



# SWO: NOAA's Next Generation of Space Weather Observations

National Environmental Satellite,  
Data, and Information Service

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**Director, Space Weather Observations**

# Space-Based Monitoring at NESDIS

## NESDIS's 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:

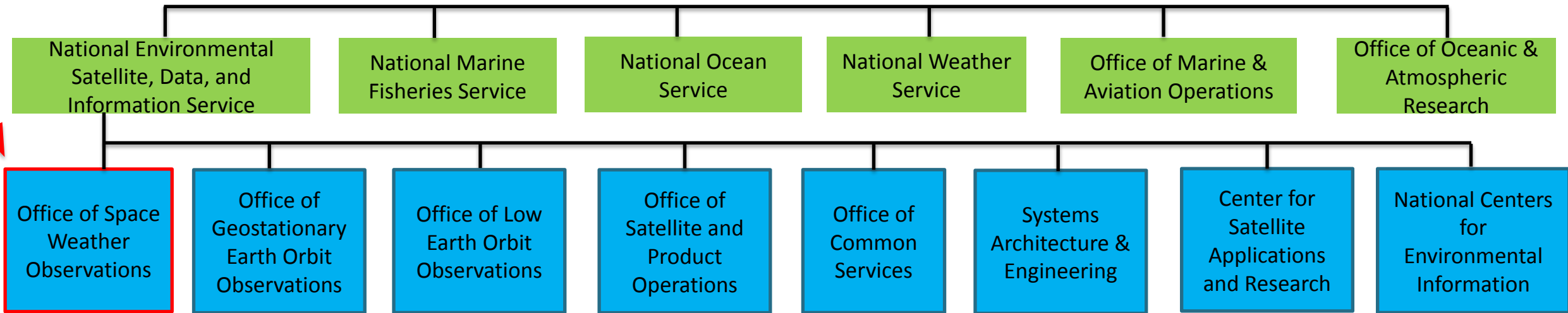
*Advance Space Weather observational leadership in LEO, GEO, and extended orbits consistent with the agency's responsibilities within the National Space Weather Strategy and Action Plan.*



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

# Establishment of the Office of Space Weather Observations

- The 2023 Consolidated Appropriations Act establishes the Office of Space Weather Observations (SWO) (Renaming the Office of Projects Planning and Analysis).
- SWO manages two main programs: Space Weather Follow-on (SWFO) and Space Weather Next (SW Next).



# 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.

- **Development underway for:**
  - SWFO-L1 Observatory
  - Instruments (CCORs, MAG, SWiPS, STIS)
  - Ground Segment (Command & Control, SWFO Antenna Network, and Product Generation and Distribution)
- **Established agreements** with NASA, NRL, and European Space Agency (L1 & L5 cooperation)
- **Completed SWFO Program & Flight Project Critical Design Reviews** (May 2022)
- **On track for launches** in 2024 (GOES-U Mission) and 2025 (SWFO L1 Mission)



**CCOR-1 integration onto GOES-U**  
Image Credit: Lockheed Martin

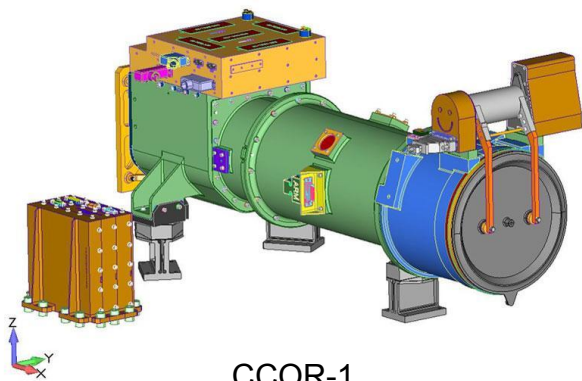


**Spacecraft assembly**  
Image credit: Ball Aerospace



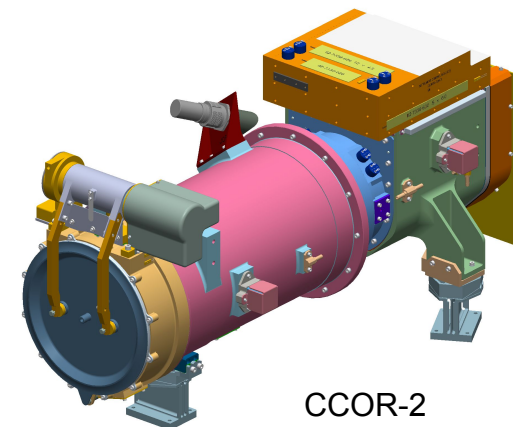
**SWFO-L1 Spacecraft**  
Image Credit: Ball Aerospace

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



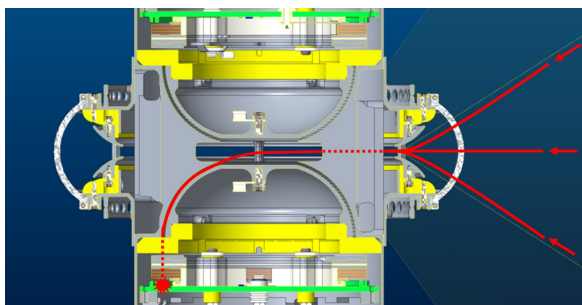
CCOR-1

**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.

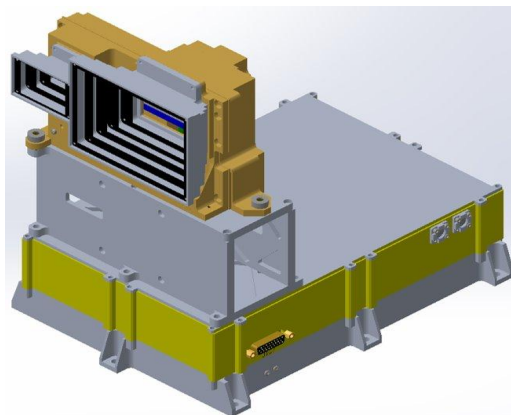


CCOR-2

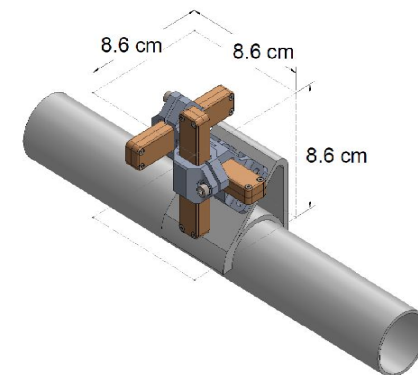
**Solar Wind Plasma Sensor (SWiPS):** Built by Southwest Research Institute (SwRI), it will measure properties of the solar wind plasma flowing past SWFO-L1, such as density, velocity, and temperature.



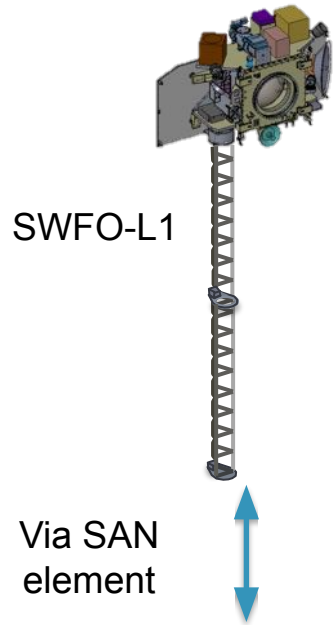
**Suprathermal Ion Sensor (STIS):** Developed by University of California, Berkeley, it will collect fast ions in the solar wind.



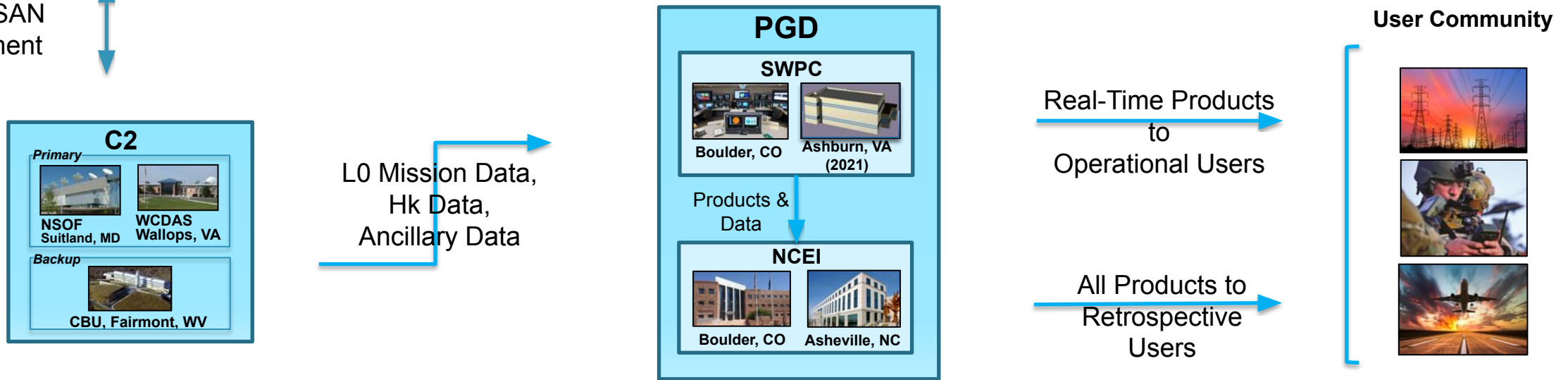
**Magnetometer (MAG):** Developed by the University of New Hampshire and SwRI, it will measure the magnetic field carried by the solar wind.



# An Upgraded Ground Segment for SWFO



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. (\*)

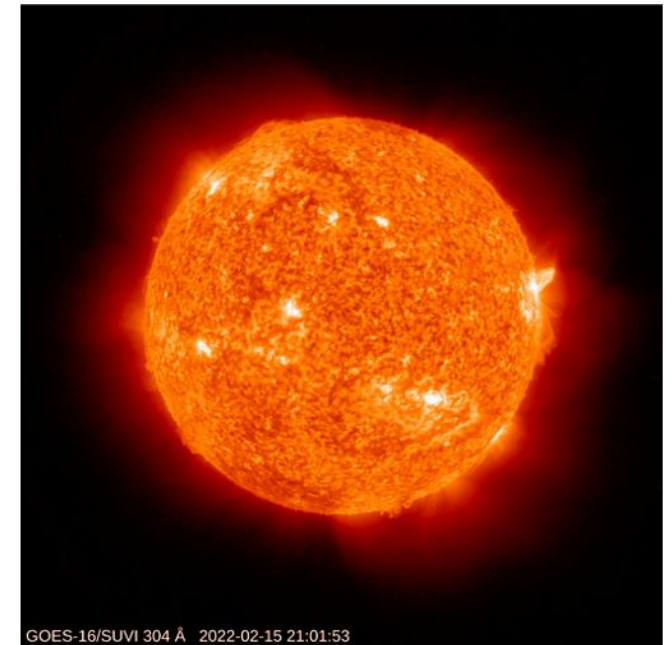


\*In addition, SWPC receives GOES-U CCOR-1 data via the GOES-R Ground Segment (GS)

# Space Weather Next (SW Next) program

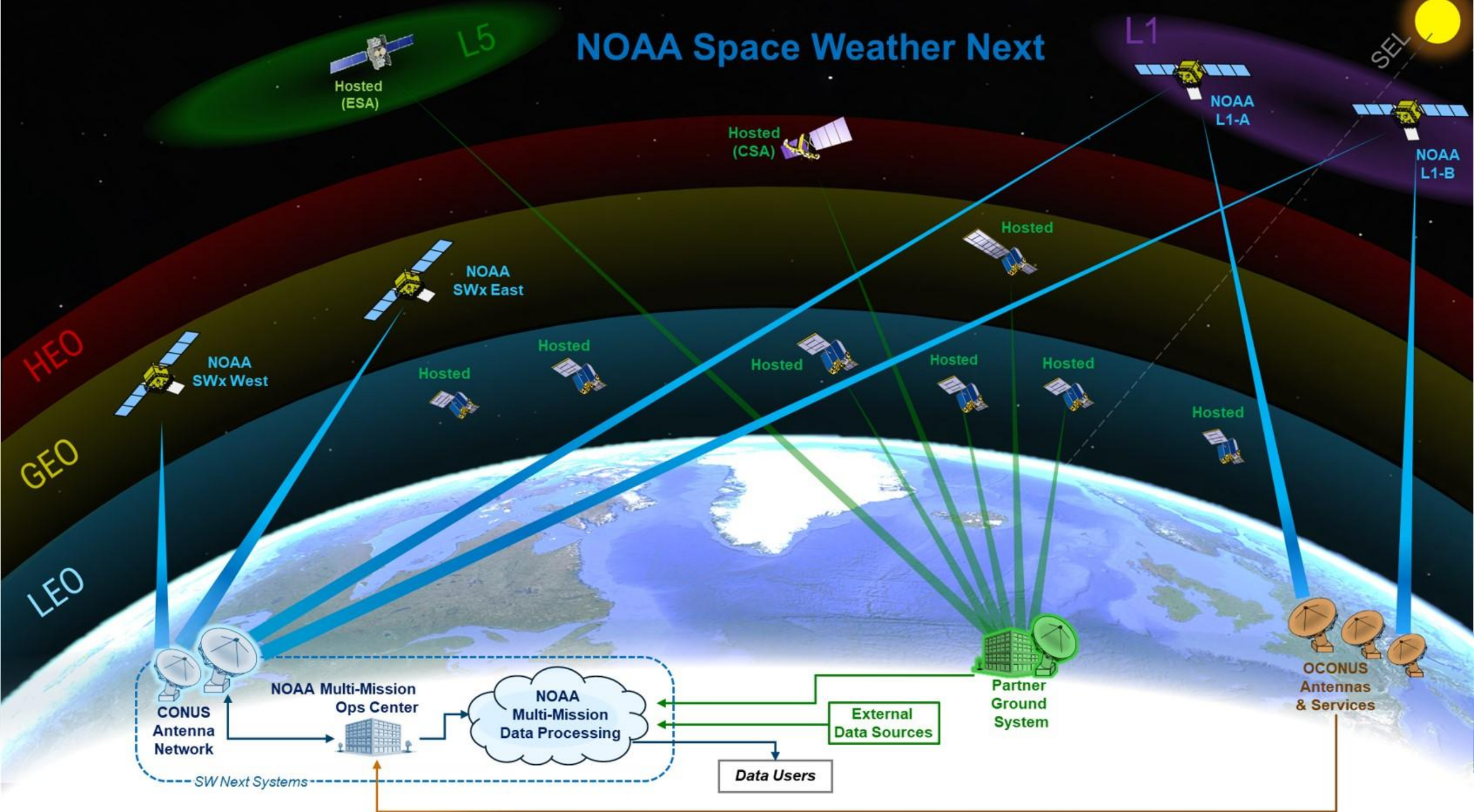
SW Next will **maintain and extend** space weather observations from a range of different observing points, selected to most efficiently provide comprehensive knowledge of the Sun and the near-Earth space environment.

- Planning for **continuity of 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



GOES-16/SUVI 304 Å 2022-02-15 21:01:53

# NOAA Space Weather Next





# Space Weather Next L1 Series Project

- Project team completed **Mission Concept Review on March 27-28**.
  - Project Level 1 & Level 2 Requirements documents are in development.
  - KDP-A is planned for July 2023. DOC Milestone 2 planned for Q2 FY2024.
- Acquisition strategy is in review.
- Five Commercial Coronagraph Studies have been awarded to:
  - Johns Hopkins Applied Physics Lab (APL); Laurel, MD
  - EO Vista; Acton, MA
  - University of Colorado, Laboratory for Atmospheric and Space Physics (LASP); Boulder, CO
  - Raytheon Intelligence & Space; El Segundo, CA
  - Southwest Research Institute (SwRI); Boulder, CO
- Spacecraft and other instrument procurements are in development.

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

# NOAA-ESA L5 Collaboration Project

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

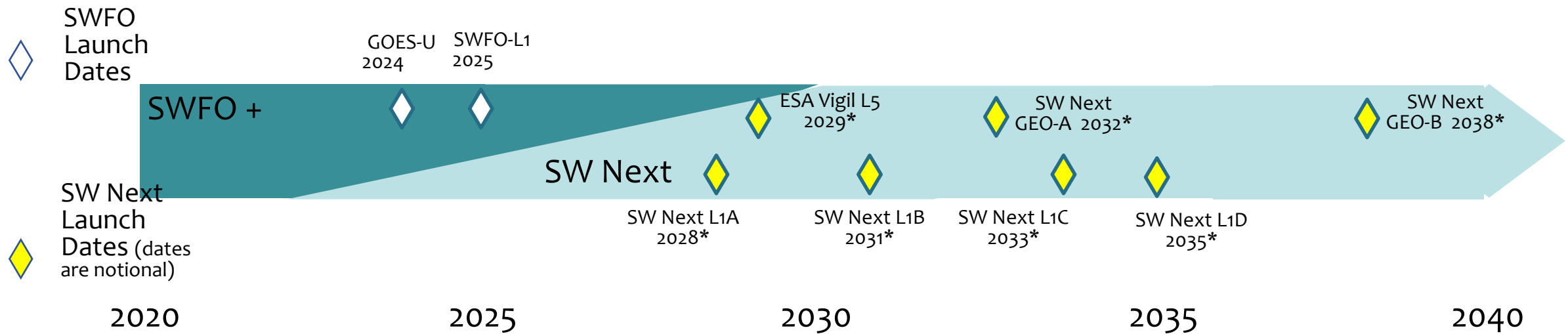
The agreement includes:

- NESDIS provision of a Compact Coronagraph to fly on Vigil mission to L5  
Status:
  - Compact Coronagraph (CCOR-3) being built by NRL as a near-copy of the CCOR-2 on SWFO-L1.
  - SW Next is defining CCOR-3 Level 0 data receipt and processing requirements.
- Exchange of data from all SWFO and Vigil instruments
  - SW Next is defining product interface and distribution requirements.



**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.**

# Preparing for a Space Weather Ready Nation



- Current **notional, unofficial** flyout chart of our planned SWO architecture
- The first SW Next L1 launch is planned to overlap with SWFO for calibration and validation
- Planned architecture supports resiliency of observations at L1 and at GEO for critical observations

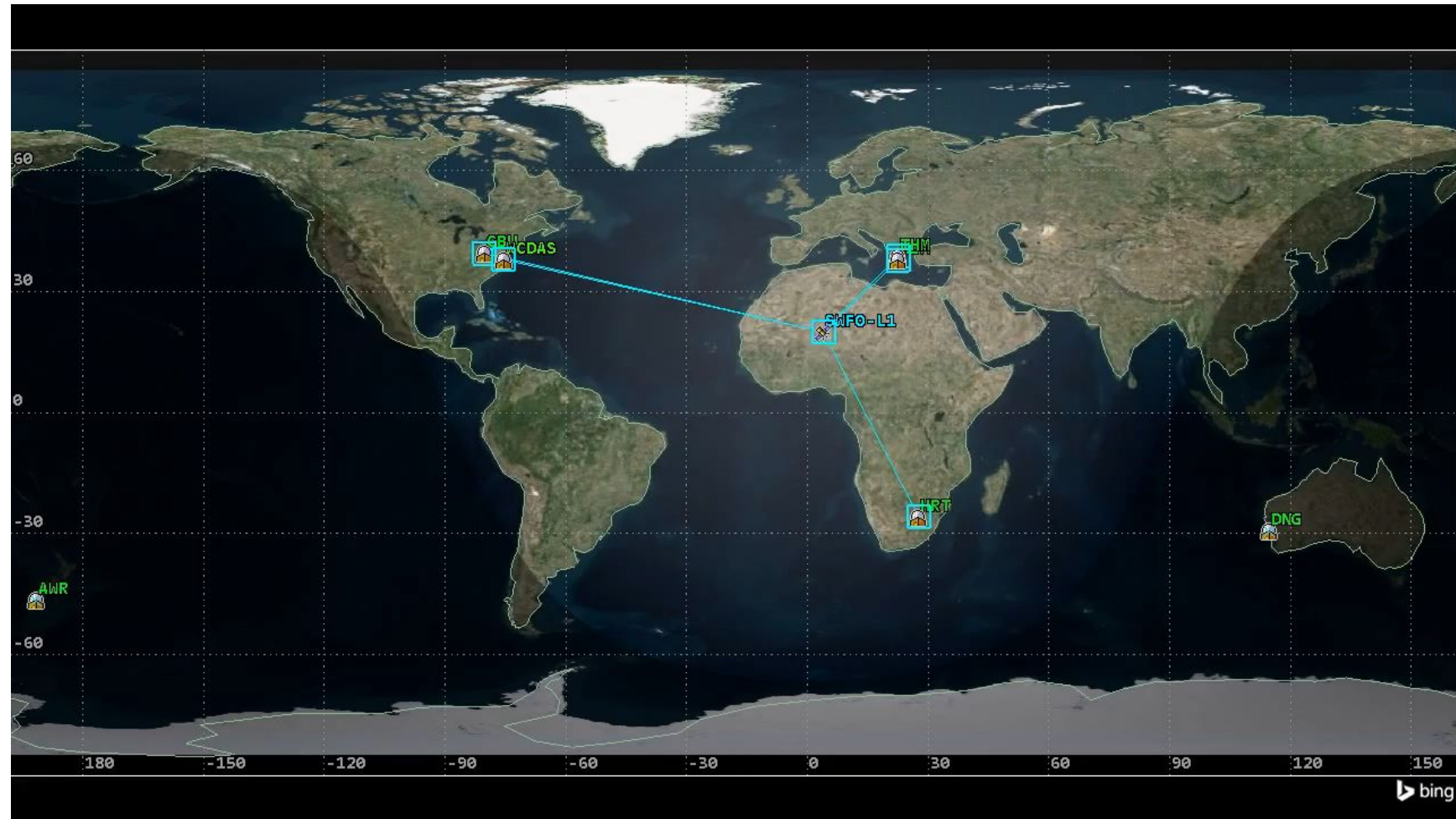
Thank You!



# SWFO: Worldwide Ground Antenna Network

As the Earth rotates below the Sun, and below the spacecraft, any given ground station can only observe the spacecraft for at most 8 hours.

Thus, the SWFO Program is building a network of 6 station (3 primary and 3 backup) in the continental US, New Zealand, Australia, and S. Europe.





# SWFO Next Steps

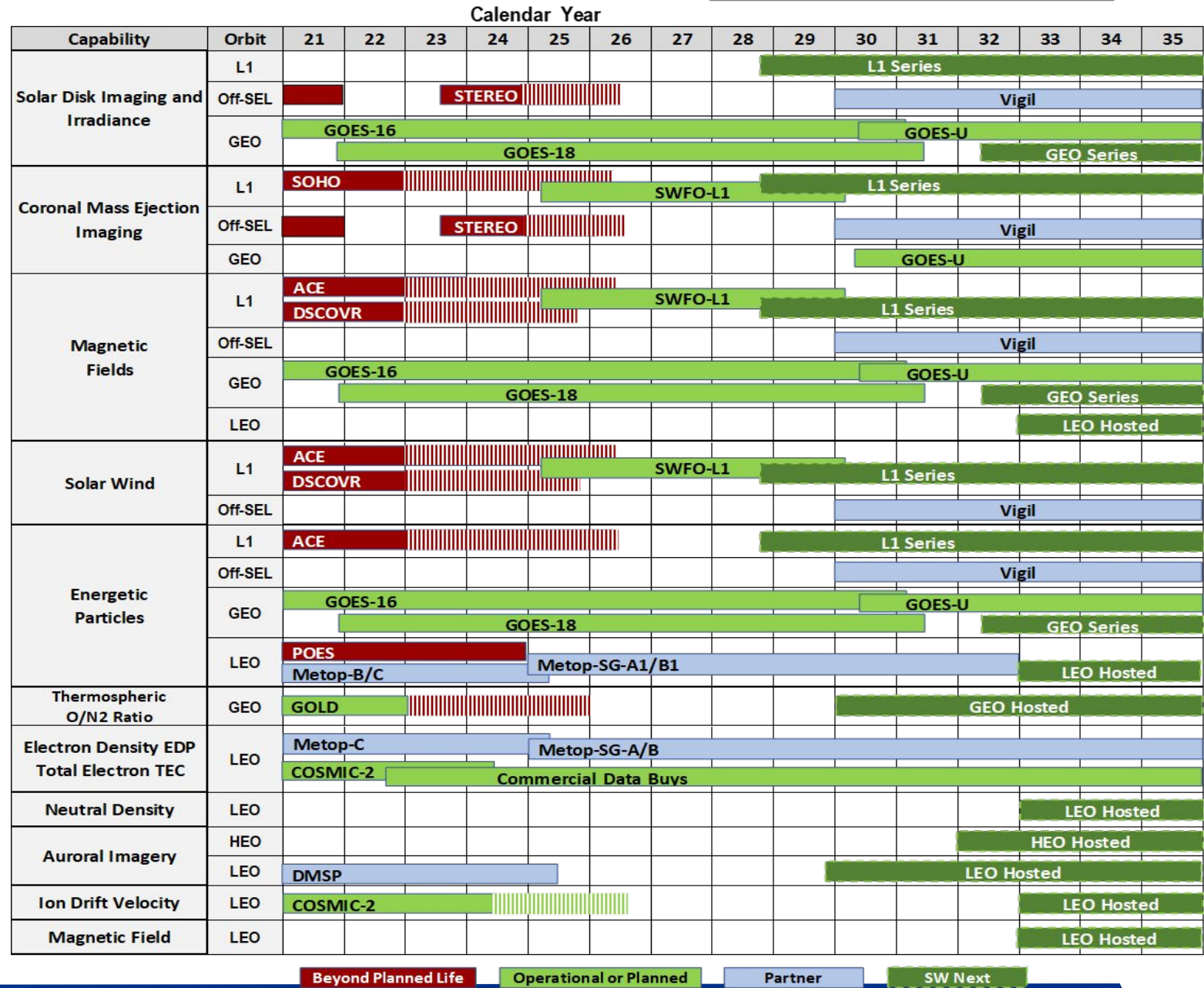
SWFO Event/Activity	Status
NOAA-European Space Agency (ESA) Agreement Signed	Completed
SWFO Program Critical Design Review	Completed
Flight Project Critical Design Review	Completed
CCOR-1 Pre-Ship Review	Completed
CCOR-2 Pre-Environmental Review	Completed
Construction of new ground antennas at Wallops Command and Data Acquisition Station and consolidated backup in Fairmont, WV	Ongoing
Ship CCOR-2 FM to Spacecraft	Q4 FY23
MAG, SWiPS, and STIS Pre-Environmental Reviews	Q4 FY23
Mission Operations Review (MOR)	Q4 FY23

# SW Next projects and partnerships will provide necessary continuity.

NOAA and partner missions collect and exchange space weather observations needed by SWPC.

Many current platforms are beyond predicted end of life, and some new missions have lifespans short of 2030.

Notional Plans shown in dark green for SW Next, subject to approval and appropriations.



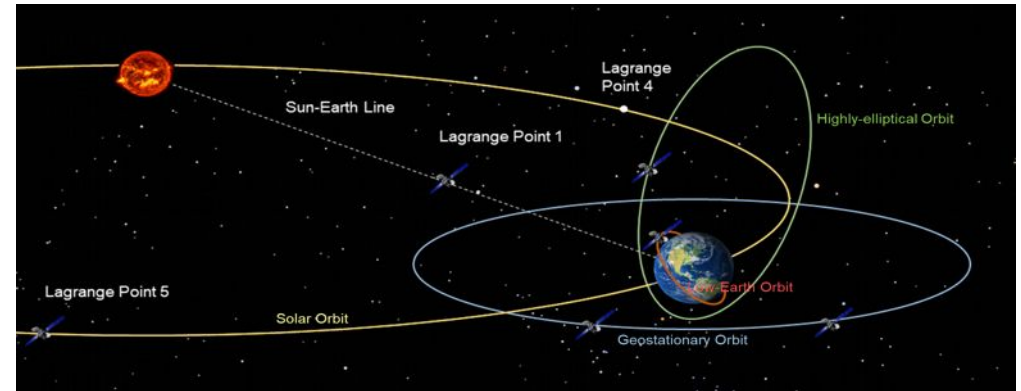
Beyond Planned Life
Operational or Planned
Partner
SW Next



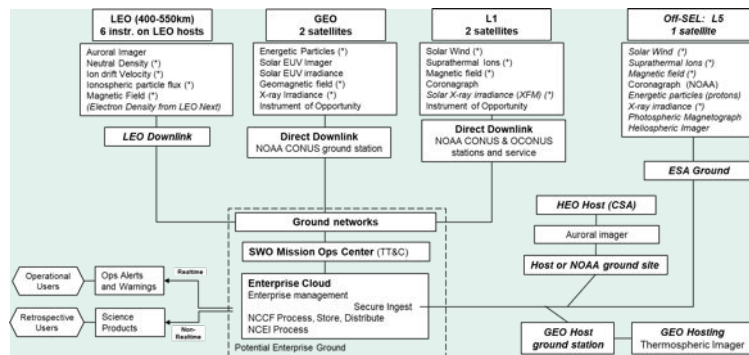


# From Strawman to Program Architecture

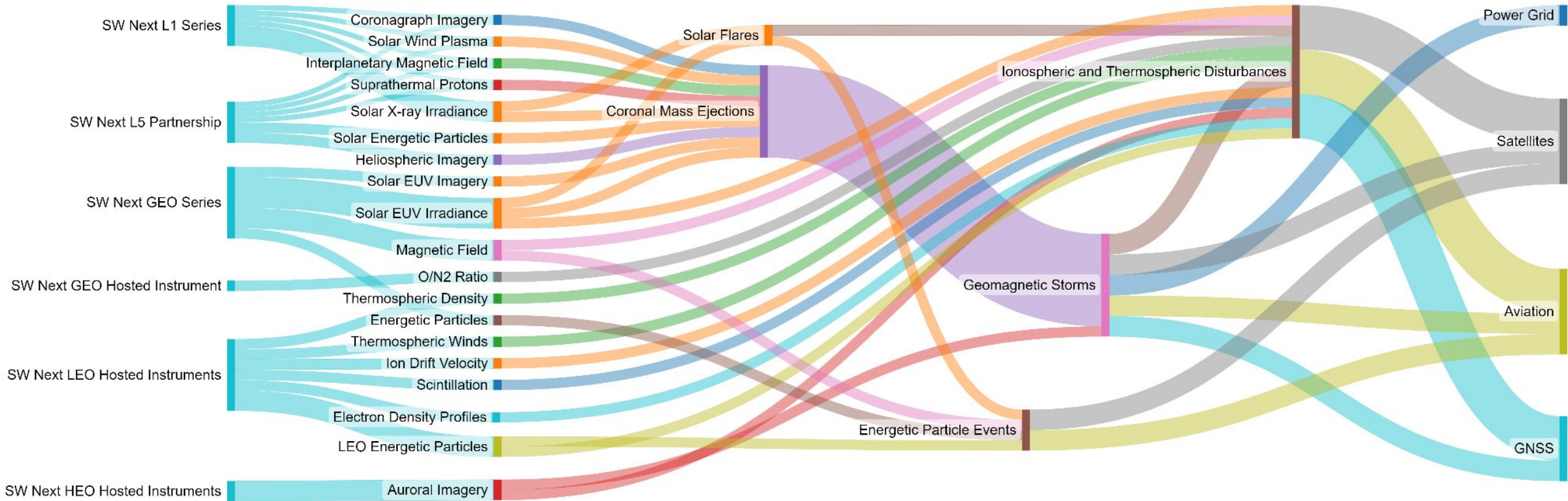
- The SW Next Program “initial” architecture contained assumptions:
  - about the location of some measurements (e.g., either L1 or GEO could satisfy a Sun-Earth Line measurement requirement)
  - about the implementation of space-ground communications and data handling systems



- Analysis of Alternatives (AoA) recommended instrument allocations and physical implementation options.



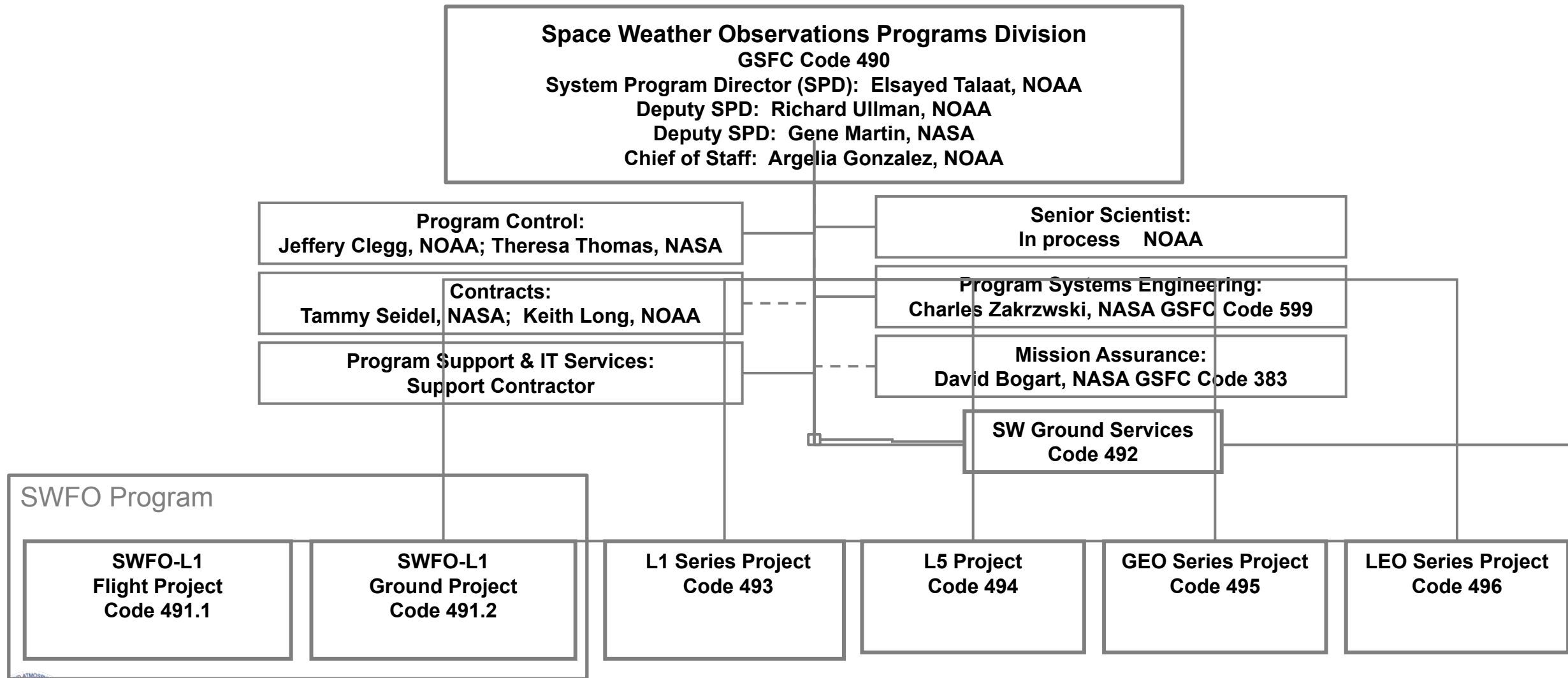
# User Engagements & Stakeholder Collaborations



Made with SankeyMATIC

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

# Joint NOAA/NASA Office

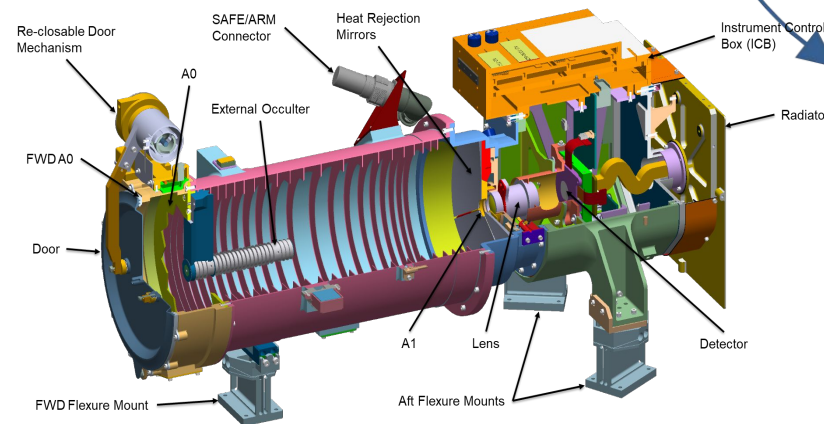
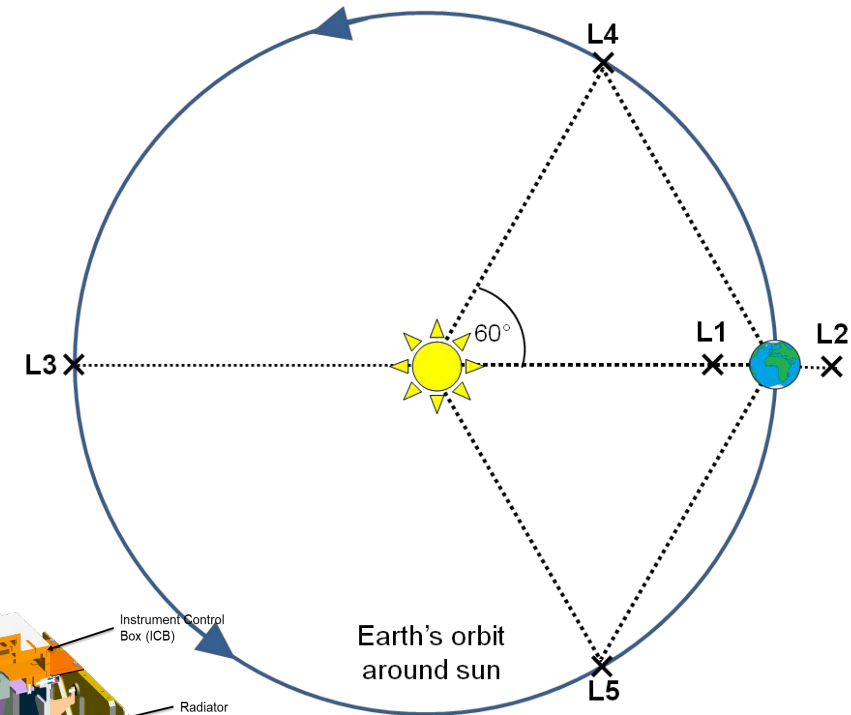


# CCOR-3 Status and Notional Milestones

- June 2023: CCOR-3 System Requirements Review
- March 2024 : CCOR-3 Preliminary Design Review
- October 2024: CCOR-3 Critical Design Review
- November 2026: CCOR-3 FM delivered to the VIGIL Spacecraft
- November 2029: Vigil Launch

**Lagrange 5 (L5) ESA-Hosted**

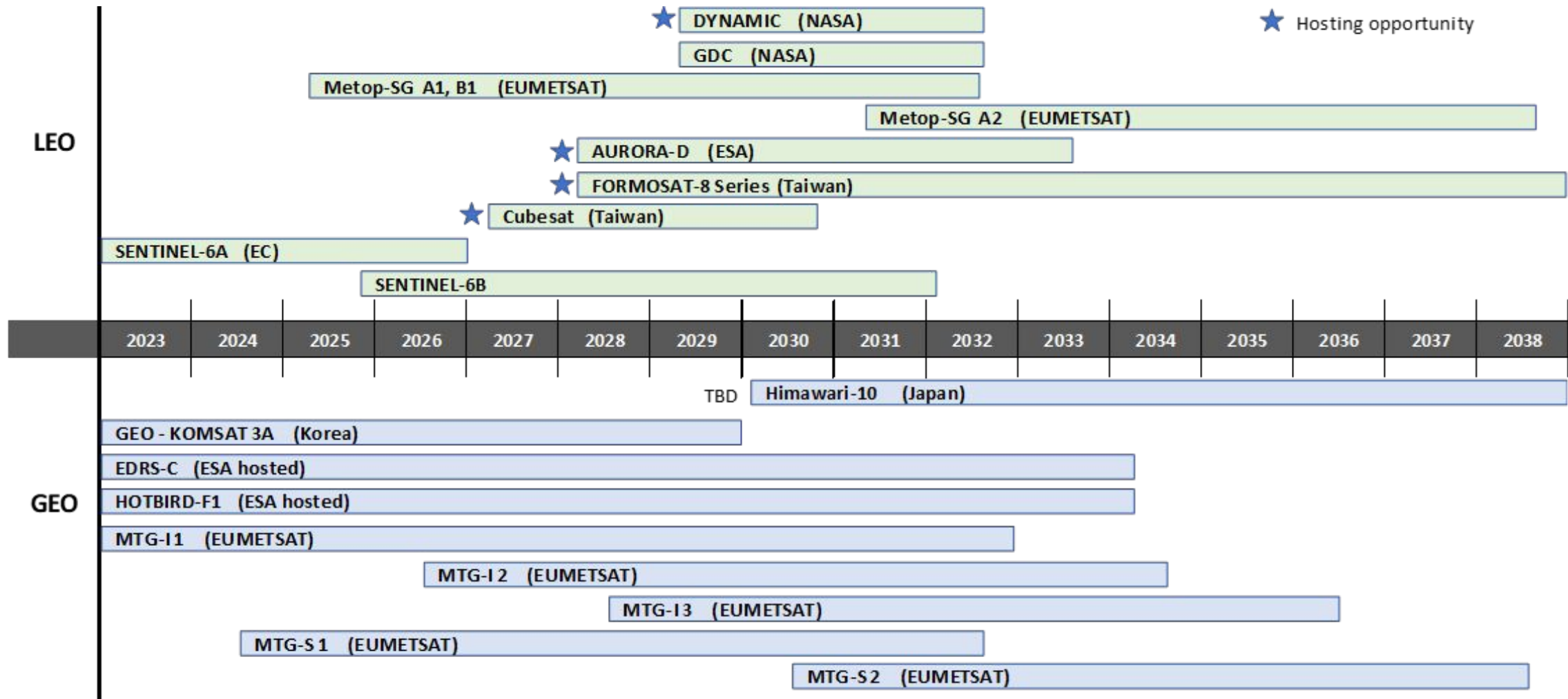
*Solar Wind Density, Temp, Velocity*  
*Heliospheric Suprathermal Proton Flux*  
*Interplanetary Magnetic Field*  
*Solar Energetic Particles*  
*X-ray Irradiance*  
*Photospheric Magnetogram*  
*Heliospheric Imagery*  
*Coronal White Light Imagery*



# SW Next Formulation Next Steps (FY22-FY23)

SW Next Formulation Event/Activity	Status
Baseline Program Requirements	Completed
NOAA Program Mission Concept Review / NASA System Requirements Review - <i>Program Technical Review</i>	Completed
DOC Program Milestone 1 - <i>Program Authorization</i>	Completed
NOAA/NASA Program Key Decision Point 0 - <i>Program Commitment</i>	Completed
Program System Definition Review	Completed
NOAA/NASA Program Key Decision Point I	Completed
NOAA/NASA L1 Series Project Mission Concept Review - <i>Project Technical Review</i>	Completed
NOAA/NASA L1 Series Project Key Decision Point A	July 2023
DOC L1 Series Project Milestone 2 - <i>Project Authorization</i>	Q2 FY24

# Examples of data sharing and instrument host opportunities being pursued



# Commercial Data Program (CDP)

- On November 10, 2021, a Request for Information (RFI) was posted to SAM.gov soliciting information on existing or planned commercial space weather data and related capabilities that will be available in the 2022 through 2028 timeframe
- On May 19, 2022 a Request for Proposal (RFP) to conduct a Commercial Weather Data Pilot (CWDP) Study of commercial space weather data sources and related capabilities that may help NOAA meet its space weather mission objectives
- On July 14, 2022, NOAA awarded three Commercial Weather Data Pilot (CWDP) space weather contracts to GeoOptics Inc. (Pasadena, CA), Space Sciences and Engineering LLC, dba PlanetiQ (Golden, CO), and Spire Global Subsidiary, Inc (San Francisco, CA)
- These contract awards constitute the next round of NOAA's CWDP studies with a particular focus on space weather data.