National Aeronautics and Space Administration

NASA LWS Program and Research to Operations

Elsayed R. Talaat
Chief Scientist, Heliophysics Division
Science Mission Directorate

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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.

Upcoming LWS missions

SPP - Solar Probe Plus

- ISOIS flight EPI-Lo first instrument to be successfully integrated onto the spacecraft
- Solar Array Cooling System mechanically and electrically integrated to primary structure
- Instruments are completing Pre-Ship Reviews
- Flight Solar Array Wing-1 successfully completed Medium Irradiance High Temperature Testing at SolAero, exposing the wing to 5.3 Suns for 15 hours

SOC - Solar Orbiter Collaboration

- Heavy Ion Sensor (HIS) Pre-Ship Review was successfully completed; instrument will remain under vacuum until shipment to MSSL.
- Solar Orbiter Heliospheric Imager (SoloHI) shipped to Airbus facility in Stevenage, UK and mechanical integration to spacecraft was completed April 25

LWS Space Environment Testbeds (SET)-1

SpaceX and AFRL anticipate a launch date in January 2018

- Dependent on SpaceX Falcon Heavy

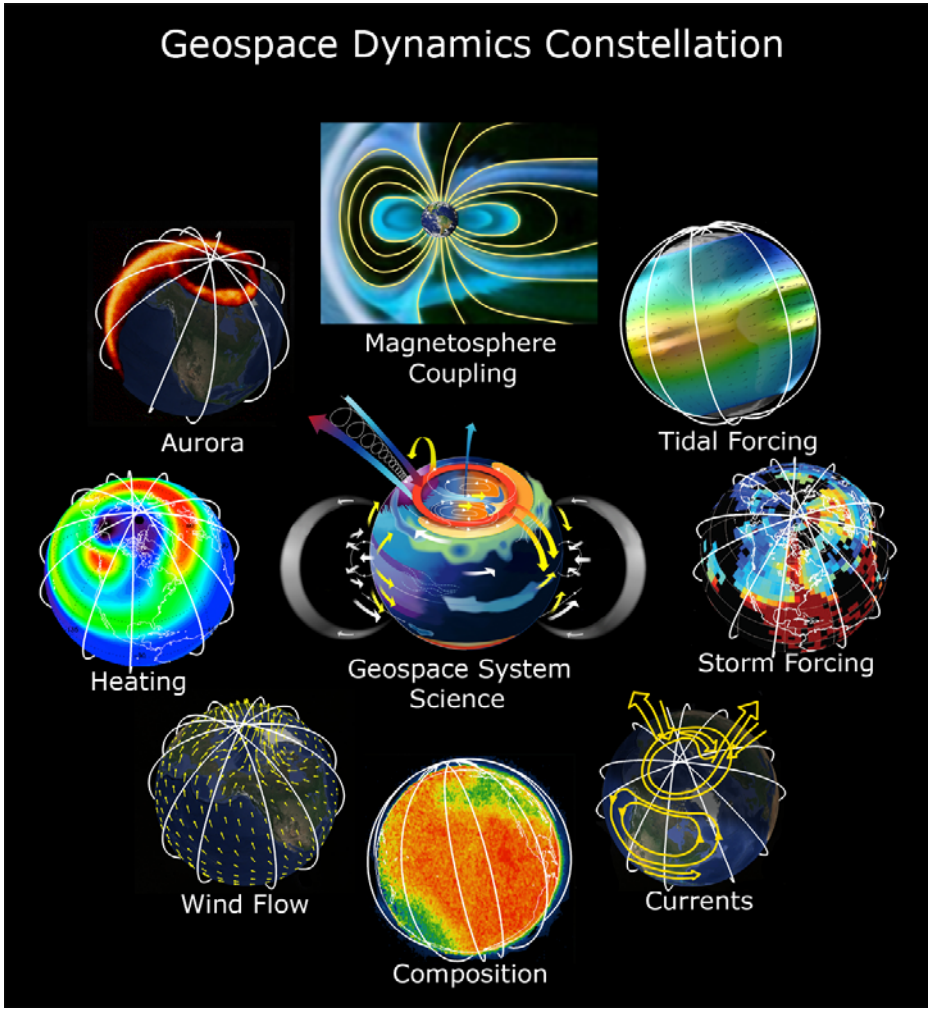
Next LWS mission recommended by NRC: Geospace Dynamics Constellation (GDC)

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.

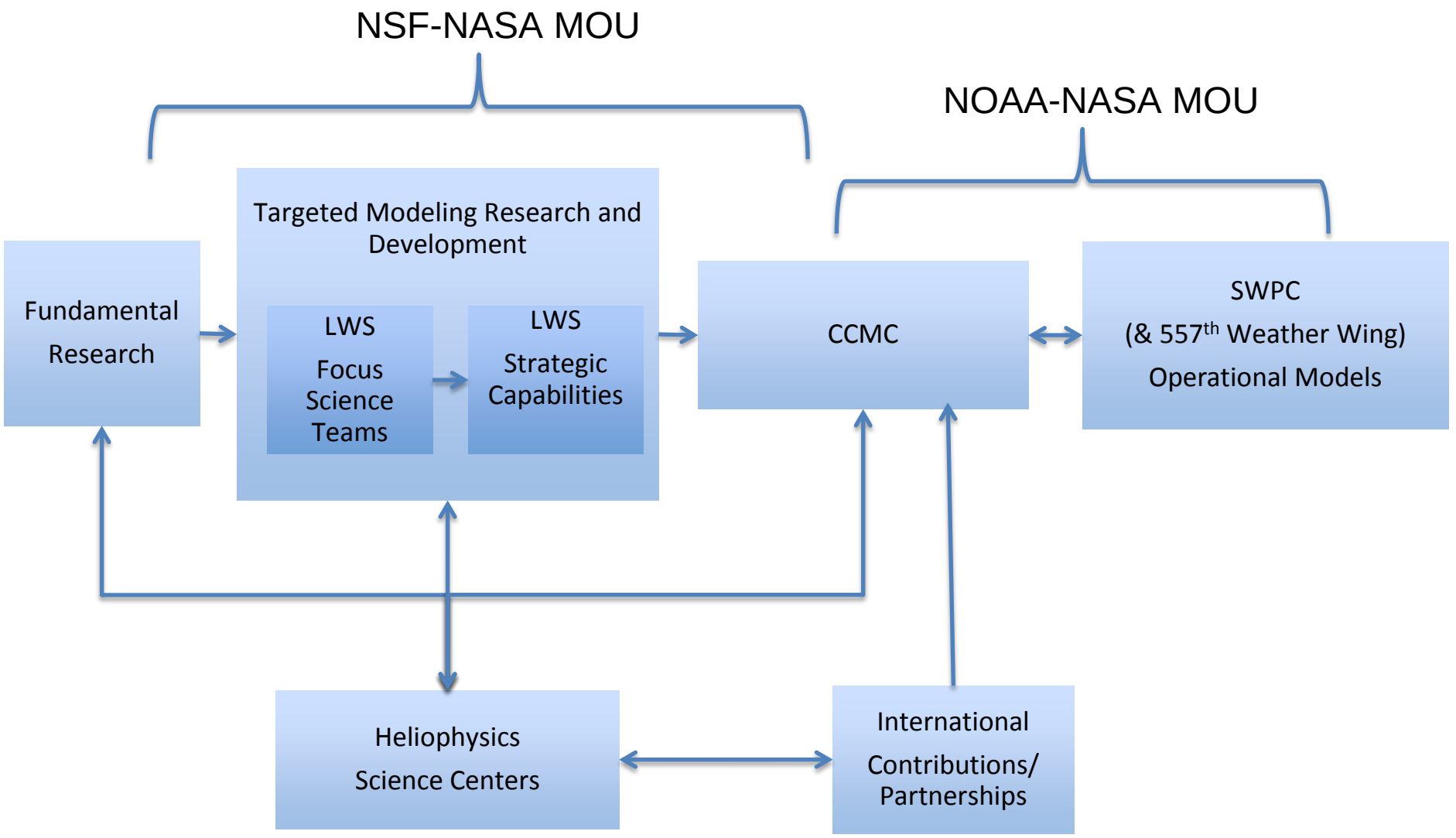
Unprecedented knowledge, for example of how global upper atmospheric winds, neutral density and E-fields (ion drifts) and currents respond to variations in solar EUV irradiance, tropospheric forcing, and solar wind/magnetospheric driving.

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

R2O Concept of Operations



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

Benchmarking happening for:

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

Steps:

Phase 1 benchmarks

Assessment report of gaps

Phase 2 updated benchmarks

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**

LWS Science looking forward

Core LWS Science activities:

- ROSES – 2016, 2017,… LWS FST calls
- ROSES – 201X LWS Strategic Capabilities (with NSF)

In addition:

- NSF-NASA Collaboration – Computational Aspects of Space Weather (working title)
- Space Weather-focused Heliophysics Science Centers

Seeking to enable Space Weather-oriented opportunities:

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

ROSES – H-LWS 2016

ROSES 2016 LWS FSTs developed incorporating inputs from previous Steering Committee reports and will be informed by SWAP science priorities.

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

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 May, 2017.

FST Development and Selection Process

New process demonstrated in ROSES 2017 development.

- 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.

ROSES – H-LWS 2017

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

1. Understand solar variability and its effects on the space and Earth environments with an ultimate goal of a reliable predictive capability of solar variability and response.
2. Obtain scientific knowledge relevant to mitigation or accommodation of undesirable effects of solar variability on humans and human technology on the ground and in space.
3. Understand how solar variability affects hardware performance and operations in space.

ROSES-2017 program element B.6 Heliophyiscs – Living With a Star

Step 1 Due June 2017

Step 2 Due August 2017

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

2017/18: Two new institutes will be solicited

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."

International CCMC-LWS Working Meeting:
Assessing Space Weather Understanding and Applications

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

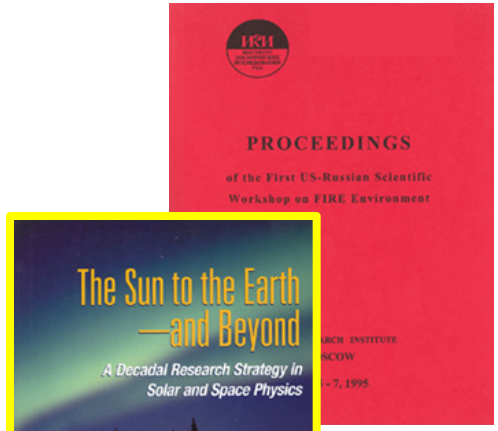
BACKUP

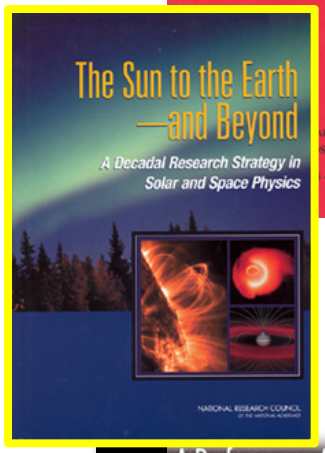
Solar Probe: Yesterday and Today

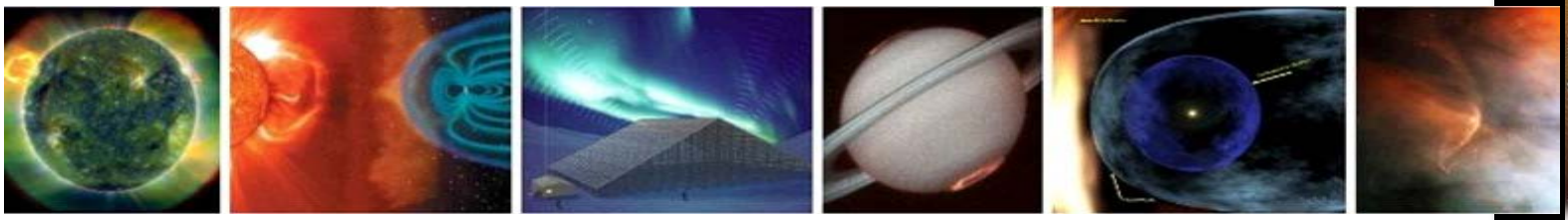
The concept for a “solar probe” dates back to “Simpson’s Committee” of the Space Science Board (National Academy of Sciences, 24 October 1958)

- 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.







Why do Science?

For Understanding \ For Utility	No	Yes
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***

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.

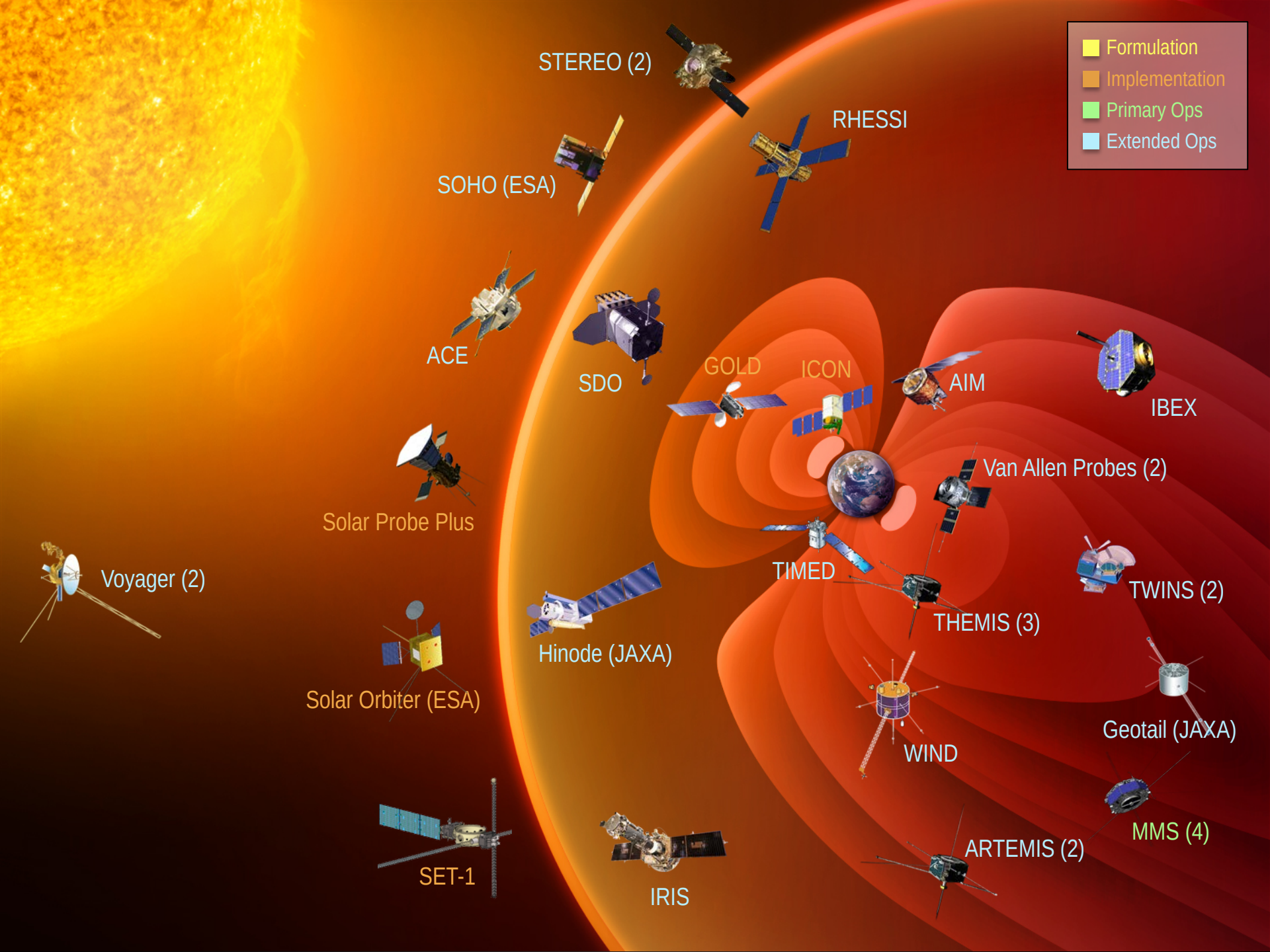
- NASA Heliophysics Subcommittee found that LWS Program should investigate developing a broad community program by which the HPD would effectively provide the science research analysis required for the success of the SWAP.

LWS Steering Committee Finding: Long-term traceability and alignment

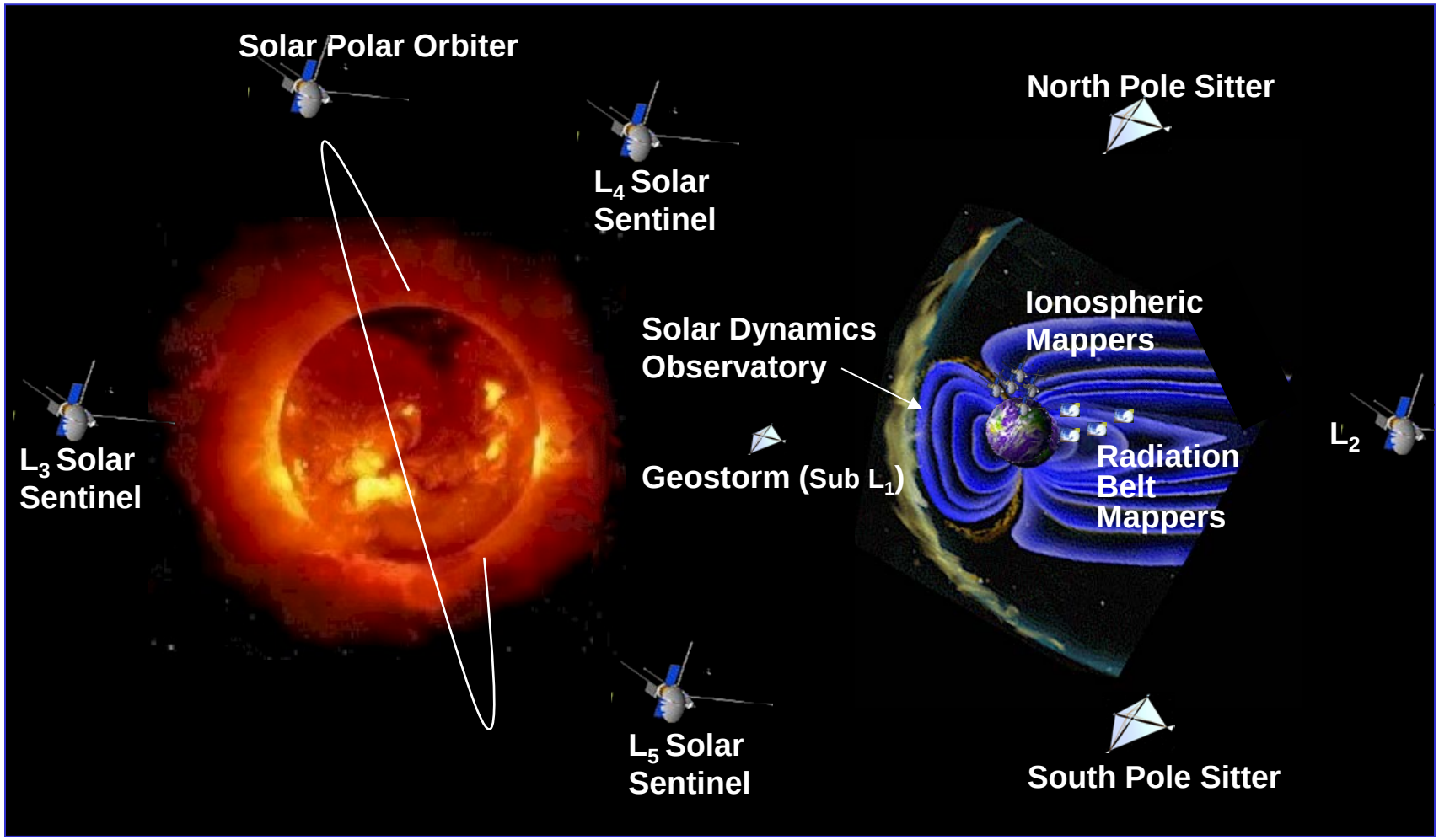
- With regards to the longer-term activities identified in the SWAP report, the TSC finds that it should trace out the correspondence between all the SWAP actions to which NASA is contributing and the LWS TR&T Strategic Science Areas (SSA's).

- 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)
Geotail (JAXA)
WIND
MMS (4)
ARTEMIS (2)
SET-1
IRIS

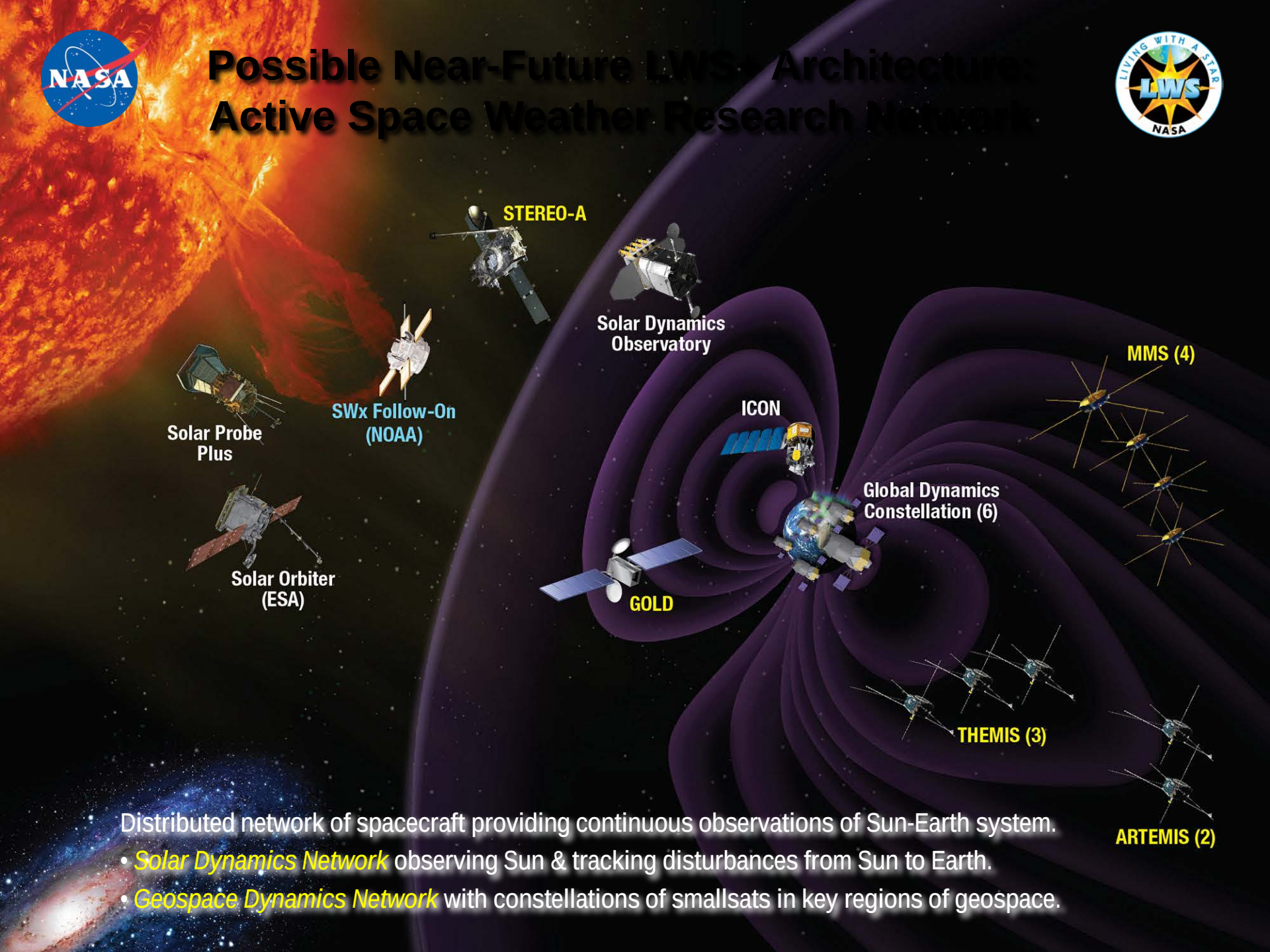
Original LWS Architecture Concept: Establish Space Weather Research Network



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



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