



# Building NOAA's Operational Space Weather Observations

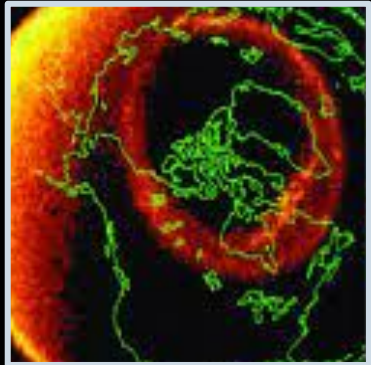
National Environmental Satellite,  
Data, and Information Service

**Elsayed Talaat**

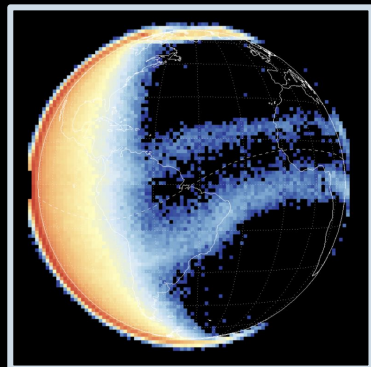
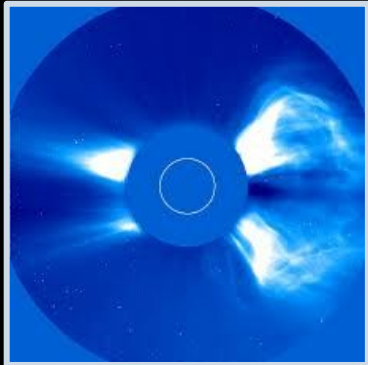
Director, Office of Space Weather Observations, NOAA;  
System Program Director, Code 490, GSFC, NASA

# NOAA is a Trusted Source of Space Weather Data, Products, & Services

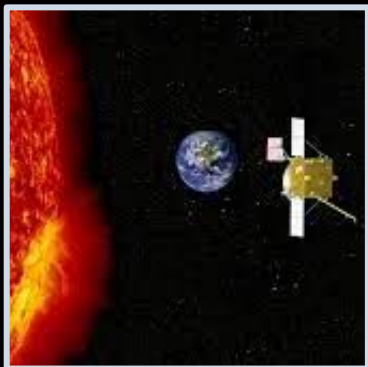
NASA Dynamic Exp-1



ESA/NASA SOHO/LASCO



NASA GOLD



ESA Vigil



GOES-16 SUVI

## NOAA Provides

Observational Data

Storm Forecasting

Data Management





# Building a Space Weather-Ready Nation!

NOAA provides operational space weather monitoring, forecasting, and long-term data archiving and access for civil applications, maintains ground-based and space-based assets, provides research to support operations, and develops requirements for space weather forecasting technologies and science.

PROSWIFT ACT §60601



## NOAA's Six Critical Societal Challenges

1. Extreme Events and Cascading Hazards
2. Coastal Resilience
3. The Changing Ocean
4. Water Availability, Quality, and Risk
5. Effects of Space Weather
6. Monitoring & Modeling for Climate Change Mitigation



# Critical Ground- and Space-based Observation Capabilities



**GONG** – NSF/NSO-NWS  
NOAA now supporting operations

**Ground-based Magnetometers** – USGS  
Critical input to SWPC's geomagnetic storm products

**Neutron Monitors** – NSF and Academia

**Solar Electro-Optical Network (SEON)** – USAF



**DSCOVR** – NOAA

**COSMIC-2; RO** – TASA & NOAA; Commercial

**GOES** – NOAA GOES U - NRL Coronagraph in 2024

**Solar Dynamics Observatory** – NASA

**Advanced Composition Explorer** – NASA

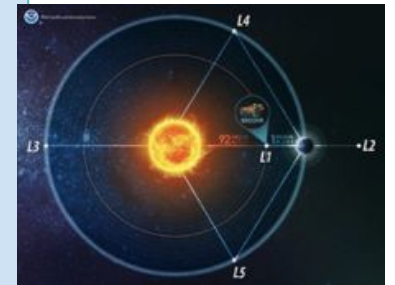
**Solar & Heliospheric Observatory mission (SOHO)** – NASA-ESA



**CRITICAL OBSERVATIONS FOR OPERATIONS**

**Vigil L5 (Future)** – ESA (TBD)

**Space Weather Follow-On and Space Weather Next (Future)** – NOAA  
Rideshare to L1 with NASA's IMAP in 2025



# Space-Based Monitoring at NESDIS

## The NESDIS Vision:

A truly integrated digital understanding of our earth environment that can evolve quickly to meet changing user expectations by leveraging NOAA's own capabilities and partnerships.

## Space Weather Strategic Objective:

Advance Space Weather observational leadership in LEO, GEO, and extended orbits consistent with the agency's responsibilities within the National Space Weather Strategy and Action Plan.

## NESDIS Strategic Objectives

NESDIS  
*Reimagined*



1  
Advance terrestrial observational leadership in geostationary and extended orbits



2  
Advance space weather observational leadership in all applicable orbits to meet mission needs



3  
Evolve LEO architecture to enterprise system of systems that exploits and deploys new observational capabilities



4  
Develop agile, scalable ground capability to improve efficiency of service deliverables and ingest of data from all sources



5  
Provide consistent ongoing enterprise-wide user engagement to ensure timely response to user needs



6  
Deliver the best value integrated suite of products and services responsive to user needs.

**Space Weather is a strategic priority for NOAA/NESDIS.**





# Establishment of the Office of Space Weather Observations

National Environmental Satellite, Data, and Information Service

Office of Space Weather Observations (SWO)

Office of Geostationary Earth Orbit Observations (GEO)

Office of Low Earth Orbit Observations (LEO)

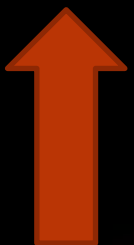
Office of Satellite and Product Operations (OSPO)

Office of Common Services (OCS)

Systems Architecture & Engineering (SAE)

Center for Satellite Applications and Research (STAR)

National Centers for Environmental Information (NCEI)



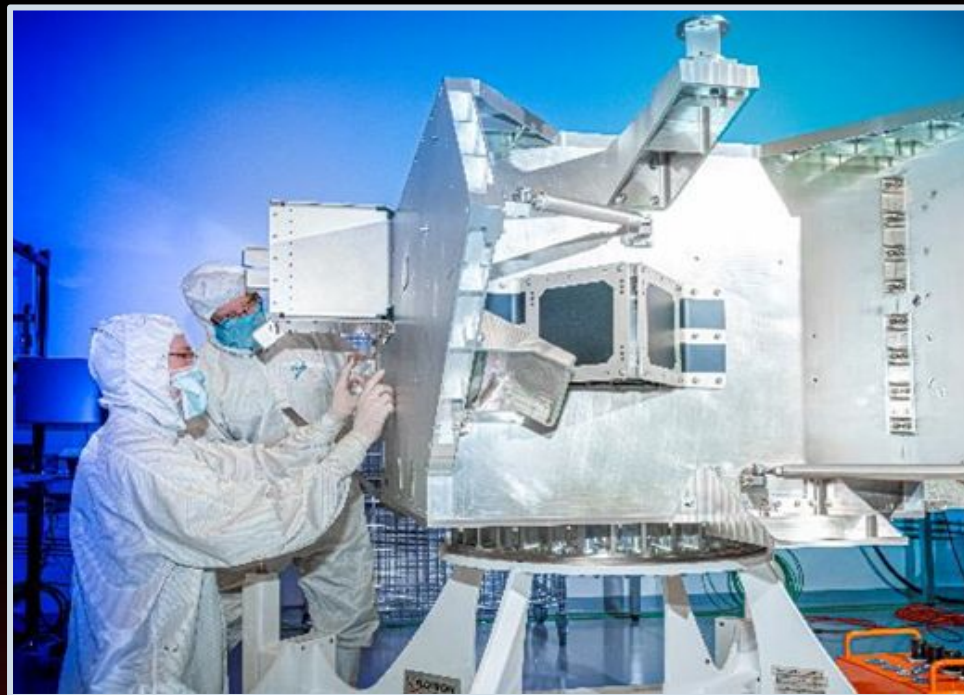
# Space Weather Follow On (SWFO) program

SWFO sustains NOAA's foundational set of space-based space weather observations and measurements to ensure continuity of critical data.



**CCOR-1 integration  
onto GOES-U**

Image Credit: Lockheed Martin



**Spacecraft assembly**

Image credit: Ball Aerospace



**SWFO-L1  
Spacecraft**

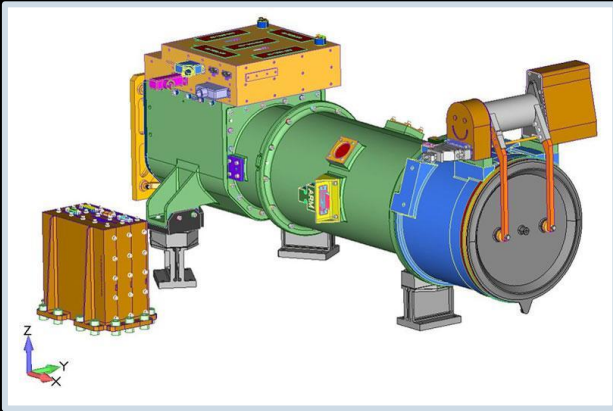
Image Credit: Ball Aerospace

**Reaching L1 riding with NASA's IMAP mission**

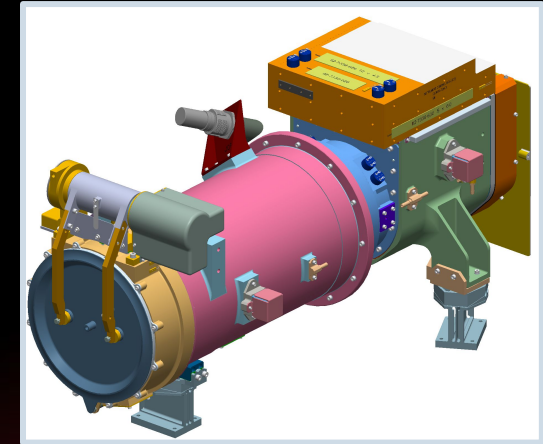




# SWFO: State-of-the-Art Heliophysics Instruments

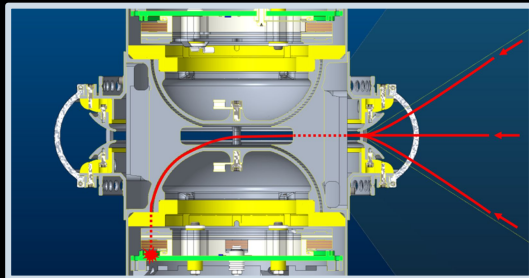


**Compact Coronagraphs (CCORs):**  
Developed by Naval Research Lab (NRL), the telescope will be used to observe the solar corona and detect coronal mass ejections (CMEs) and other structures. CCOR-1 will fly on the GOES-U satellite and a nearly identical CCOR-2 on SWFO-L1.

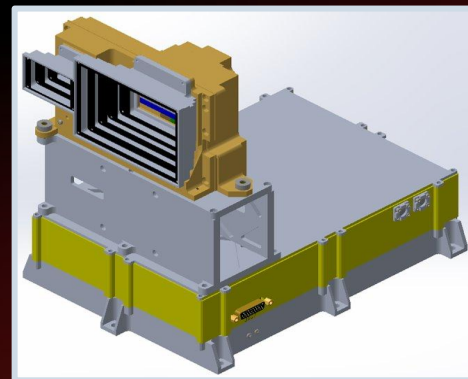


U.S. NAVAL  
RESEARCH  
LABORATORY

**Solar Wind Plasma Sensor (SWiPS):**  
Built by Southwest Research Institute (SwRI), it will measure properties of the solar wind plasma flowing past SWFO-L1, such as density, velocity, and temperature.

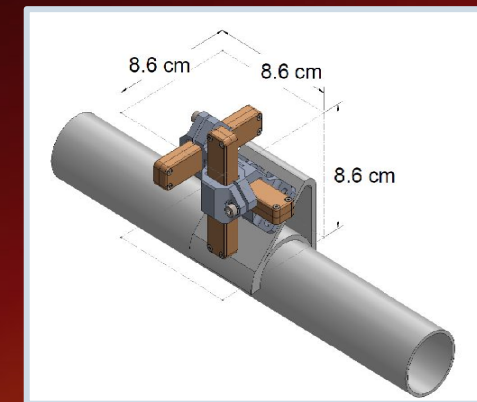


**Suprathermal Ion Sensor (STIS):**  
Developed by University of California, Berkeley, it will collect fast ions in the solar wind.



Berkeley  
UNIVERSITY OF CALIFORNIA

**Magnetometer (MAG):** Developed by the University of New Hampshire and SwRI, it will measure the magnetic field carried by the solar wind.



University of New Hampshire





# An Upgraded Ground Segment for SWFO



SWFO-L1

The SWFO Ground Segment contains three elements.

Data are downlinked to the **SWFO Antenna Network (SAN)**.

The **Command and Control (C2)** element provides SWFO-L1 mission and housekeeping (HK) data to the **Product Generation and Distribution (PGD)** element. (\*)



\*In addition, SWPC receives GOES-U CCOR-1 data via the GOES-R Ground Segment (GS)



# Space Weather Next (SW Next) program

SW Next will **maintain and extend** space weather observations from a range of different observing points, selected to most efficiently provide comprehensive knowledge of the Sun and the near-Earth space environment.

Planning for **continuity and increased capability** from **observations** from:

- L1 and L5 Orbits
- Geostationary Orbit
- Low Earth Orbit

Development of Space Weather Ground Support Networks

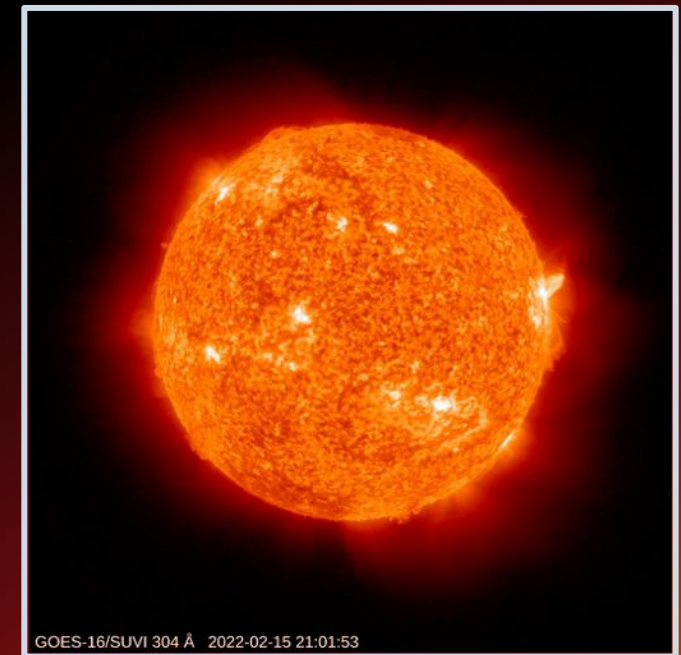
Program and L1 Series Project are in formulation phase

Engaging stakeholders through:

**User outreach** targeting civil aviation, electric grid, and satellite operator communities

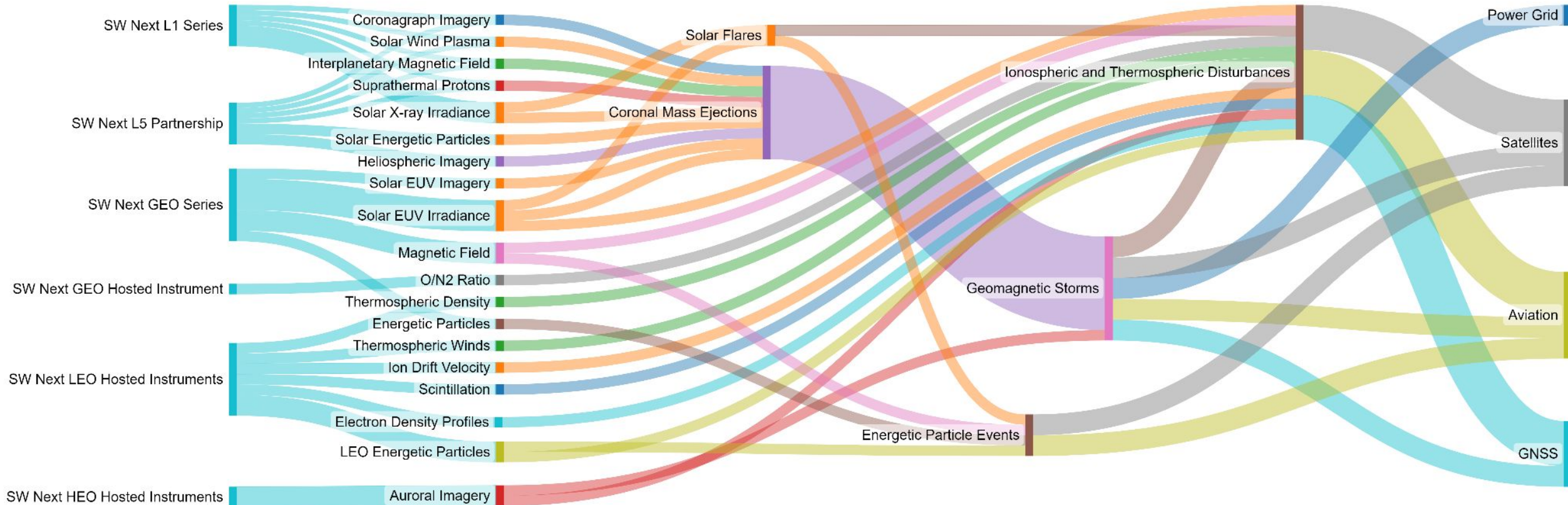
**Partnerships** for observational support and exchange of space weather observational data

**RFIs and RFPs** for L1 Series Project instruments and observatory





# User Engagements & Stakeholder Collaborations



Made with SankeyMATIC

Example of a trace from space weather observations to user needs.



# SW Next L1 Series Project

## Updates

Project team completed **KDP-A on September 20, 2023!**

Project Level 1 & Level 2 Requirements documents are in development.

DOC Milestone 2 planned for Q2 FY2024.

In situ instrument RFPs have been released. Spacecraft and coronagraph requirements are in development.

Coronagraph Formulation Studies completed last month.

Five definition-phase awards with an 8-month period of performance

Executed pre-priced options for four additional months to work towards PDR

The L1 Series Project will provide **continuity of coronal imagery and upstream solar wind observations** beyond SWFO-L1.





# NOAA-ESA L5 Collaboration Project

The L5 Project will manage the CCOR-3 development effort, the integration of the instrument into the ESA mission, and the development of data services.

## Updates

NOAA and ESA have a signed partnership agreement for space weather collaboration.

NESDIS provision of a **Compact Coronagraph to fly on Vigil mission to L5**

**Exchange of data from all SWFO and Vigil instruments**



# Space Weather Prediction Testbed (SWPT) Exercises

## 2022 SWPT Aviation Exercise

Explored current and future aviation products and services from SWPC and ICAO to prepare the aviation community for the upcoming solar maximum.



## 2023 SWPT Satellite Environment Exercise

Explored space weather effects on the drag and radiation environments that LEO satellites operate in and current and future products and services to address these needs.



## 2024 Space Weather Tabletop Exercise (TTX)

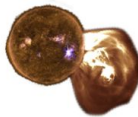
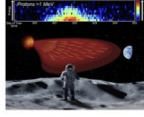
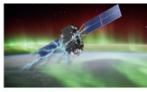

The Space Weather TTX will simulate a space weather event with widespread impact on the nation's critical infrastructure and space assets to gauge the national response, identify gaps, and enhance the nation's space weather preparedness. Participants include federal, state, and local agencies.

### First end-to-end Space Weather Tabletop Exercise (TTX)



IMPLEMENTATION PLAN OF THE NATIONAL SPACE WEATHER STRATEGY AND ACTION PLAN

- New national Space Weather strategy released in Dec 2023
- Section 3.5 calls for exercises to gauge national preparedness & identify gaps
- NASA, NOAA, and NSF sponsoring Space Weather TTX
- Managed, designed, and conducted at APL on May 8<sup>th</sup> and 9<sup>th</sup>, 2024
- Multiple federal, state, and local agencies involved

	Module 1	Module 2	Module 3	Modules 4 and 5
Scenario	 Solar Drivers	 Solar radiation storm	 CME impact	 Geomagnetic storms and aftermath





# Space Weather Advisory Group (SWAG)

**Purpose:** Advises the White House Space Weather Subcommittee (SWORM) on facilitating advances in the space weather (SWx) enterprise

## Released a Recommendations Report in April 2023

- o **Identified 25 findings with 56 recommendations**
  - o Directed to NOAA, NASA, NSF, and Department of Defense
  - o If implemented, will provide the resources, processes, support, and structure to **foster transformative change across the national SWx enterprise**
- o **Effort underway to develop a one-NOAA strategy among NOAA line offices:**
  - o National Environmental Satellite, Data, and Information Service (NESDIS)
  - o National Weather Service (NWS)
  - o Office of Oceanic and Atmospheric Research (OAR)

**Goal:** Space weather is an integrated, properly resourced, end-to-end function fueled by healthy connective tissue that empowers decision-makers and cultivates a society ready, responsive, and resilient to SWx impacts.



# One-NOAA SWx Strategy: Why This, Why Now?

Keeping the status quo will not meet our end users' needs and does not comply with provisions of **PROSWIFT Act**. We need to respond to **national directives** that call for advancing the SWx enterprise to fill critical gaps:

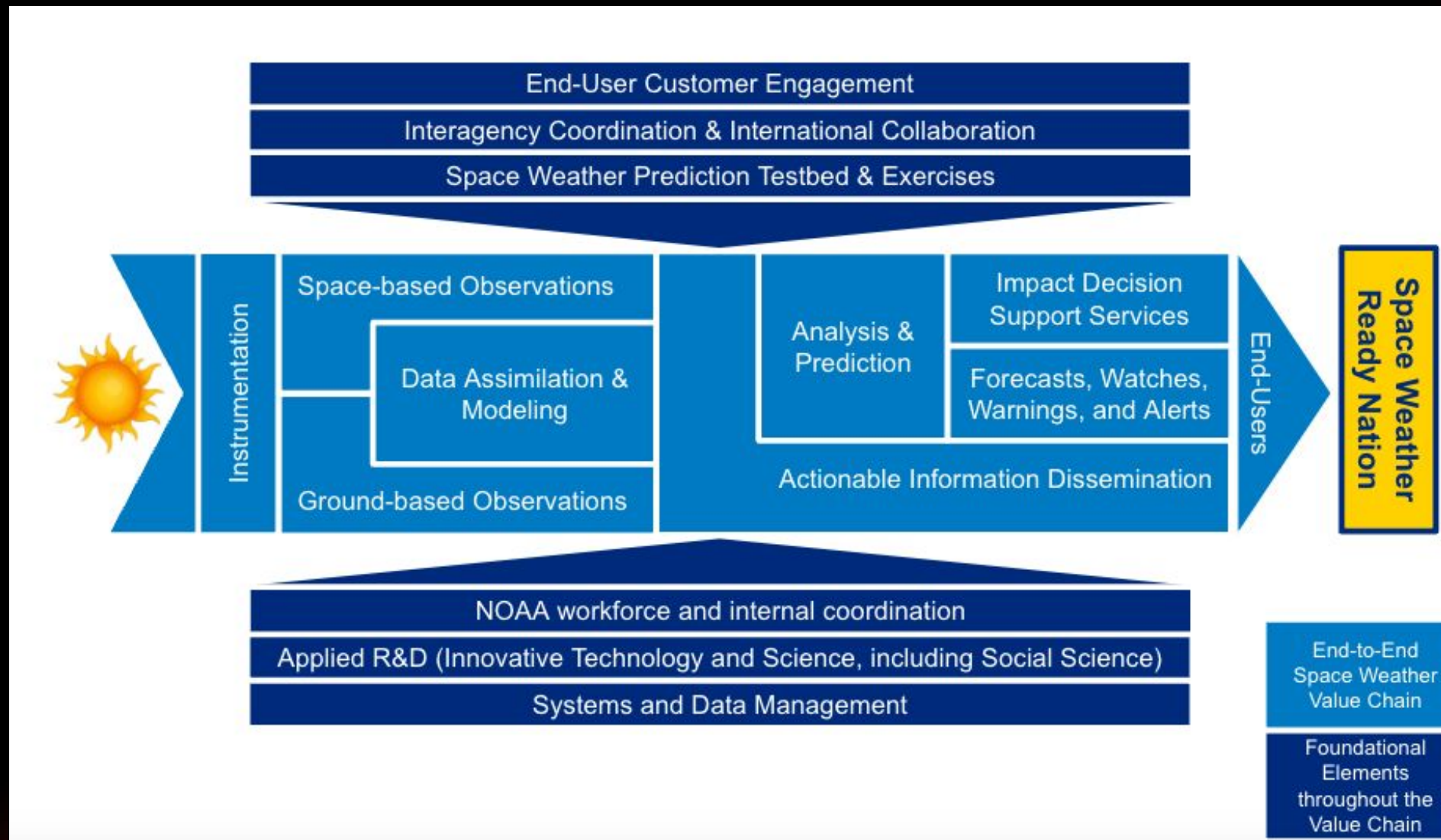
- Space Weather Operations, Research, and Mitigation (SWORM) Interagency Subcommittee identified the **absence of a formal framework** for sustaining and transitioning models and observational capabilities from R2O2R.
- Space Weather Advisory Group (SWAG) recommended NOAA develop internal strategies to **ensure agency-wide coordinated implementation of PROSWIFT** and their national space weather policy responsibilities—both overall and within each service office.

Moreover, **NOAA's 2023-2027 Weather, Water, and Climate strategy** identified SWx as one of six critical challenges that NOAA must address.





# One-NOAA Space Weather Value Chain



# Achieving the Future State

## What makes it hard?

- Space Weather is perceived as “good enough”
- Lack of cross-organizational engagement and commitment to Space Weather enterprise
- Resource prioritization managed as a zero-sum game

## What will help accelerate our efforts?

- Building upon the energy and momentum of the Space Weather Follow On and Space Weather Next Programs, Quad Agency MOA, establishment of Space Weather Testbed
- Engaging with the Space Weather Advisory Group
- Enduring cross-NOAA focus on Space Weather integration

## What shifts in mindset or behaviors are needed?

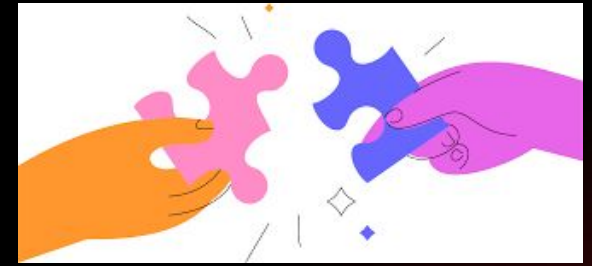
- Operating as if we are entitled to “take the reigns” for the Space Weather enterprise
- Leading with a “big hat” or end-to-end mindset





# NOAA/NESDIS Joint Venture Program

Leveraging capabilities being developed by other federal partners & industry to provide high return on funds



## Recent and Current Space Weather Projects

- Improving Thermospheric Density Forecast Capabilities through Utilization of SpaceX/Starlink Satellite Data, PI: Dr. Eric Sutton, University of Colorado, Boulder
- Solar Sail Fabrication, NeXolve0
- Tiny Remote-sensing Instrument for Thermospheric Oxygen and Nitrogen, PI: Bruce Fritz, NRL
- Additional 3 new space weather projects in FY24 (to be awarded soon)

# NOAA SBIR Program

Six critical challenges that highlight important NOAA mission and research priorities

- 9.1 Extreme Events and Cascading Hazards
- 9.2 Coastal Resilience
- 9.3 The Changing Ocean
- 9.4 Water Availability, Quality, and Risk
- **9.5 Effects of Space Weather**
- 9.6 Monitoring and Modeling for Climate Change Mitigation

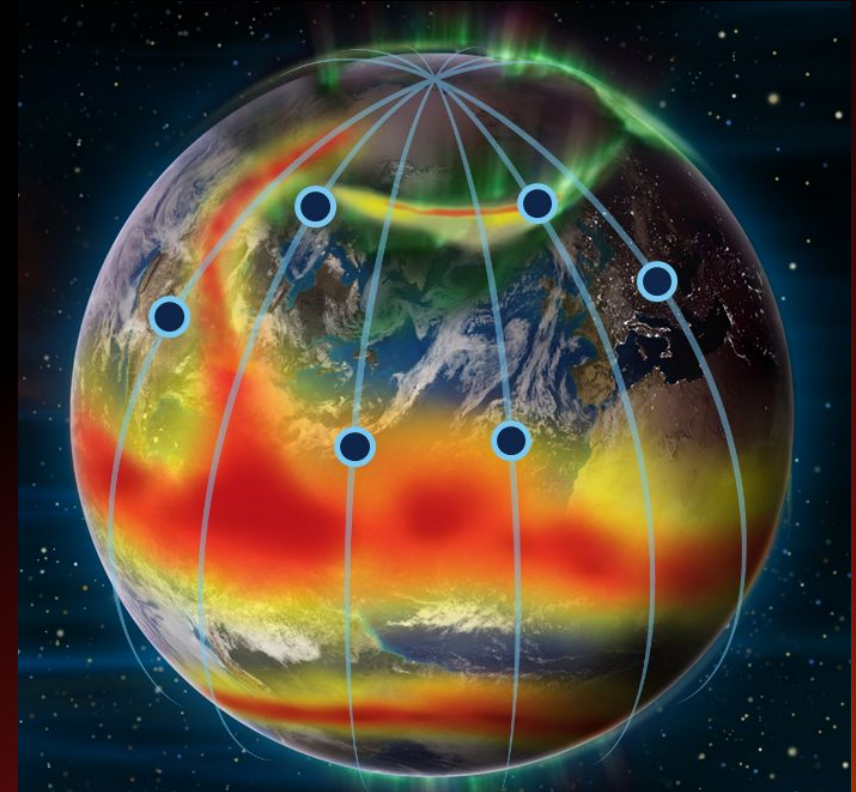


POWERED BY



# NOAA use of GDC Observations

- NOAA observation requirements cross referenced to GDC capabilities such as magnetic field, neutral wind, I-T characteristics, total electron content and energetic particle populations and precipitation.
- Assessment of geomagnetic disturbances from GDC **will enable space weather predictions of ground level technological events, e.g. GICs in the power grid** among others.
- Assessing the radiation environment from GDC impacting spacecraft systems and human exposure.



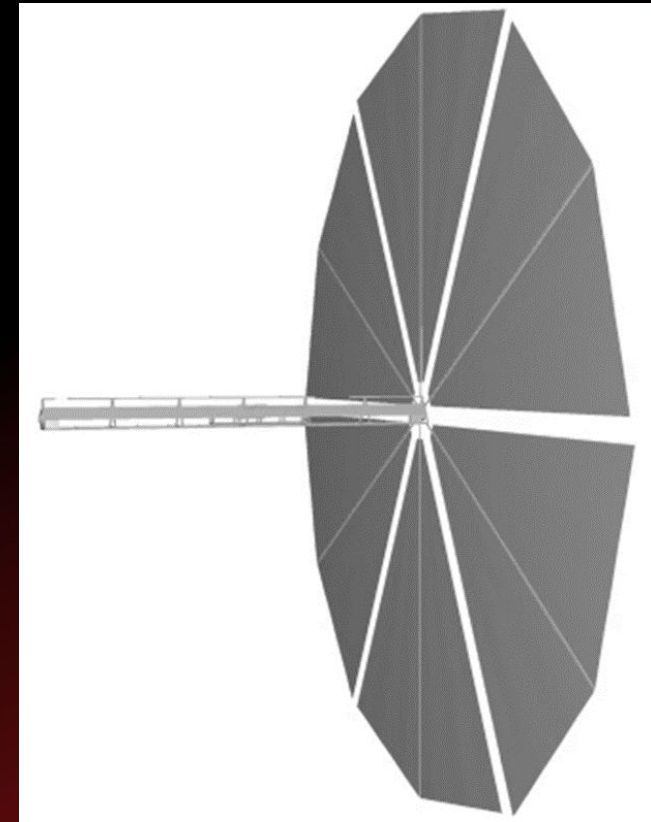
- From the IRB (Sept. 2022): GDC observations of I-T conditions will lead to “improvements in I-T models that are foundational to Space Situational Awareness and Space Weather prediction.”



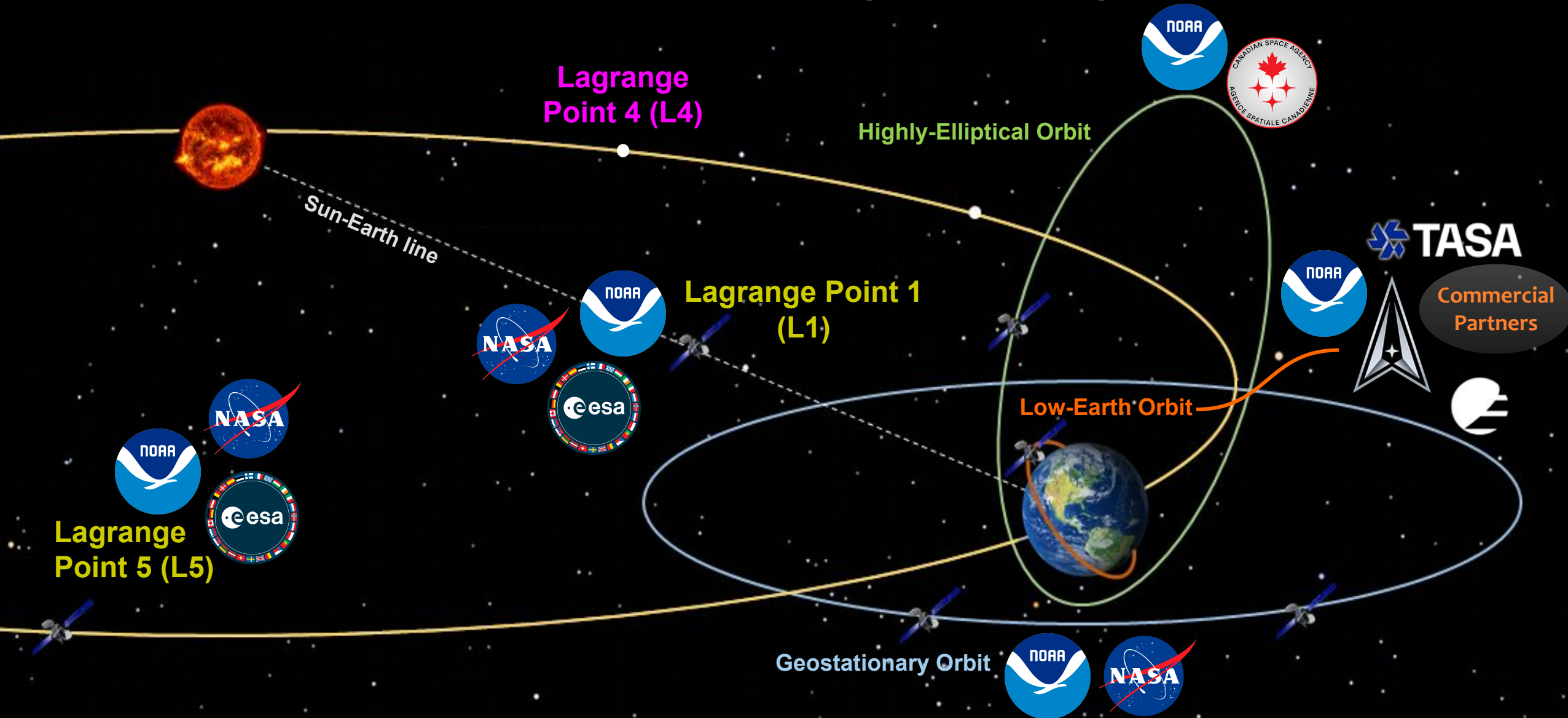


# Solar Sail Technology Optimization for Space Weather Observations

- **NESDIS is supporting several efforts related to solar sail technology**
  - Evaluating cost and design to acquire sail/sensor interaction data from a future solar sail flight demo
  - Examining and characterize conflict between thrust Vector angle and line of sight for use of a comm/sail at L5
  - Examining sail-embedded antennas and developing compact science payloads for solar sail missions
- **Solar Sail propulsion remains the most promising technology to increase lead time from geomagnetic storm alerts.** Much technical risk will be retired with the Solar Cruiser mission. The issue of sail/sensor impact will need to be resolved on a future mission, but sensor accommodation will not be challenging or very costly.



# A Planetary System Observing Challenge, Met By ...



... Merging Research (NASA, ESA) and Operational (NOAA) Observations



# Thank You!



## Total Solar Eclipse

### April 8, 2024

[nesdis.noaa.gov/events/total-solar-eclipse](https://nesdis.noaa.gov/events/total-solar-eclipse)



# Key Implementation Plan Actions

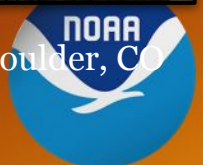
- **Quad MOA to implement R2O2R framework signed! (Action 2.7.2)**
  - Dept of Air Force, NSF, NASA, and NOAA
  - To encourage and support interagency collaboration
  - Meet Agency PROSWIFT Act Obligations
  - Advance the Nation's space weather R2O2R capabilities
- **Space Weather Prediction Testbed (SWPT) (Action 2.7.3)**
  - A key component of the formal R2O2R Framework
  - Will expand collaboration between researchers, developers, forecasters, and customers to validate, demonstrate, and accelerate the transition of advanced cutting-edge innovations and technology into operations
  - Demonstrated initial success in testbed exercises with Aviation industry (2022) and Satellite industry (2023)
  - **Buildout of the testbed will begin this year!**



News story links: [Spacenews](#), [NOAA](#), [NASA](#)



Testbed exercise with satellite industry held in Boulder, CO



# Overview of Implementation Plan of the NSW-SAP

**NSW-SAP Objective 1:** Enhance the protection of national security, homeland security, and commercial assets and operations against the effects of space weather.

- **27 Implementation Plan Actions**

**NSW-SAP Objective 2:** Develop and disseminate accurate and timely information of space weather characterization and forecasts.

- **49 Implementation Plan Actions**

**NSW-SAP Objective 3:** Establish plans and procedures for responding to and recovering from space weather events.

- **17 Implementation Plan Actions**

**TOTAL Implementation Plan Actions = 93**



## IMPLEMENTATION PLAN OF THE NATIONAL SPACE WEATHER STRATEGY AND ACTION PLAN

A Report by the  
SPACE WEATHER OPERATIONS,  
RESEARCH, & MITIGATION SUBCOMMITTEE  
COMMITTEE ON HOMELAND & NATIONAL SECURITY

of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

DECEMBER 2023

[Link to the Implementation Plan](#)

Implementation Plan detailed discussion with SWAG/SWORM: Today @ 12:15-1:15, Key 11 (Second Floor, Hilton Baltimore Inner Harbor)



# NOAA Space Weather Prediction Center (SWPC)

*Safeguarding society with actionable space weather information*

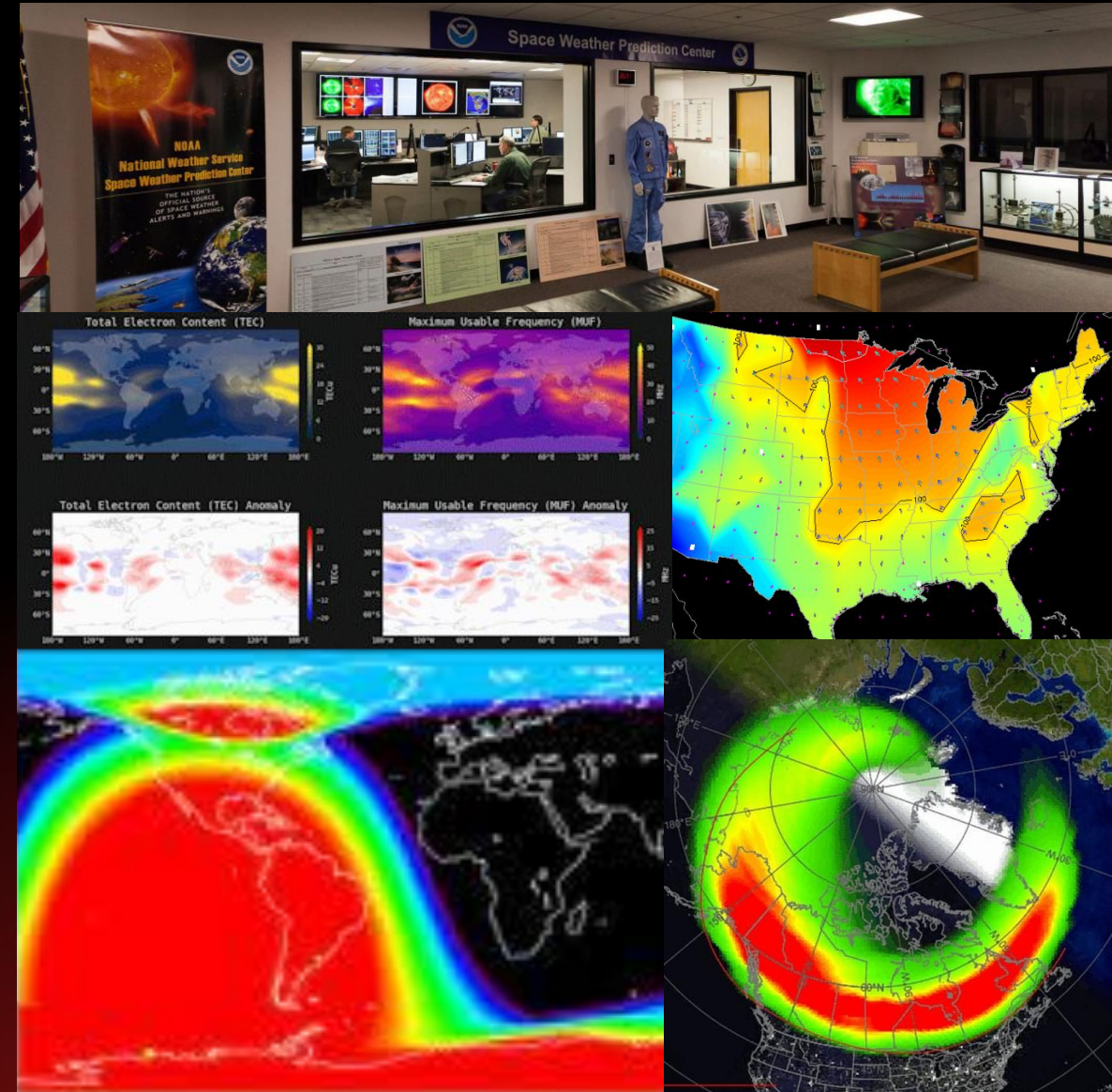
24/7 National Center: Alerts, Watches and Warnings

NOAA Space Weather Scales:

- Geomagnetic Storms
- Solar Radiation Storms
- Solar Flare Radio Blackouts

Global provider of operational space weather models and observations

USAF (557th Weather Wing) provides space weather services in support of DOD



# PROSWIFT Act

Building Resilience by advancing the Space Weather Enterprise

White House Space Weather Operations, Research, and Mitigation (SWORM) Subcommittee

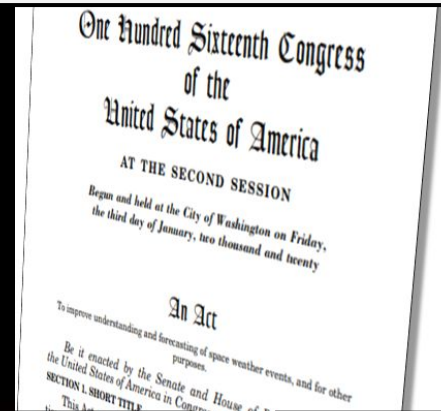
PROSWIFT §60601

34 Federal Departments, Agencies and Offices

~ 50 principal members, 100+ SMEs



Advices the SWORM



Facilitate communication and knowledge transfer



Space Weather Advisory Group

PROSWIFT §60601

15 non-governmental members: Commercial, Academic, End User

National Academy

Space Weather Roundtable

PROSWIFT §60606

20 members: SWORM, Academic, and Commercial

