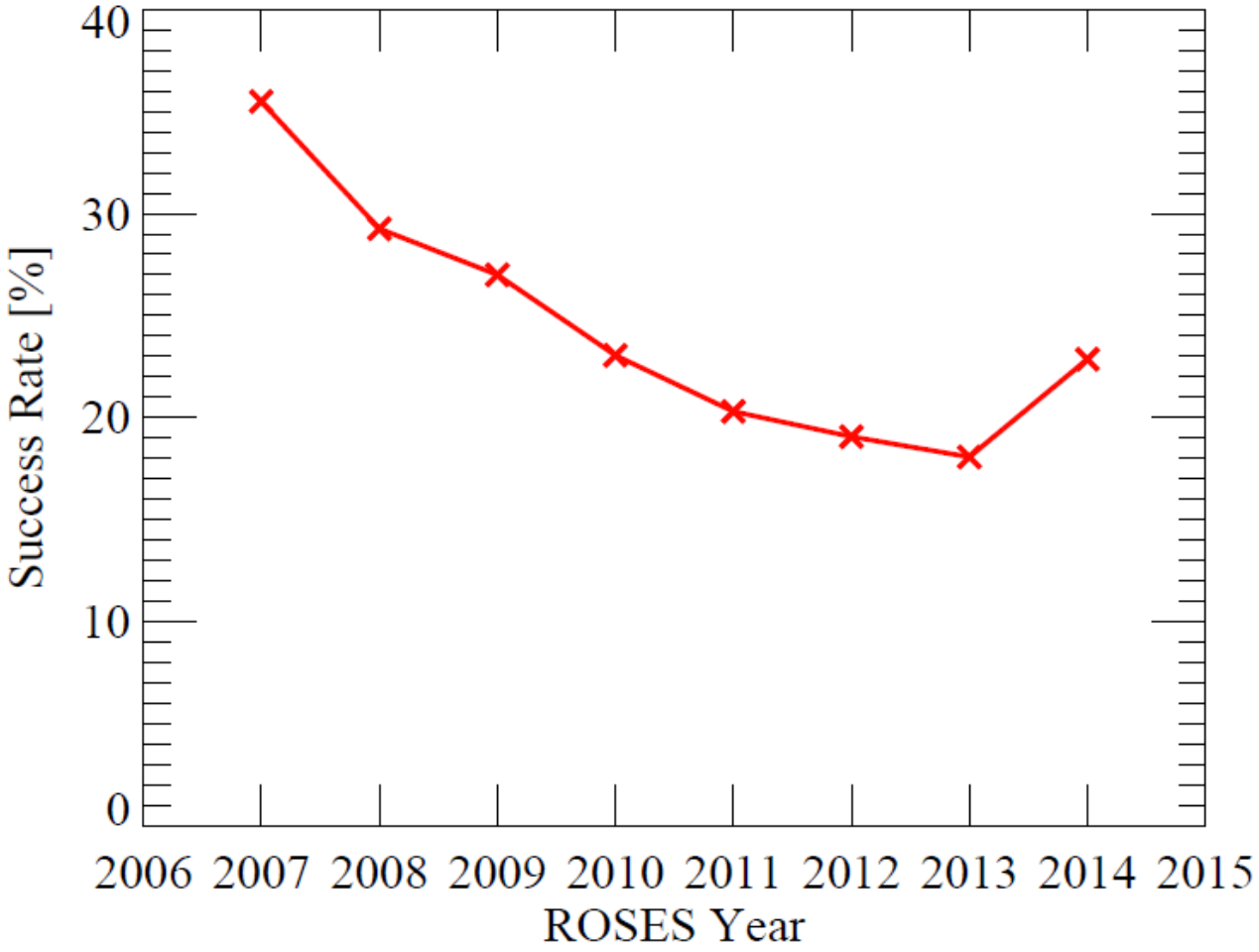
# Research Program Current Issues

- We continue to receive high numbers of proposals to review. Constraints on success rate, proposing/reviewing work loads. Impact on notification dates. ~$5M increase in FY16 helped improve success rate slightly.
- Question of combining H-SR and H-Guest Investigator (H-GI) discussed with Management and Operations Working Groups and the HPS. Programs were not combined in ROSES15.
- H-GI15 resulted in 200+ step-1 proposals, an increase of ~70% over ROSES14.
- President's budget shows DS DRIVE Initiative wedge slowly growing. Expect low success rate.

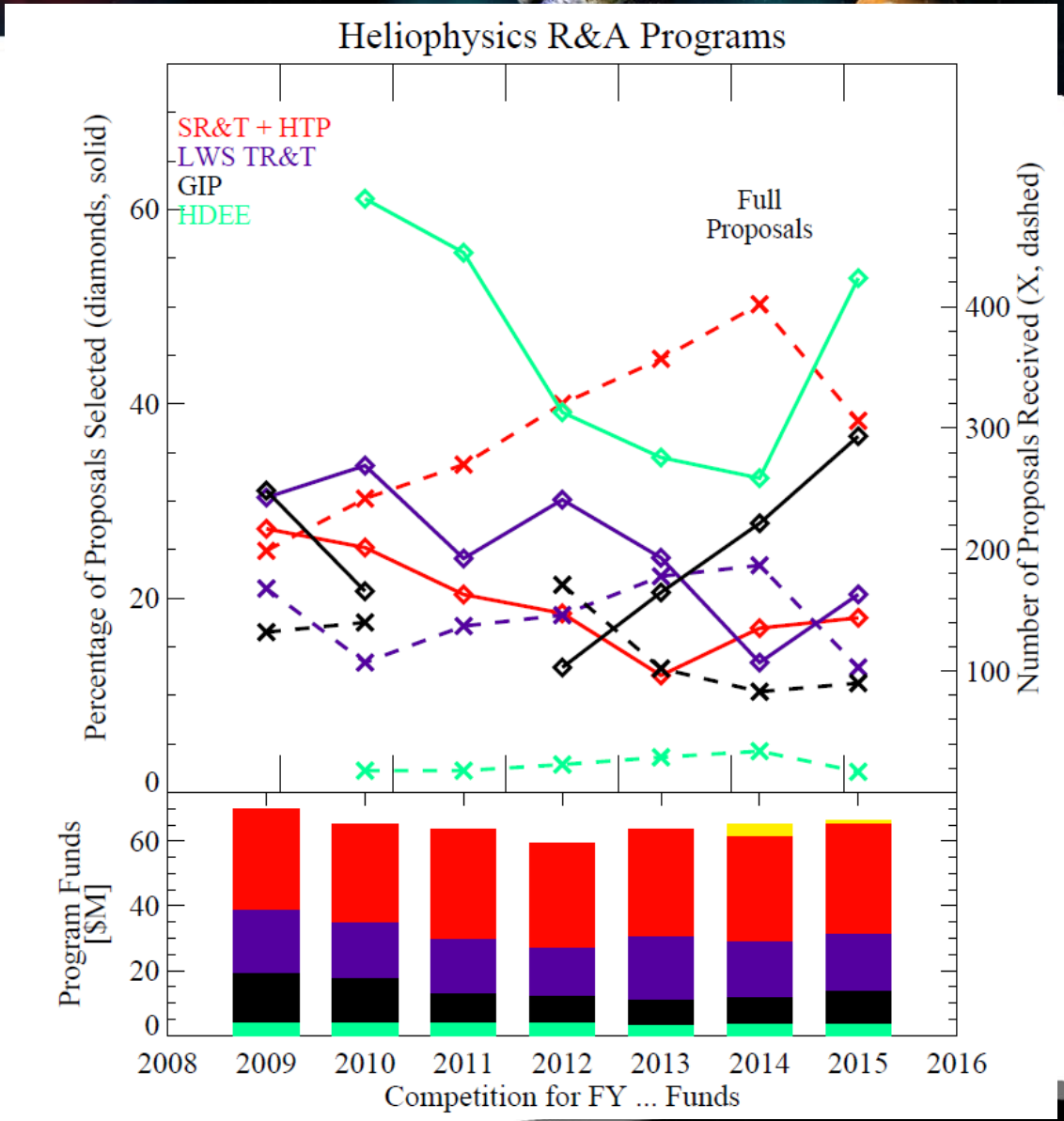
# Proposal Submission Stats



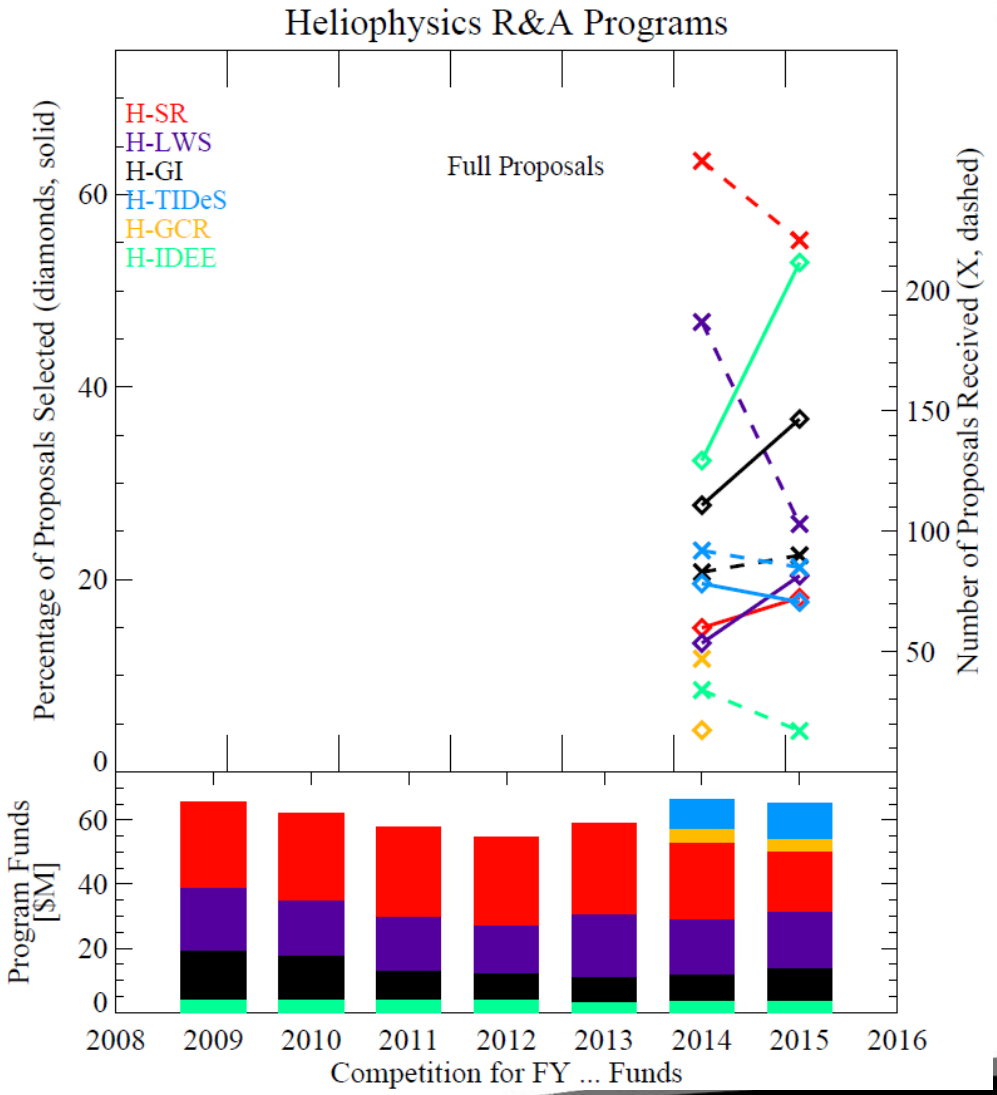
# Updated Success Rates



# Old ROSES Program Stats



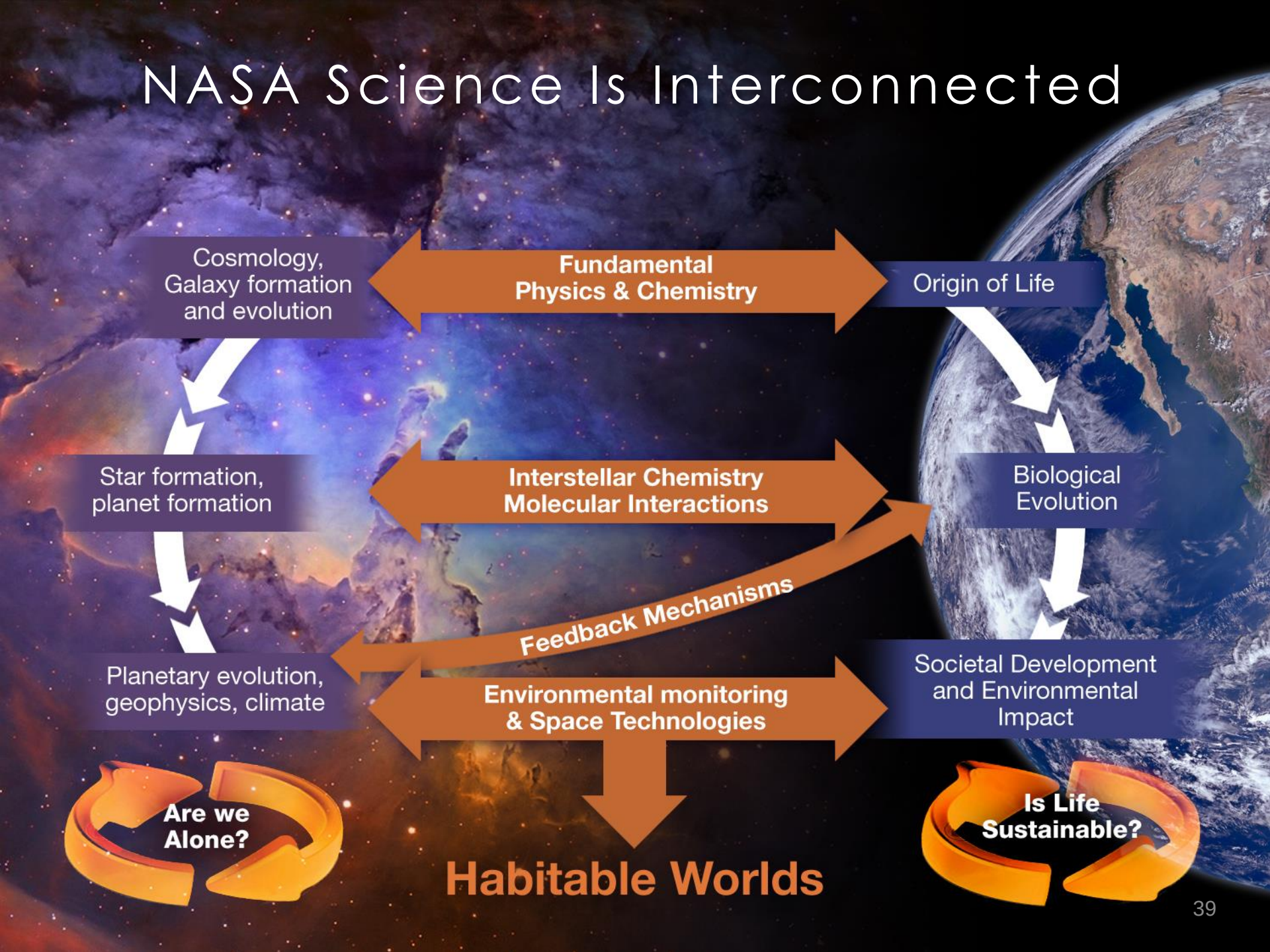
# Restructured Program Stats



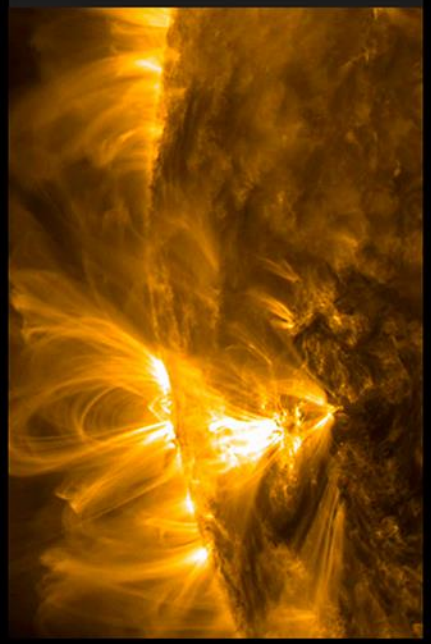

# Science @ NASA executes:

- 97 missions
- 124 spacecraft
- 8 Balloon launches (FY 2014)
- 12 Sounding rockets (FY 2014)
- 4,600 Airborne hours (FY 2014)

# NASA Science Is Interconnected

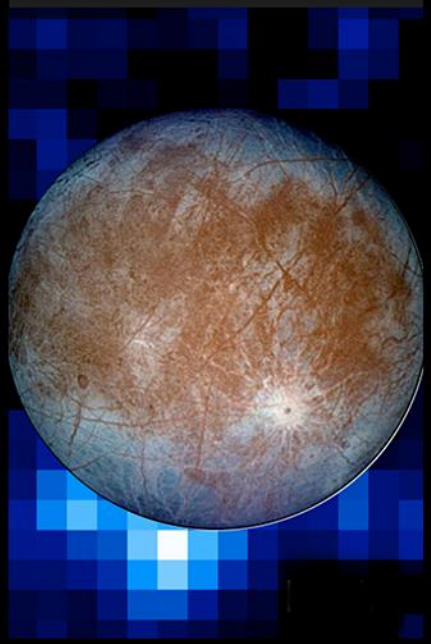


# Science Mission Directorate



HELIOPHYSICS

EARTH SCIENCE



PLANETARY SCIENCE

ASTROPHYSICS

An Integrated Program of Science

# SMD FY 2016 Program/Budget Strategy

- Provide the most productive Earth & space science program for the available resources
  - Guided by national priorities
  - Informed by NRC Decadal Surveys recommendations
  - Incorporating new ideas and partnerships
  - Increase cross-directorate collaboration on strategic projects (ISS, Mars 2020, NEOs…)
- Responsibly manage the national investment in robotic space missions
  - Confirm new missions only after sufficient technology maturation, and budget at an appropriate confidence level
  - Take aggressive steps with missions that do not stay within budget
  - Proactively manage JWST to the cost and schedule baseline
- Increase cadence of competed PI-led flight missions

# SMD FY16 Program Highlights

- Support Mars 2020 mission and formulation of a potential Europa mission
- Pre-formulation of WFIRST/AFTA
- Provide for a sustained land imaging capability beyond Landsat 8
- Increase efforts to detect and study NEOs
- Increase collaboration with NASA's Space Technology Mission Directorate
- Implement the revised and competed STEM education program to ensure that the most meritorious activities within SMD are supported

# SMD Recent Cost Performance

*NASA Science is providing reliable cost estimates for its missions, contributing to program stability*

| | Original Baseline | Current/ Actual | Actual vs. Original | |
|---|---|---|---|---|
| Juno | 742.0 | 708.8 | -4% | |
| GRAIL | 427.0 | 398.0 | -7% | |
| Suomi NPP | 593.0 | 765.2 | 29% | |
| Curiosity | 1069.0 | 1769.0 | 65% | |
| NuSTAR | 110.0 | 116.0 | 5% | |
| Van Allen | 534.0 | 504.0 | -6% | |
| Landsat 8 | 583.4 | 502.8 | -14% | |
| IRIS | 141.0 | 143.0 | 1% | |
| LADEE | 168.0 | 191.4 | 14% | |
| MAVEN | 567.0 | 472.0 | -17% | |
| GPM | 555.0 | 484.3 | -13% | |
| OCO-2 | 249.0 | 320.3 | 29% | |
| SMAP | 485.7 | 479.0 | -1% | final costs TBD after launch |
| MMS | 857.3 | 884.5 | 3% | final costs TBD after launch |
| | 7081.4 | 7738.4 | 9% | |

The total cost to develop 14 Science missions launched (or nearly launched) in the last 3.5 years exceeds the sum of our *original* estimates by 9%. Excluding Curiosity from that list, the figure becomes -1% (a slight underrun in total).

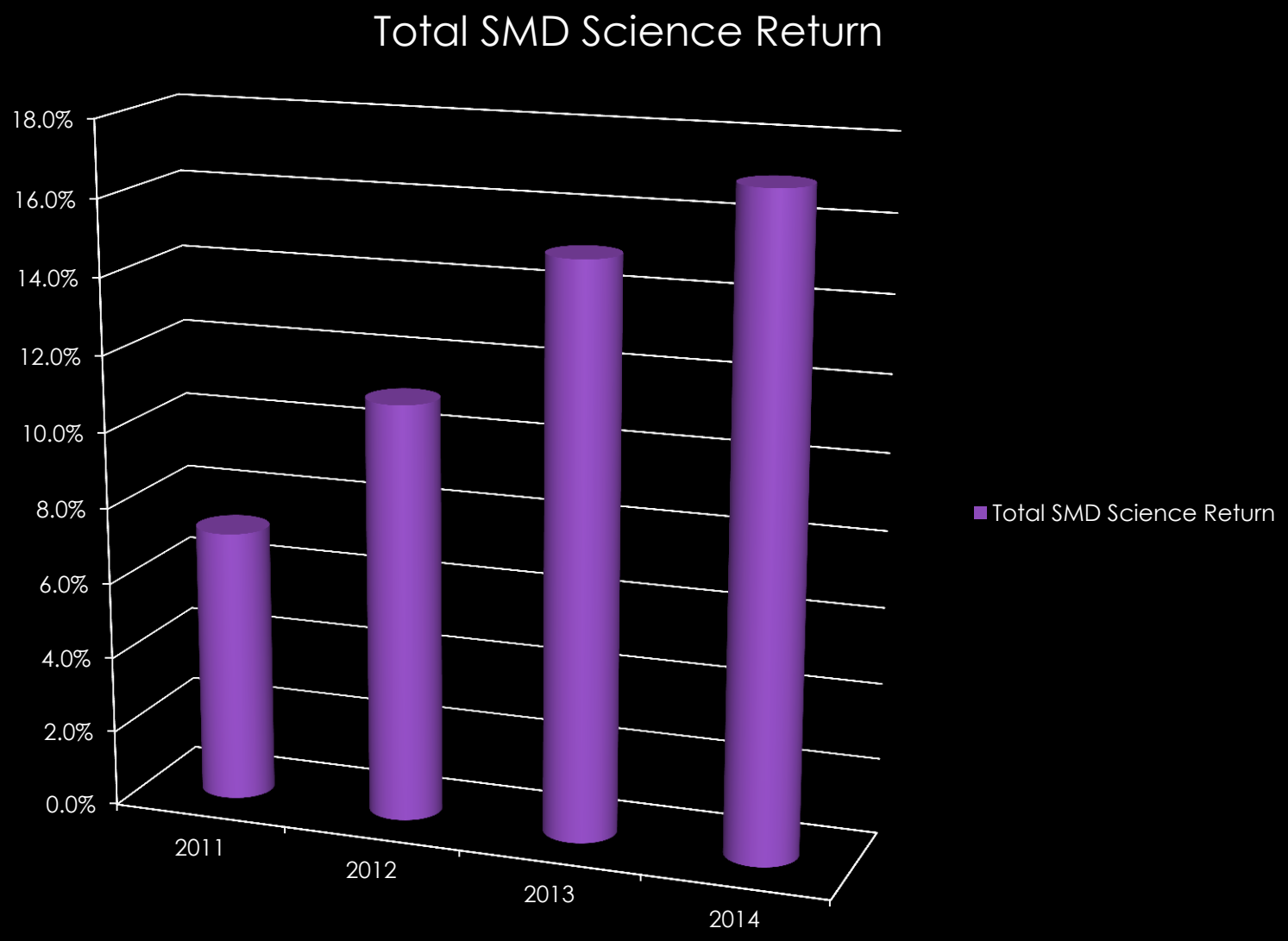

SMD Science Education

# SMD Science Education Restructuring

- Restructuring program to enable NASA scientists and engineers to engage more effectively with learners of all ages. We are taking a strategic approach, building on our science-disciplined based legacy, and looking for new approaches given stakeholder priorities.

- Objectives:
  - Enable STEM Education
  - Improve US Scientific Literacy
  - Advance National Educational Goals
  - Leverage Through Partnerships
- The competitive selection of organizations that utilize NASA data, products, or processes will meet education objectives that will enable our scientists and engineers, with education professionals, tools, and processes, to better meet user needs.
  - Solicitation released February 4, 2015
  - Award(s) by end of FY 2015

# SMD Science as a Percentage of Worldwide Science




Source: Greg Davidson's *Science News* Metric (2011–2014)

# Where is the Heliophysics Division Going?

**NASA's SMD Heliophysics Division Mission Statement (Why we exist… Not our Agency Objective):**

Vision: Committed to creating a world in which our technological society benefits from understanding the sun, the space environment, and our place in the galaxy

Mission Statement: Empower the community to advance our understanding of Heliophysics and reap the benefits through science missions and enabling technology and research

- **Approach to implementing Decadal Survey recommendations**
  - Heliophysics Roadmap defines our detailed implementation plan for the Decadal Survey, including technology development requirements
  - Perform on our commitments to complete the current program on time and on budget
    - President's FY16 budget supports Solar Probe Plus launch in 2018
  - Strengthen our Research and Analysis, MO&DA, and Technology Programs
    - Work towards rebalancing research program (DRIVE) as recommended by the Decadal Survey
  - Plan for more frequent, lower cost missions: Expand Explorers and Missions of Opportunity
    - CubeSat line started in FY14, next Heliophysics Explorer A/O likely in FY2016, STP in FY2017
  - Commence development of the highest priority Strategic Program (STP, LWS) science targets, consistent with the budget and with Research and Explorer priorities
- **Continue to build our understanding of heliophysics (the sun and its interaction with the Earth and the solar system, including space weather)**

# Backup