National Aeronautics and Space Administration

NASA LWS Program Metrics Needs
International CCMC-LWS Working Meeting

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NASA SMD Motivation

Fundamental Understanding

- Heliophysics provides the underlying science required to enable space weather forecasting

Heliophysics role in Space Weather

- Roughly one third of Heliophysics addresses Space Weather science
  - Living With a Star Program (SDO, Van Allen (RBSP) and TR&T)
  - STEREO (STP Program), SOHO, ACE
  - CCMC
- Heliophysics formulates and implements a national research program for understanding the Sun and its interactions with the Earth and the Solar System.
- Currently, data from Heliophysics science missions are vital to the nation’s Space Weather infrastructure

Why do Science?

For Utility

		No	Yes
For Understanding	**Yes**	**Bohr**	**Pasteur**
	No		**Edison**

From Donald Stokes (Woodrow Wilson School for Public and International Affairs, Princeton University)

The Sun-Earth Connection -- Science in the Pasteur Mode

- *How a star works*
- *How it affects humanity's home*
- *How to live with a star*

Living With A Star (LWS)

- Emphasizes the science necessary to understand those aspects of the Sun and the Earth's space environment that affect life and society.
- Ultimate goal is to provide a predictive understanding of the system, and specifically of the space weather conditions at Earth and in the interplanetary medium.
- LWS program includes coordinated ***strategic missions, targeted research and technology development***, a space environment test bed flight opportunity, and partnerships with other agencies and nations.
- LWS missions are formulated to answer specific science questions needed to understand the linkages among the interconnected systems that impact us.
- LWS products impact technology associated with space systems, communications and navigation, and ground systems such as power grids.

Living With a Star Target Research and Technology

The Targeted Research and Technology (TR&T) component of LWS provides the theory, modeling, and data analysis necessary to enable an integrated, system-wide picture of Sun-Earth connection science with societal relevance.

Focus Science Topics coordinate large-scale investigations that cross discipline and technique boundaries leading to an understanding of the system linking the Sun to the Earth and Solar System.

Strategic Capabilities develop one or more deliverables that address a significant and specific need for achieving the LWS and NSWP goals; incorporating the latest scientific results from LWS Focus Science Teams as well as other research.

LWS Institutes are designed to facilitate a bridge between cutting-edge heliophysics research and a societally relevant technology area that is affected by space weather. Working groups will define and scope new research that will make a critical difference to this technology.

Targeted but not necessarily applied!

NASA-NSF Partnership for Collaborative Space Weather Modeling

LWS Heliophysics Science Mid-term Review & Technical Interchange Meeting 2016

A Modular Capability for Community Modeling of Flares, CMEs and their Interplanetary Impacts (Spiro Antiochos)

Corona-Solar Wind Energetic Particle Acceleration (Nathan Schwadron)

Coronal Global Evolutionary Models (George Fisher)

Medium Range Thermosphere Ionosphere Storm Forecasts (Anthony Mannucci)

A First-Principles-Based Data Assimilation System for the Global Ionosphere-Thermosphere-Electrodynamics (Robert Schunk)

MHD and Kinetic Effects in Magnetosphere Models (Amitava Bhattacharjee)

Magnetic Flux Emergence and Transport (Nagi N. Mansour)

Integrated Real-Time Modeling System for Heliospheric Space Weather Forecasting (Dusan Odstrcil)

Living With a Star Institutes

2015: Principles in relation to the effects of geomagnetically induced currents (GICs) during CME-driven geomagnetic disturbances (GMDs)

2016: Now-casts of atmospheric drag for LEO spacecraft

2017: Now-casts of radiation storms (proton events) at energy levels that could create a radiation hazard for aircrew and passengers

Goal 1: Establish Benchmarks for Space-Weather Events (5 topic areas)

Benchmarking will happen for:

1. Induced geo-electric fields
2. Ionizing radiation
3. Ionospheric disturbances
4. Solar radio bursts
5. Upper atmospheric expansion

Timeline:

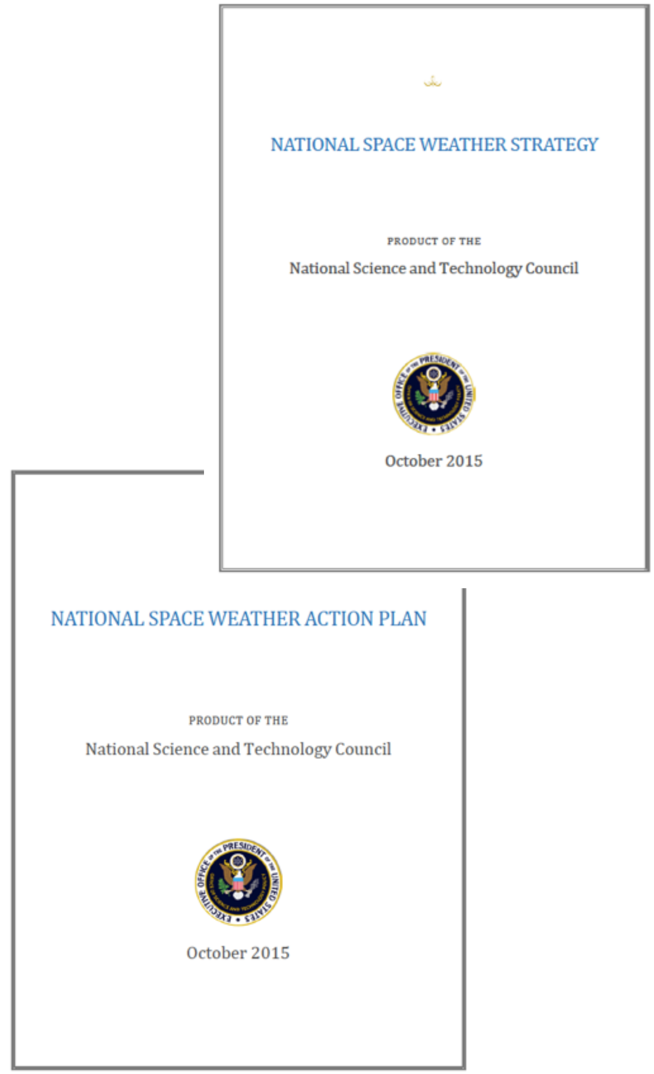
Phase 1 benchmarks: 180 days (April 2016)

Complete Assessment report of gaps: 1 yr (November 2016)

Phase 2 updated benchmarks: 2 yr (November 2017)

Integrated Approach to Forecasting and Mitigation

- Action 5.6 - Improve Effectiveness and Timeliness of the Process that Transitions Research to Operations
  - 5.6.1 – Develop a formal process to enhance coordination between research modeling centers and operational forecast centers (R2O)
  - 5.6.2 – Develop a plan that will ensure the improvement, testing, and maintenance of operational forecasting models leveraging existing capabilities in academia and the private sector and enable feedback from operations to research to improve operational space-weather forecasting (O2R)
- NASA, NSF, NOAA, DOD developed a coordinated briefing on R2O and O2R concepts and presented it to OMB and OSTP.


NATIONAL SPACE WEATHER STRATEGY

PRODUCT OF THE

National Science and Technology Council

October 2015

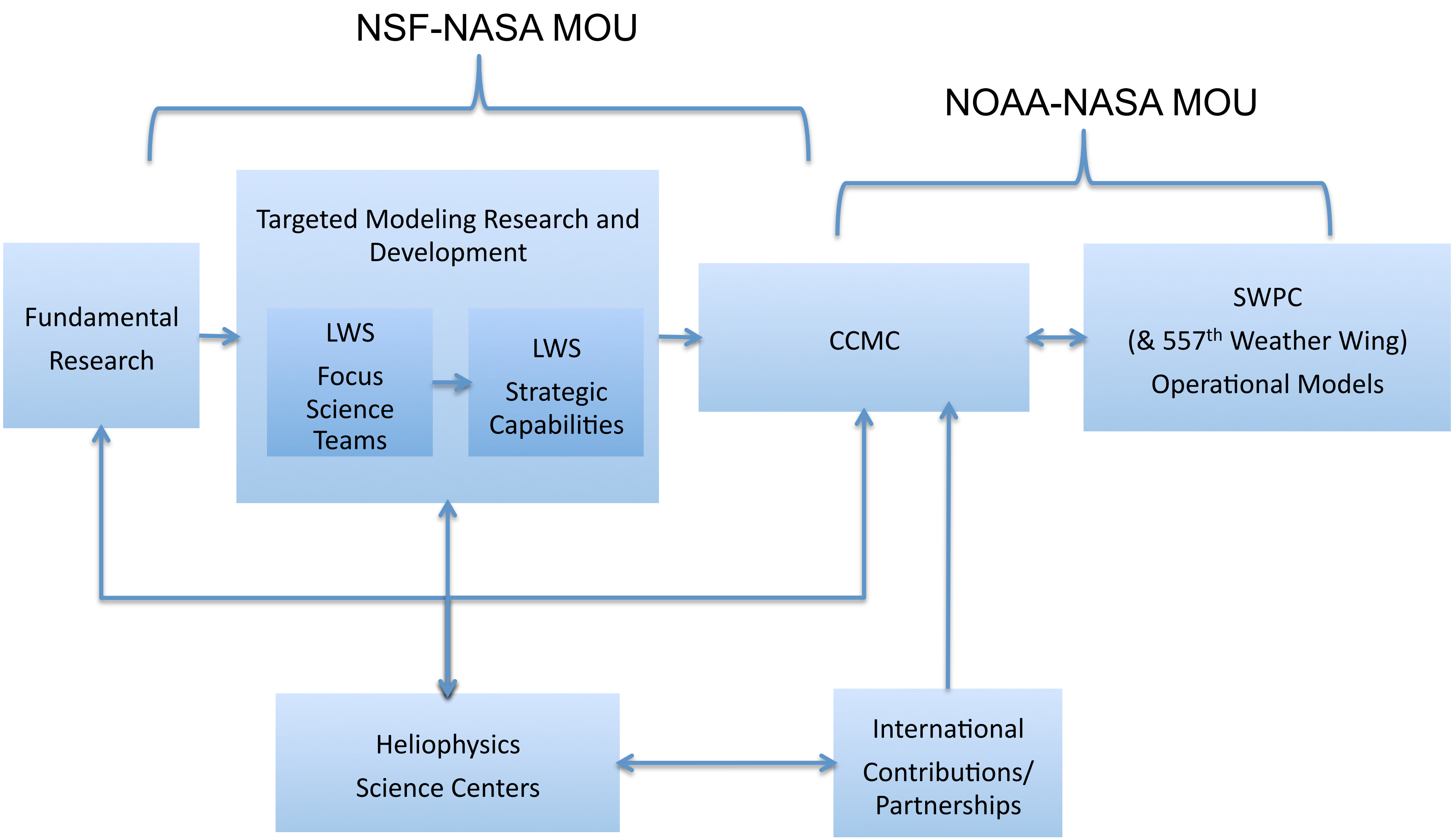
NATIONAL SPACE WEATHER ACTION PLAN

PRODUCT OF THE

National Science and Technology Council

October 2015

Future Modeling R2O Concept of Operations



Living With a Star and DRIVE

National Space Weather Action Plan charged US agencies to improve effectiveness and timeliness of the process that Transitions Research to Operations

Core LWS Science activities informed by SWAP benchmark priorities:

ROSES – 2016 LWS FST

- Advances Toward a Near Real Time Description of the Solar Atmosphere and Inner Heliosphere
- Characterization of the Earth's Radiation Environment
- Studies of the Global Electrodynamics of Ionospheric Disturbances

ROSES – 2017 LWS FST

- Understanding The Onset of Major Solar Eruptions
- Toward a Systems Approach to Energetic Particle Acceleration and Transport on the Sun and in the Heliosphere
- Ion Circulation and Effects on the Magnetosphere and Magnetosphere - Ionosphere Coupling
- Understanding Physical Processes in the Magnetosphere--Ionosphere / Thermosphere / Mesosphere System During Extreme Events.

In addition:

NSF-NASA Collaboration - Physics-based Model of Solar Activity and Space Weather with Quantified Uncertainties

Space Weather-focused Heliophysics Science Centers

Seeking to enable Space Weather-oriented opportunities:

R2O & O2R tools; SBIR's; Space Weather-oriented technology development

LWS 10-Year Vision Beyond 2015: Strategic Science Areas (SSA)

- **SSA-0, Physics-based forecating of solar electromagnetic, energetic particle and plasma outputs**
- **SSA-1, Physics-based Geomagnetic Forecasting Capability**
- **SSA-2, Physics-based Satellite Drag Forecasting Capability**
- **SSA-3, Physics-based Solar Energetic Particle Forecasting Capability**
- **SSA-4, Physics-based TEC Forecasting Capability**
- **SSA-5, Physics-based Scintillation Forecasting Capability**
- **SSA-6, Physics-based Radiation Environment Forecasting Capability**

NOAA's Needs for Space Weather Research

- Forecasts of solar flares (timing and magnitude)
- Forecasts of Solar Energetic Particle (SEP) events and radiation storms at Earth
- Specification and forecasts of the radiation levels at LEO and aircraft altitudes
- Forecasts of Bz (z component of the magnetic field) with a CME when it arrives at Earth
- Spatially resolved forecasts of geomagnetic storm impacts
- Forecasts of the location and intensity of the Aurora
- Forecasts of ionospheric scintillations and TEC gradients

R2O, O2R and LWS

New procedure for development of annual TR&T science topics to increase community involvement

NOAA and NSF contribute to the long-term science direction and annual goals and priorities via the steering committee; will be adding DoD representation

Metrics – "Mechanisms for monitoring how well products that result from the program are transferred into societal benefits."

Feedback from LWS institutes

Alignment with National Space Weather Action Plan

Coordination and integration with potential O2R capability/facility

- Science questions and priorities that are borne out of or as a result of O2R activities

BACKUP

Metrics

- What to measure?
- What are the defined steps/paths in development?
- What are the
- What are the

Upcoming LWS missions

SPP - Solar Probe Plus

Integration and testing ongoing at APL

- Spacecraft Bus Mass Properties completed
- Flight Radiators installed on Truss Structure Assembly

Pre-Environmental Reviews held for EPI-Lo, SWEAP SPANs and SWEM, and FIELDS sensor; Testing underway

SOC - Solar Orbiter Collaboration

- Heavy Ion Sensor (HIS) and Solar Orbiter Heliospheric Imager (SoloHI) instruments successfully completed thermal vacuum testing.
- The first Ground Operations Working Group (GOWG) was held for the Solar Orbiter mission at Kennedy Space Center; ESA and Airbus gained new insight into the thorough spacecraft processing plan.

LWS Space Environment Testbeds (SET)-1

SpaceX and AFRL signed a contract with a launch date of September 15, 2017

- Dependent on SpaceX Falcon Heavy

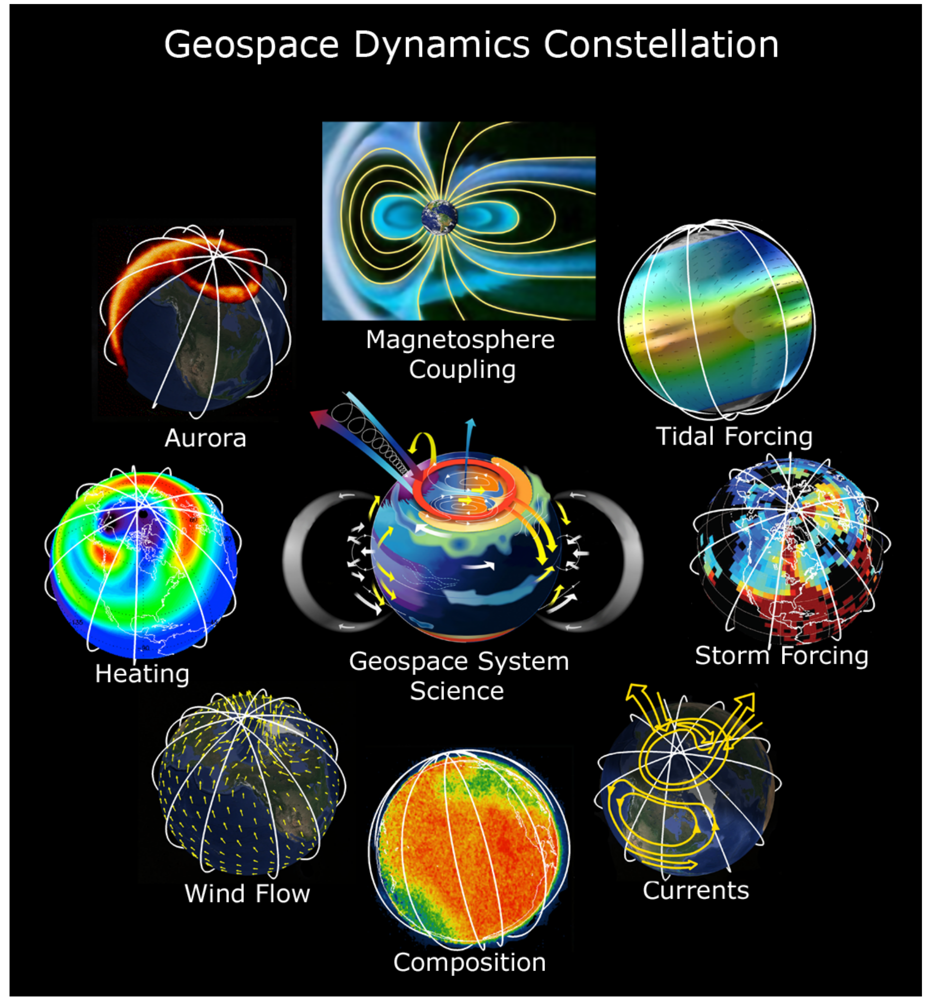
Next LWS mission recommended by NRC: Geospace Dynamics Constellation (GDC)

Geospace Dynamics Constellation
will provide:

Breakthroughs in our understanding, providing simultaneous, self-consistent global patterns at 320-450 km of key parameters and interconnections that produce the dynamical global interaction between the atmosphere-ionosphere and the magnetosphere/solar wind.

Unprecedented knowledge, for example of how global upper atmospheric winds, neutral density and E-fields (ion drifts) and currents respond to variations in solar EUV irradiance, tropospheric forcing, and solar wind/magnetospheric driving.

Global, simultaneous measurements as input for data-starved models that will of great benefit for both ionospheric/thermospheric and magnetospheric research as well as a large variety of space weather applications.



Expected Outcome → Major impact to our knowledge of I/T/Mag System and its coupling to the Sun, Space Weather effects

ROSES – 16

The following three Focused Science Topics (FST) were included in the ROSES 2016 LWS Science solicitation.

1. Advances Toward a Near Real Time Description of the Solar Atmosphere and Inner Heliosphere;

2. Characterization of the Earth's Radiation Environment;

3. Studies of the Global Electrodynamics of Ionospheric Disturbances.

- A total of 63 Step-2 proposals were submitted to NSPIRES.

- The review process is underway.

- Selections planned for Spring, 2017.

Current FST Development and Selection Process

This process will be described in more detail in the following talks.

- Steering Committee discussed and recommended a process which involved significant community input. Heliophysics Subcommittee (HPS) approved this process.

- Community provided ~ 60 inputs to the Steering Committee. These were used to develop a set of 15 Focused Science Topics (FST).

- These FSTs were presented by the Steering Committee to the HPS which provided a ranking of these FSTs.

- Heliophysics staff compared the current 15 FSTs to FSTs that appeared in recent ROSES announcement (past 5 – 6 years).

- Based on the HPS ranking, available funds, and recently selected topics, the following four FSTs were selected.

Release of H-LWS 2017 Draft Text

The Targeted Investigations element this year consists of ***four*** Focused Science Topics (FSTs):

1) Understanding The Onset of Major Solar Eruptions;
2) Toward a Systems Approach to Energetic Particle Acceleration and Transport on the Sun and in the Heliosphere;
3) Ion Circulation and Effects on the Magnetosphere and Magnetosphere - Ionosphere Coupling;
4) Understanding Physical Processes in the Magnetosphere - Ionosphere/ Thermosphere/ Mesosphere System During Extreme Events.

A draft version of the ROSES-2017 program element B.6 Heliophyiscs – Living With a Star will appear on the NSPIRES web page for ROSES-2016 B.6 under the 2016 text with "DRAFT ROSES-2017" in the title.

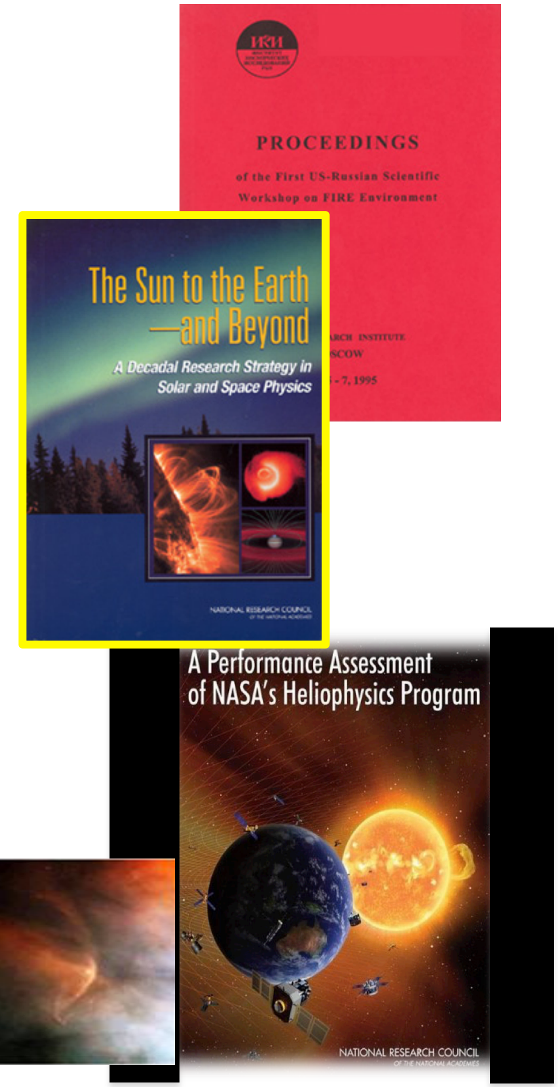
The public is invited to send comments on this draft program element to both Jeff Morrill at jeff.s.morrill@nasa.gov and Elsayed Talaat at elsayed.r.talaat@nasa.gov by January 9, 2017.

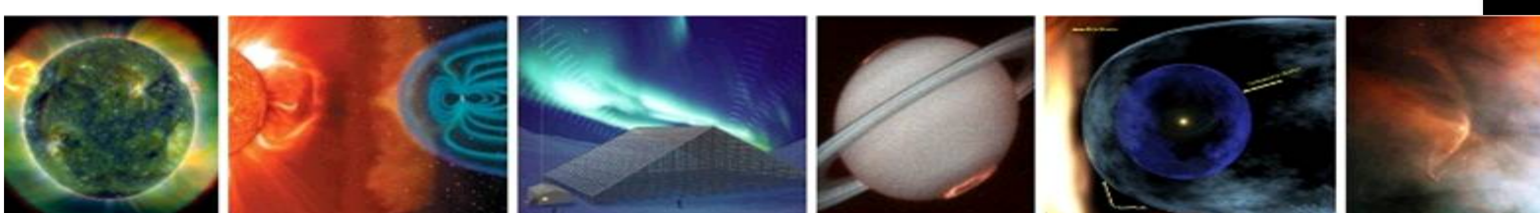
Solar Probe: Yesterday and Today

The concept for a "solar probe" dates back to "Simpson's Committee" of the Space Science Board (National Academy of Sciences, 24 October 1958)

- The need for extraordinary knowledge of Sun from remote observations, theory, and modeling to answer the questions:
  - Why is the solar corona so much hotter than the photosphere?
  - How is the solar wind accelerated?

The answers to these questions can be obtained only through in-situ measurements of the solar wind down in the corona and been of top priority in multiple Roadmaps and Decadal Surveys.





LWS Short-term NSWAP tasks and alignment

LWS TR&T Steering Committee (TSC) Finding:

The TSC suggests the following short-term task to assist NASA in carrying out its SWORM benchmarking activities:

- NASA should establish LWS SWORM "Tiger Teams" to support the five SWORM benchmarking activities. These teams would be distinct from, but complementary to current LWS teams, such as the Focused Science Topic teams and the Strategic Capability teams.
- The charter of each Tiger Team would be to
  - Assist and support the government study board by providing findings as directed and by reviewing the gap assessment performed by the governmental study board. Specifically, the teams would identify gaps in science, perform evaluation of uncertainties, and identify collections of available data, as well as critical missing data.
  - Identify and implement any short-term science actions that need to be taken to feed into the Phase-2 improved benchmarking process. Science actions could include synthesizing models and data, and providing tools relevant to benchmarking.
- A fast-track selection process should be implemented so that the Tiger Teams have sufficient time to complete their tasks within the deadlines identified in the SWAP. Based on these deadlines, the announcement-to-selection process should be no more than a few months.
- For this fast-track process, no restrictions should be put on proposal teaming structures in order to maintain flexibility to best serve the SWORM activities. For example, both team proposals and individual proposals should be allowed for each benchmarking topic, thus allowing the LWS Program Office the flexibility to form the tiger teams from these proposals and / or to select individual investigations.

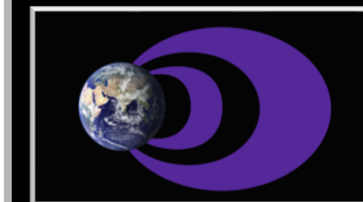
NASA's Van Allen Probes Revolutionize View of Radiation Belts

A new study based on data from NASA's Van Allen Probes shows that all 3 regions—inner belt, slot region, outer belt—can appear different depending on the energy of electrons considered and general conditions in the magnetosphere.

A recent study of data from the Van Allen Probes published on Dec. 28, 2015 in the Journal of Geophysical Research has given us new understandings on the shape of the Van Allen Belts, or radiation belts, and how electrons behave at different energy levels within the belts themselves. This new analysis reveals that the observed shape can vary from a single, continuous belt with no slot region, to a larger inner belt with a smaller outer belt, to no inner belt at all. While the shapes of the belts do change, we now know that most of the observed differences are accounted for by considering electrons at different energy levels separately.

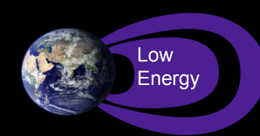
The twin Van Allen Probes satellites expand the range of energetic electron data we can capture. In addition to studying the extremely high-energy electrons—carrying millions of electron volts, the Van Allen Probes can capture information on lower-energy electrons that contain only a few thousand electron volts. Additionally, the spacecraft measure radiation belt electrons at a greater number of distinct energies than was previously possible.

Precise observations like this, from hundreds of energy levels, rather than just a few, will allow scientists to create a more precise and rigorous model of what, exactly, is going on in the radiation belts, both during geomagnetic storms and during periods of relative calm. This information will help us better predict and prepare for dangerous space weather events that have the potential to impact Earth's environs.

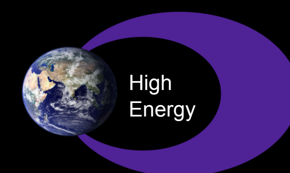


Traditionally, the radiation belts have been thought to include a larger, more dynamic outer belt and a smaller, more stable inner belt with an empty slot region separating the two. Now we know the shape appears different depending on what energy electrons one observes.

When looking at the **lowest electron energy levels** – about 0.1 MeV, the inner belt expands into the empty slot region, diminishing the outer belt



At the **highest electron energies** measured—above 1 MeV—we only see electrons in the outer belt.



During geomagnetic storms, the empty slot region can fill in completely with lower-energy electrons.

The Johns Hopkins Applied Physics Laboratory in Laurel, Md., built and operates the Van Allen Probes for NASA's Science Mission Directorate. The mission is the second mission in NASA's Living With a Star program, managed by NASA's Goddard Space Flight Center in Greenbelt, Md.

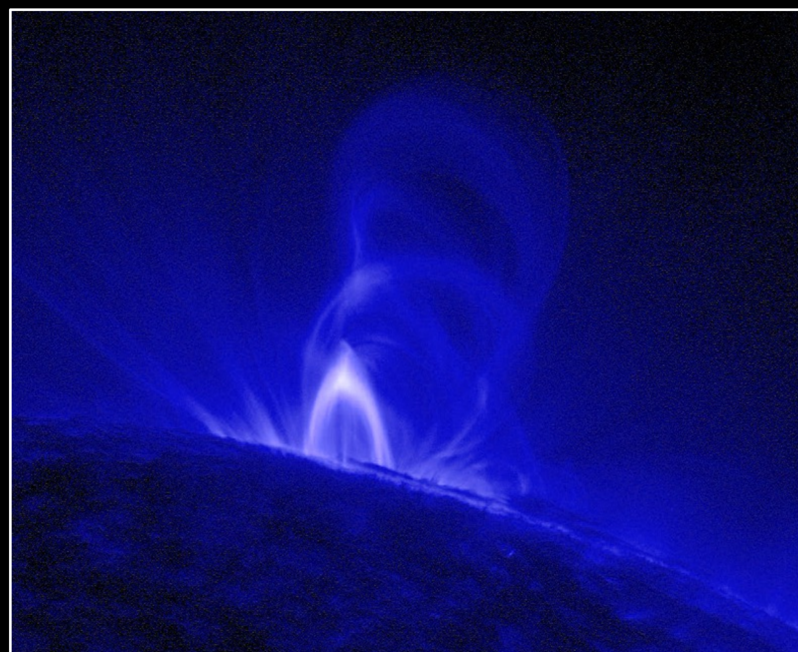
Connecting the Dots: Furthering our Understanding of 'Sympathetic Solar Events' with NASA SDO and STEREO data

Jin, M., Schrijver, C., Cheung, M., DeRosa, M., Nitta, N., & Title, A. (2016).
A NUMERICAL STUDY OF LONG-RANGE MAGNETIC IMPACTS DURING CORONAL MASS EJECTIONS. The Astrophysical Journal, 820(1)

The term "sympathetic solar events," or SSEs, refers to sequences of eruptions from the solar corona that have causal relations, even though they are far apart.

With the simultaneous operation of the NASA Heliophysics Solar TErrestrial RElations Observatory (STEREO) from behind the sun and the Solar Dynamics Observatory (SDO) near Earth, we have reached, for the first time, nearly complete coverage of the sun from multiple perspectives. This gives us an unprecedented opportunity to investigate sympathetic solar events on a global scale. SSEs may also present important implications in understanding space weather.

The physical mechanisms of how CMEs spread from one region of the sun to another, and how they interact with the large-scale magnetic field around them to cause SSEs, remain largely unknown.



The "flux ropes" of a CME, which refer to erupting structures of magnetized plasma that form loops of different orientations and strengths, seem to play a role in how and why CME's spread and SSEs are triggered. It is thought that flux ropes of a CME connect through magnetic coupling to other CME flux ropes, either directly or through connecting to the large-scale magnetic field around it, causing SSEs.

New research by Jin, et. al published in the Astrophysical Journal this week used data on solar activity from February 15, 2011 as inputs into the Space Weather Modeling Framework model to investigate what mechanisms contribute to the creation and existence of this solar phenomenon. They show that a CME's impact on surrounding solar structures, particularly in causing SSEs, depends not only on the intrinsic magnetic strength of those surrounding structures and the distance to the CME source region, but also on the interaction of the CME with the large-scale solar magnetic field. The orientation of the connecting flux ropes also plays a large role in whether or not magnetic coupling will occur to trigger an SSE. With continued research and analysis, it may be possible to establish an empirical relationship to predict regions that are likely to be more active due to SSEs. Understanding what causes active regions to erupt would greatly aid space weather forecasting.

Image from SDO instruments, July 2012
http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11180

Solar Probe Plus

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.

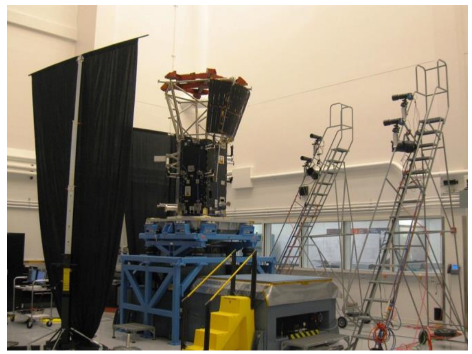
Upcoming Milestones

SIR – May 2016

PER – October 2017

PSR – March 2018

LRD – July 2018



High-Speed Camera Setup for Flight Spacecraft Modal Test

ISOIS EPI-Lo FM Sensor Wedge

Recent Accomplishments

- MOR – Nov 2015
- FIELDS whip antenna: Testing and analysis of EM antenna and clam shell successfully completed,
- retiring this risk.
- 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
- Structure: Vibration testing was successfully completed on the repaired Flight Truss Structure Assembly.

Watch Items/Concerns

- Late delivery of first Solar Array platen could impact schedule reserve.

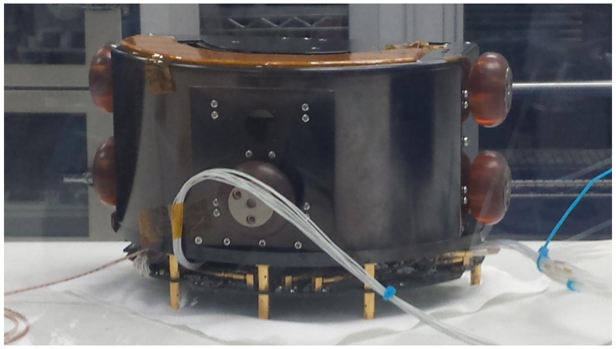
Solar Orbiter Collaboration

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.

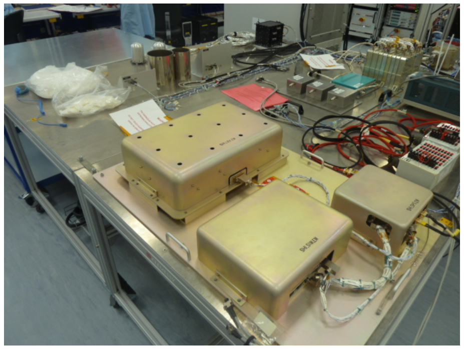
Upcoming Milestones

Mission Delta-CDR
- Kick-Off – April 2016
- Close-Out – June 2016

SoloHI PER – April 2016
HIS PER – June 2016
SoloHI PSR – June 2016
HIS PSR – September 2016
LRD – October 2018



HIS Flight Model Detector Section-Time Of Flight



SoloHI Electrical Model

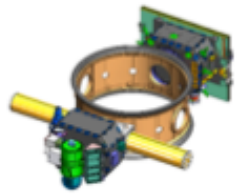
Recent Accomplishments

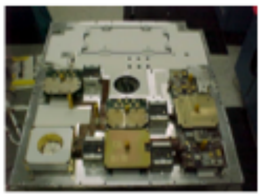
- Heavy Ion Sensor (HIS) instrument Post Acceleration (PAC) isolator completed peer review, fabrication and testing beginning.
- Solar Orbiter Heliospheric Imager (SoloHI):
  - Thermal correlation successfully completed; no requirement for additional heaters or heater resizing.
  - Stray light testing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

Watch Items/Concerns

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

Space Environment Testbeds





Launch Information:

- **Spacecraft:** AFRL Deployable Structures Experiment (DSX)
- **Launch Vehicle:** SpaceX Falcon Heavy
- **Date:** March 2017
- **Site:** Cape Canaveral
- **Orbit:** 6,000 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.

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.

Recent 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.

Watch Items/Concerns

- None

LWS Short-term NSWAP tasks and alignment

- LWS TR&T Steering Committee (TSC) found that NASA should establish LWS SWAP “Tiger Teams” to support the five SWAP benchmarking activities. These teams would be distinct from, but complementary to current LWS teams, such as the Focused Science Topic teams and the Strategic Capability teams.

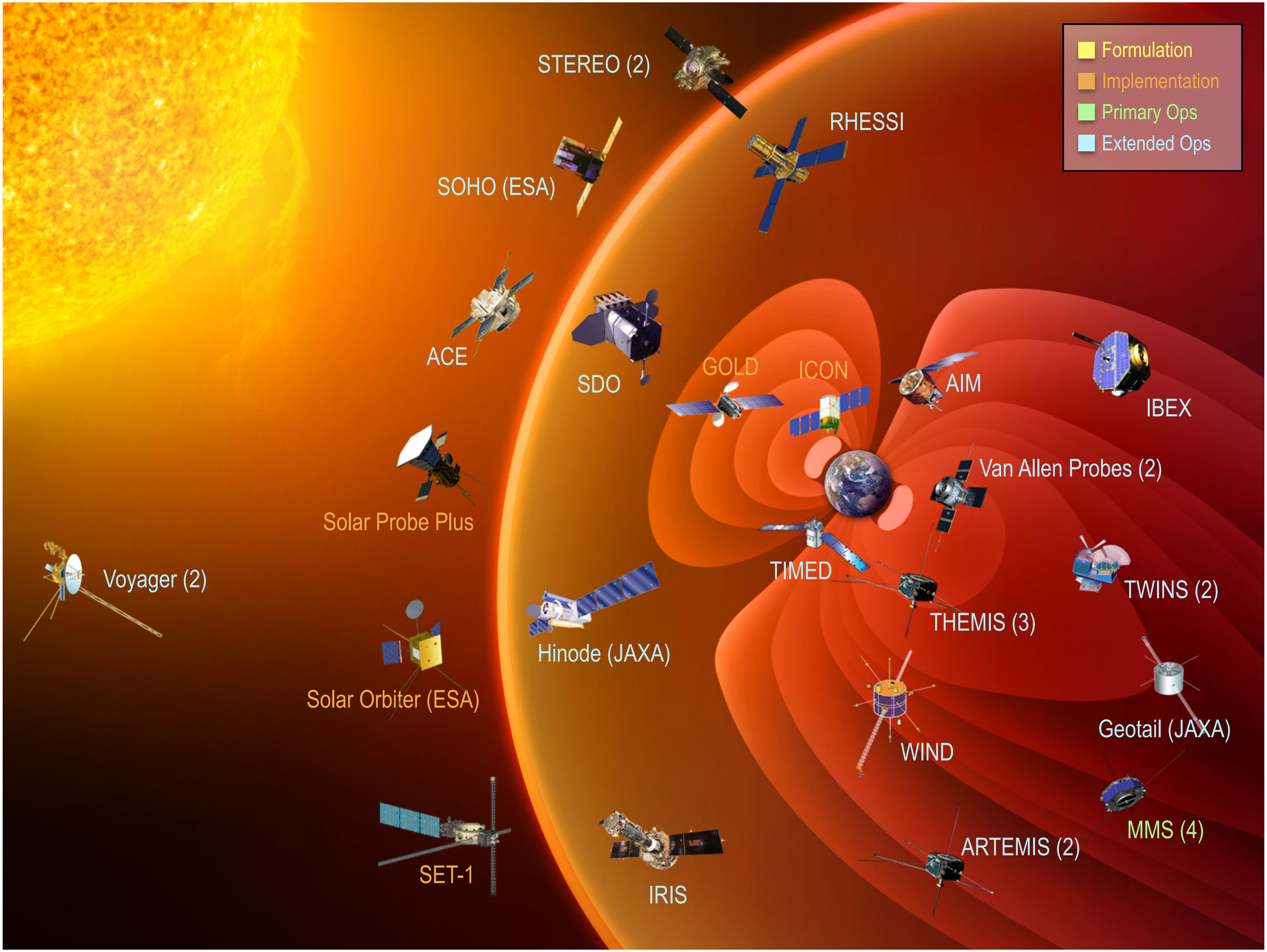
- NASA Heliophysics Subcommittee found that LWS Program should investigate developing a broad community program by which the HPD would effectively provide the science research analysis required for the success of the SWAP.

LWS Steering Committee Finding: Long-term traceability and alignment

- With regards to the longer-term activities identified in the SWAP report, the TSC finds that it should trace out the correspondence between all the SWAP actions to which NASA is contributing and the LWS TR&T Strategic Science Areas (SSA's).

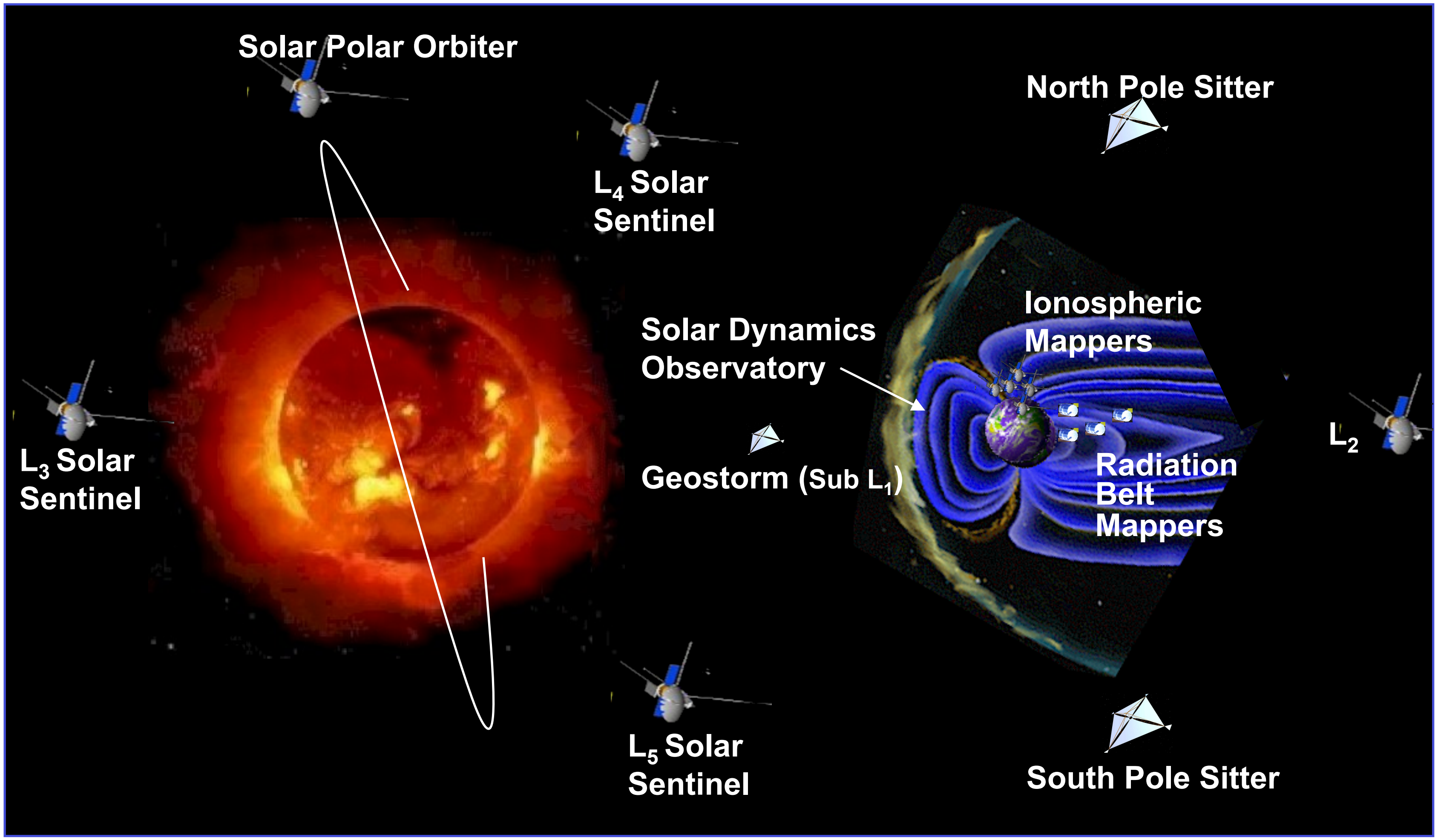
- Based on this correspondence, the TSC should develop findings at its next meeting detailing how the TR&T's SSA-targeted activities can feed into and / or address NASA SWORM actions.

- In future years, the TSC should include SWORM efforts feedback to the program in order to more closely align TR&T activities to the SWORM goals.



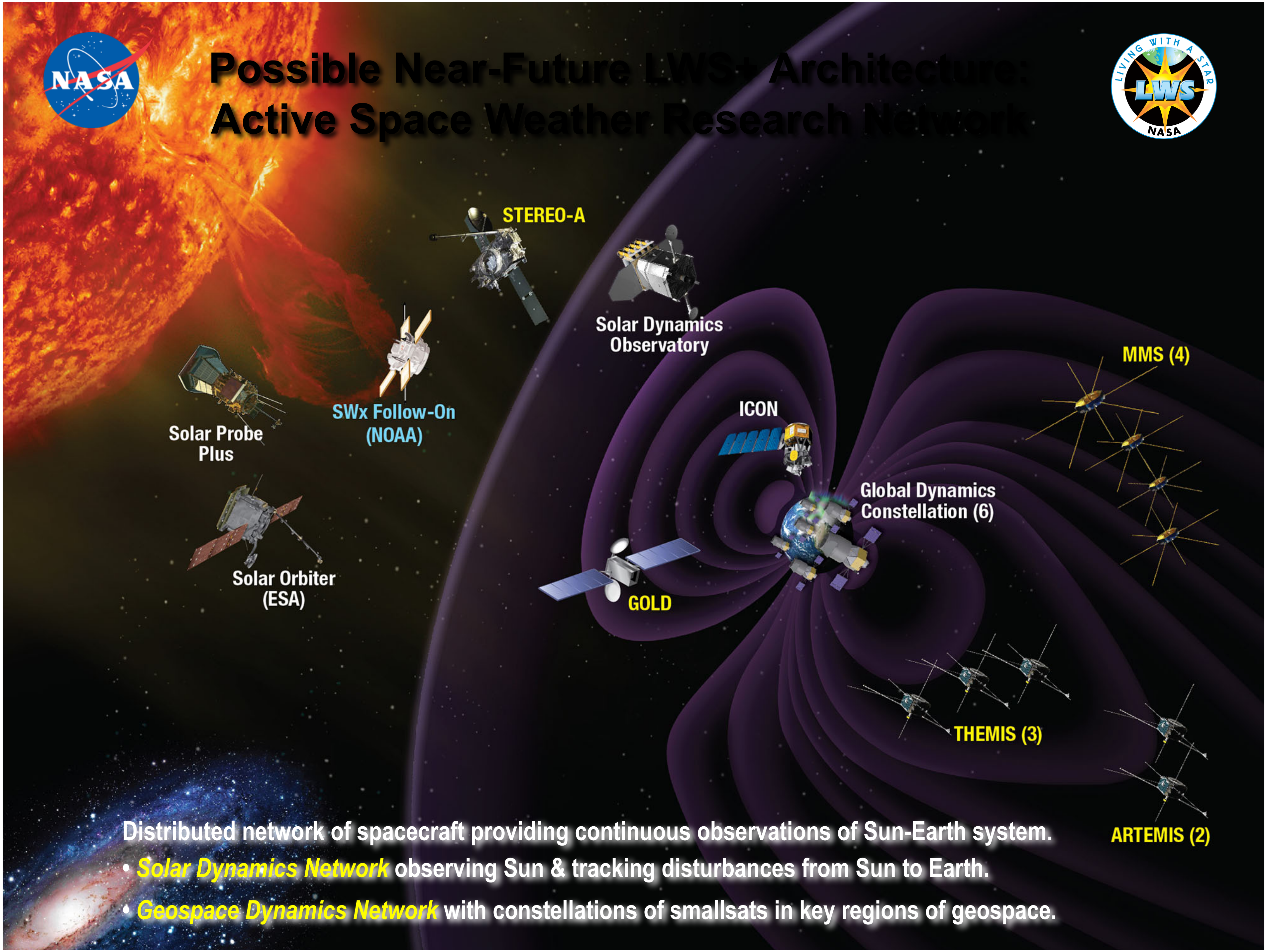
Formulation
Implementation
Primary Ops
Extended Ops
STEREO (2)
RHESSI
SOHO (ESA)
ACE
SDO
GOLD
ICON
AIM
IBEX
Van Allen Probes (2)
Solar Probe Plus
Voyager (2)
TIMED
TWINS (2)
THEMIS (3)
Hinode (JAXA)
Solar Orbiter (ESA)
WIND
Geotail (JAXA)
MMS (4)
ARTEMIS (2)
SET-1
IRIS

Original LWS Architecture Concept: Establish Space Weather Research Network



Distributed network of spacecraft providing continuous observations of Sun-Earth system.

- ***Solar Dynamics Network*** **observing Sun & tracking disturbances from Sun to Earth.**
- ***Geospace Dynamics Network*** **with constellations of smallsats in key regions of geospace.**



Possible Near-Future LWS+ Architecture:
Active Space Weather Research Network
NASA
LIVING WITH A STAR
LWS
NASA
STEREO-A
Solar Dynamics Observatory
Solar Probe Plus
SWx Follow-On (NOAA)
Solar Orbiter (ESA)
ICON
Global Dynamics Constellation (6)
GOLD
MMS (4)
THEMIS (3)
ARTEMIS (2)
Distributed network of spacecraft providing continuous observations of Sun-Earth system.
• Solar Dynamics Network observing Sun & tracking disturbances from Sun to Earth.
• Geospace Dynamics Network with constellations of smallsats in key regions of geospace.

Goal 1: Establish Benchmarks for Space-Weather Events (5 topic areas)

Benchmarking will happen for:

1. Induced geo-electric fields
2. Ionizing radiation
3. Ionospheric disturbances
4. Solar radio bursts
5. Upper atmospheric expansion

Timeline:

Phase 1 benchmarks: 180 days (April 2016)

Complete Assessment report of gaps: 1 yr (November 2016)

Phase 2 updated benchmarks: 2 yr (November 2017)

National Space Weather Strategy

- Office of Science Technology Policy (OSTP), Executive Office of the President, lead the multi-agency effort that developed a National Space Weather Strategy (NSWS).

- NSWS articulates strategic goals for improving forecasting, impact evaluation, and enhancing National Preparedness (protection, mitigation, response and recovery) to a severe space weather event.

- Space Weather Action Plan (SWAP) was developed to establish cross-Agency actions, timelines and milestones for the implementation of the NSWS.
  - Enhances the transition of research to operations for space weather observations, modeling tools, advance warning capabilities and mitigation approaches
  - Incorporates severe space weather events in Federal emergency preparedness, planning, scenarios, training, and exercises
  - Establishes Federal and non-Federal stakeholder collaborations to enhance observing systems and networks and data management activities

Release of H-LWS 2017 Draft Text - 1

ROSES-16 Amendment 49: This amendment releases draft text for ROSES-2017 program element B.6 Heliophyiscs – Living With a Star.

The Living With a Star (LWS) Program emphasizes the science necessary to understand those aspects of the Sun and Earth's space environment that affect life and society. The ultimate goal of the LWS program is to provide a scientific understanding of the system, almost to the point of predictability, of the space weather conditions at Earth and the interplanetary medium, as well as the Sun-climate connection.

The stated goal of LWS, that of achieving an understanding of those aspects of the Sun-Solar System that have direct impact on life and society, poses two great challenges for the LWS program. First, the program must tackle large-scale problems that cross discipline and technique boundaries (e.g., data analysis, theory, modeling, etc.); and second, the program must identify how this new understanding will have a direct impact on life and society. Over time, the Targeted Investigations provide advances in scientific understanding to address these challenges.