NOAA's Current and Future Space Weather Architecture

NOAA Satellite and Information Service
www.nesdis.noaa.gov

June 16, 2020

Dr. Elsayed Talaat
Director, Office of Projects, Planning, and Analysis

Infrastructure Workshop, National Academies of Science, Engineering and Medicine

NOAA Space Weather Prediction Center

- The Nation's official source of space weather alerts, watches and warnings

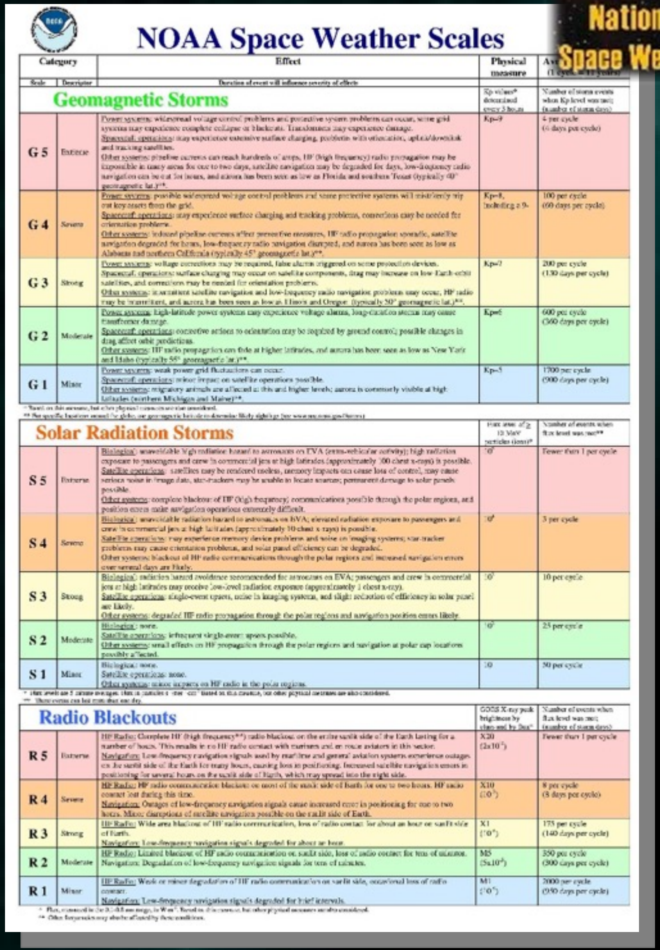
- Provides 24x7 analysis and forecasting of space weather storms

NOAA Space Weather Watches and Warnings are based on the NOAA Space Weather Scales:

Geomagnetic Storms (G-scale)
(Magnetic field)

Solar Radiation Storms (S-scale)
(Energetic charged particles)

Radio Blackouts (R-scale)
(Electromagnetic radiation)


NOAA Space Weather Scales

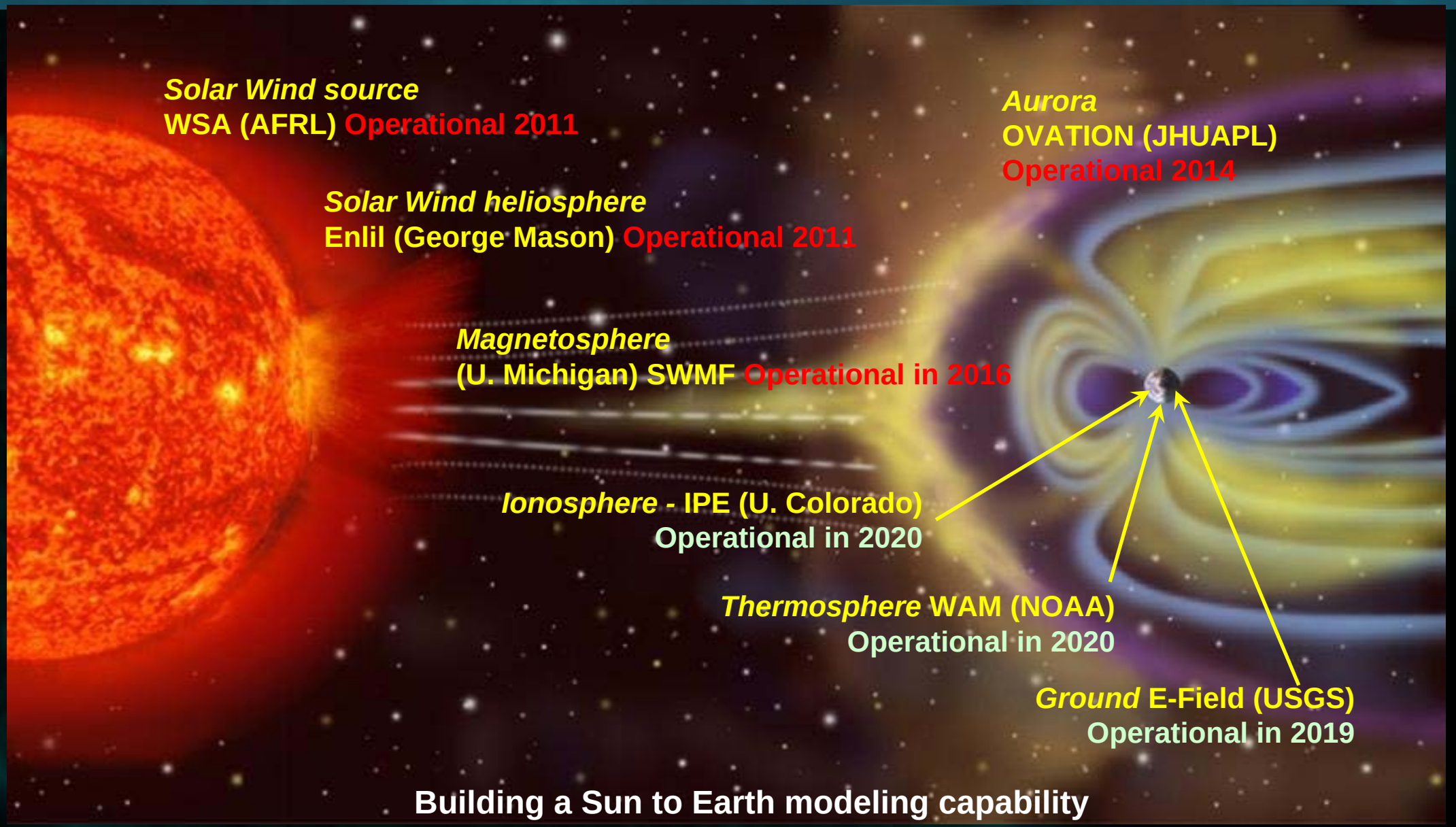
Geomagnetic Storms
G 5
G 4
G 3
G 2
G 1

Solar Radiation Storms
S 5
S 4
S 3
S 2
S 1

Radio Blackouts
R 5
R 4
R 3
R 2
R 1

DoD services provided by
USAF 557th Weather Wing

NOAA Space Weather Modeling



Pillars of NESDIS Observing System Implementation

Integrated, Adaptable and Affordable: Orbits, Instruments & Systems

GEO

Continuous real-time observations supporting warnings and watches of severe weather and hour-by-hour changes. High-inclination orbits to observe northern latitude & polar regions.

LEO

Miniaturized instruments on small, affordable and proliferated satellites and partner data improving forecasts through better and additional data. Better precipitation forecasts, wave height predictions, ocean currents, and more.

Space Weather

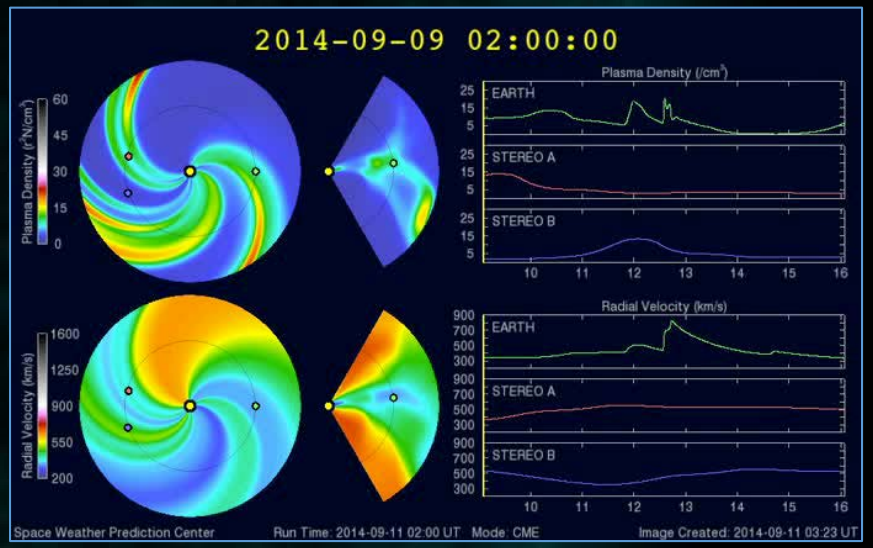
Reliably monitoring space weather from L1, GEO and LEO can protect the nation's valuable, vulnerable infrastructure. New capabilities at L5 and HEO can provide additional insight and improve forecasts.

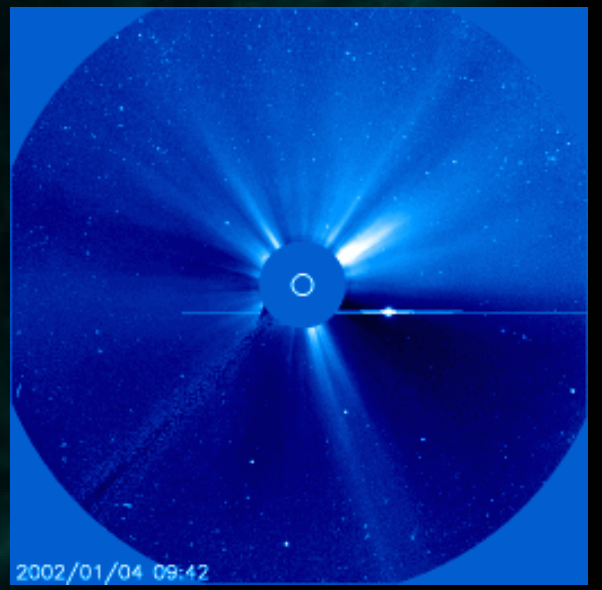
Common Ground Services

Secure ingest of data in different formats from different partners requires a flexible, scalable platform. Common Services approach integrates Cloud, AI and machine-learning capabilities to verify, calibrate and fuse data into new and better products and services.

Solar Wind and CME Imagery for Space Weather Prediction

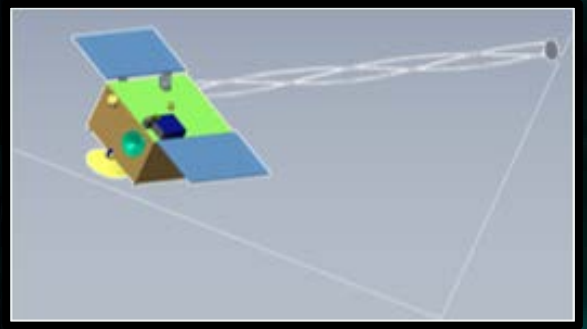
- The NWS Space Weather Prediction Center (SWPC) is the nation's official source of space weather Watches, Warnings and Alerts.
- Coronal Mass Ejection (CME) Imagery
  - Visible light imagery of CMEs used for 1-4 day warnings of geomagnetic storm conditions
  - Primary source: ESA/NASA Solar and Heliophysics Observatory (SOHO, 1995) - solar power limited to 2025
  - Backup: *none*
- Solar Wind In-Situ at Sun-Earth Lagrange – L1
  - Solar wind magnetic field and bulk plasma provide 15-60 minute warning of geomagnetic storm conditions
  - Primary source: NOAA/Deep Space Climate Observatory (DSCOVR), launch 2015
  - Backup: NASA Advanced Composition Explorer (ACE) launch 1997 – propulsion limited to 2026





SWFO Program Key Technical Components

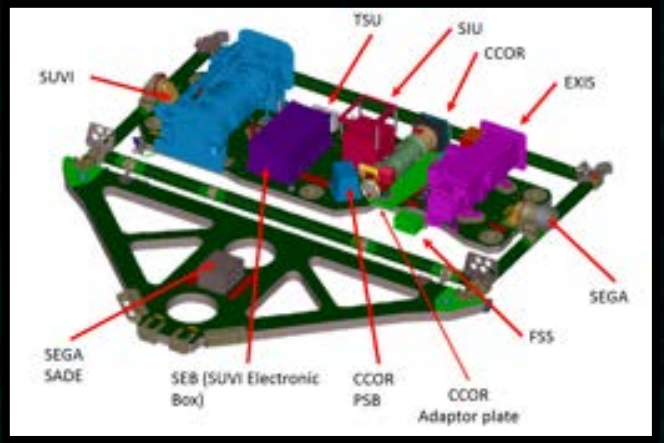
3-Axis Stabilized ESPA Class Spacecraft



Compact Coronagraph (CCOR)

GOES-U Solar Pointing Platform (SPP)

CCOR + SUVI + EXIS



SWFO-L1 Mission Overview

- Space Weather Operational Observation at Earth-Sun Lagrange Point 1
- IAA with NASA to procure an ESPA Grande compatible spacecraft
- SWIS (Solar Wind Instrument Suite) awards nearly complete, CCOR in Phase D
- NOAA ground services
- Rideshare with NASA IMAP
- Nominal launch: 2024
- Potential ESA contributed instrument (X-Ray flux monitor)

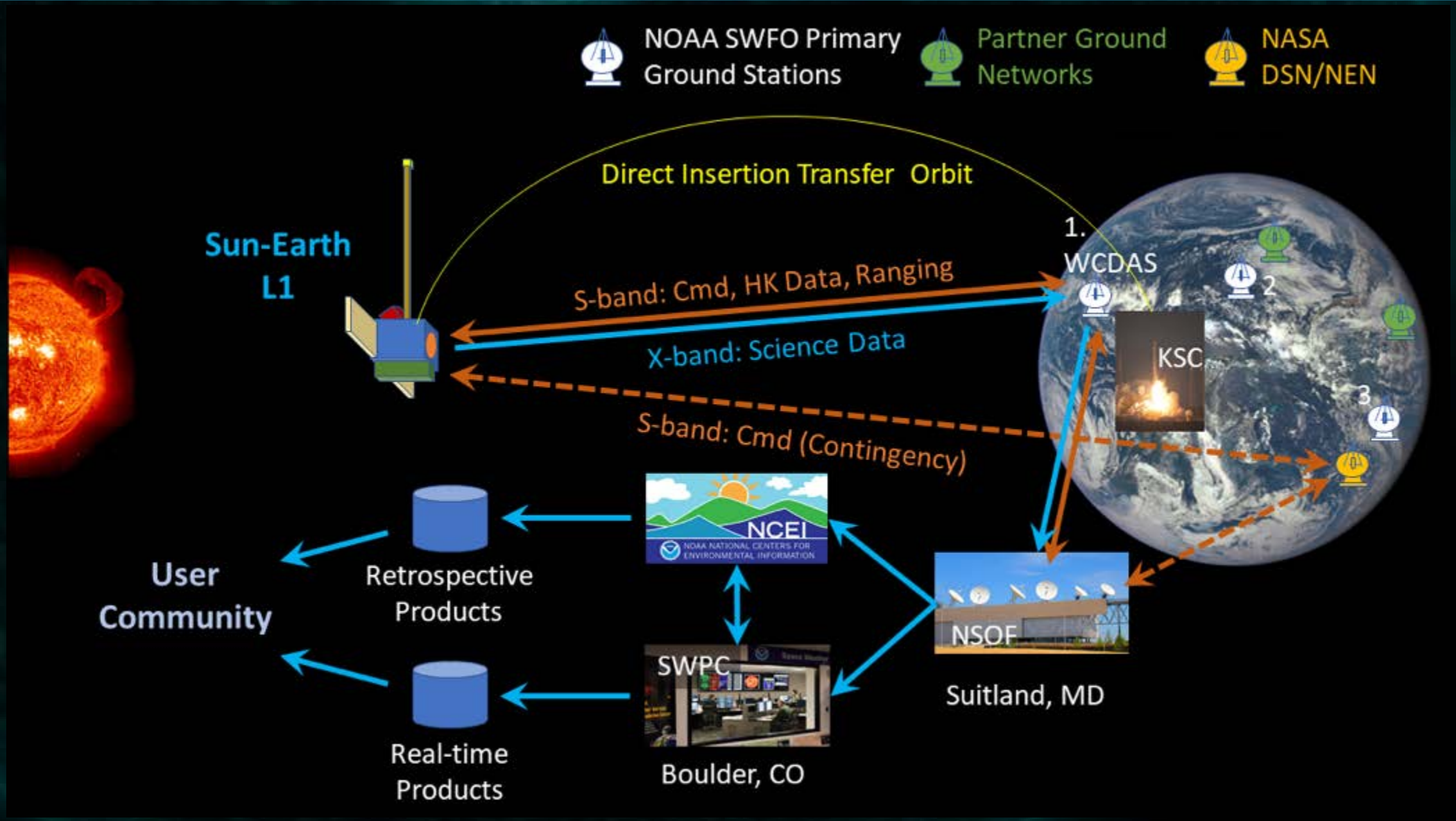
Coronagraph Project

- Compact Coronagraphs under development by NRL via an IAA
- CCOR for SWFO-L1 Satellite, deliver 2022
- CCOR for GOES-U, deliver 2021
- Potential CCOR for ESA-L5 Satellite, deliver 2023

Coronagraph Accommodation on GOES-U

CME imaging from geostationary orbit
CCOR Integrated onto GOES-U SPP
Commanding and data flow through GOES-R ground services
Nominal launch: 2024

SWFO Mission Architecture



NOAA – in the last two years …

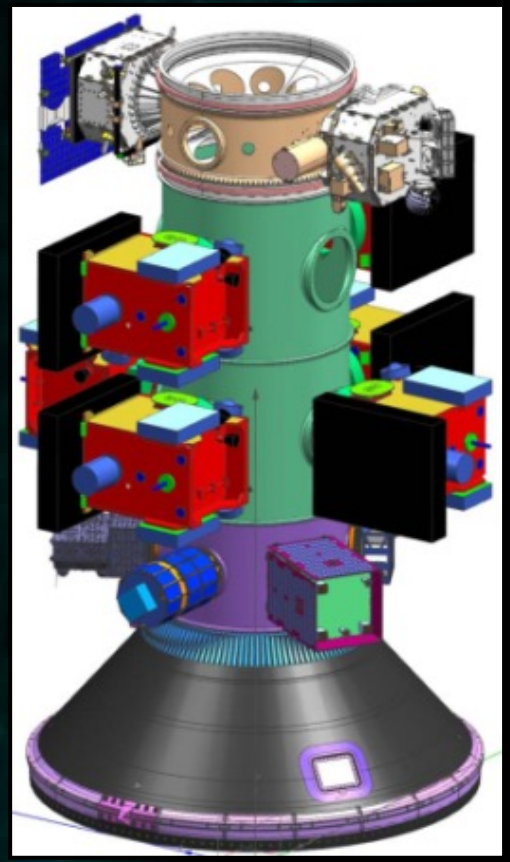
Established the baseline operational Space Weather Follow On (SWFO) Program

- Secured funding in the NOAA budget for L1 coverage
- Begun flight fabrication of the Compact CORonagraph (CCOR) with NRL
- Secured funding in the NOAA budget for CCOR on GOES-U
- Established a joint project office with NASA for SWFO
- Established an agreement with the NASA IMAP mission for a rideshare for SWFO-L1
- Let procurement RFPs for instruments
- Formulated arrangements with ESA for data sharing with the L5 mission
- Negotiating with ESA for instrument exchanges

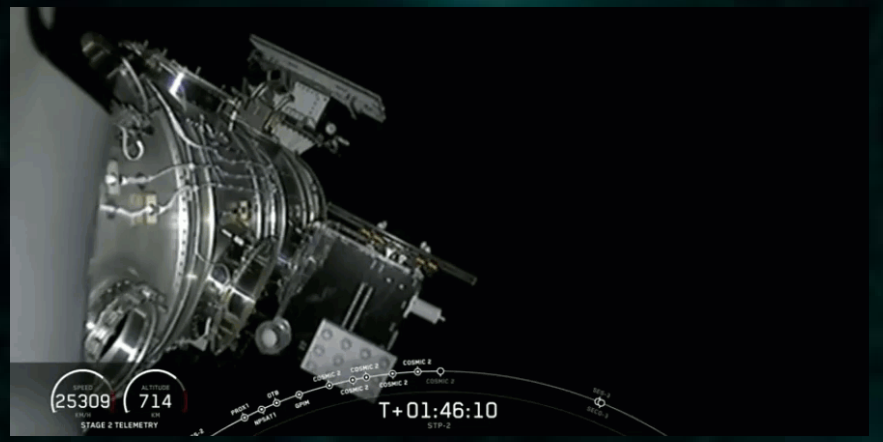
Launched the COSMIC-2 mission with Taiwan

COSMIC-2/FORMOSAT-7 Mission

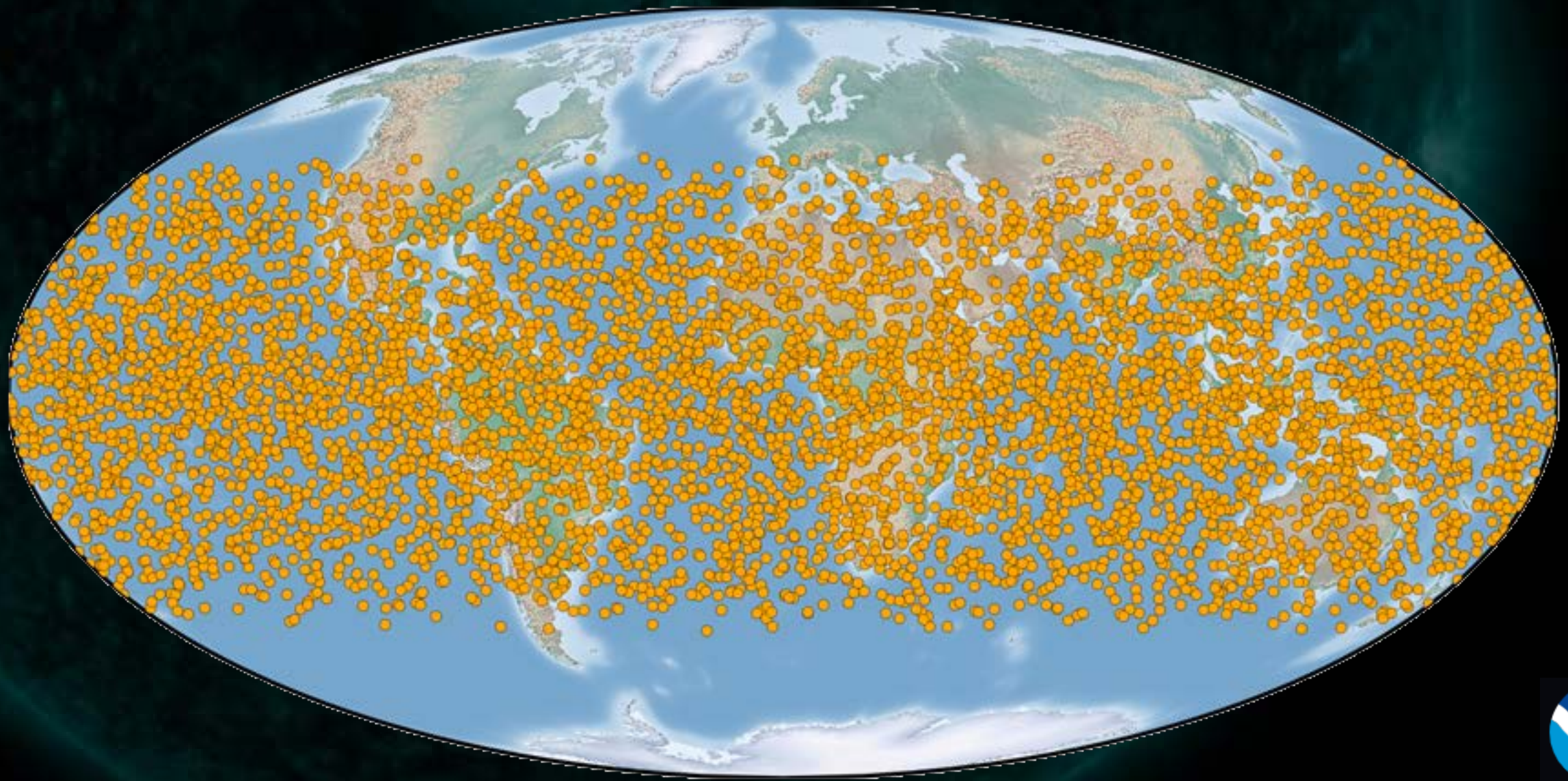
- 6 Satellite constellation around the equator (24 degree inclination orbit)
- Each satellite has 3 instruments:
  - TriG GNSS-RO receiver (TGRS) – Primary Instrument
  - Ion Velocity Meter (IVM) – Secondary Instrument
  - RF Beacon – Secondary Instrument
- Mission Design Life: 5 years
- Launch Date: June 25, 2019
- Launch Vehicle: Falcon Heavy (STP-2 mission stack shown in right figure)
- All weather coverage (4,000+ occ/day) with 30 min avg data latency



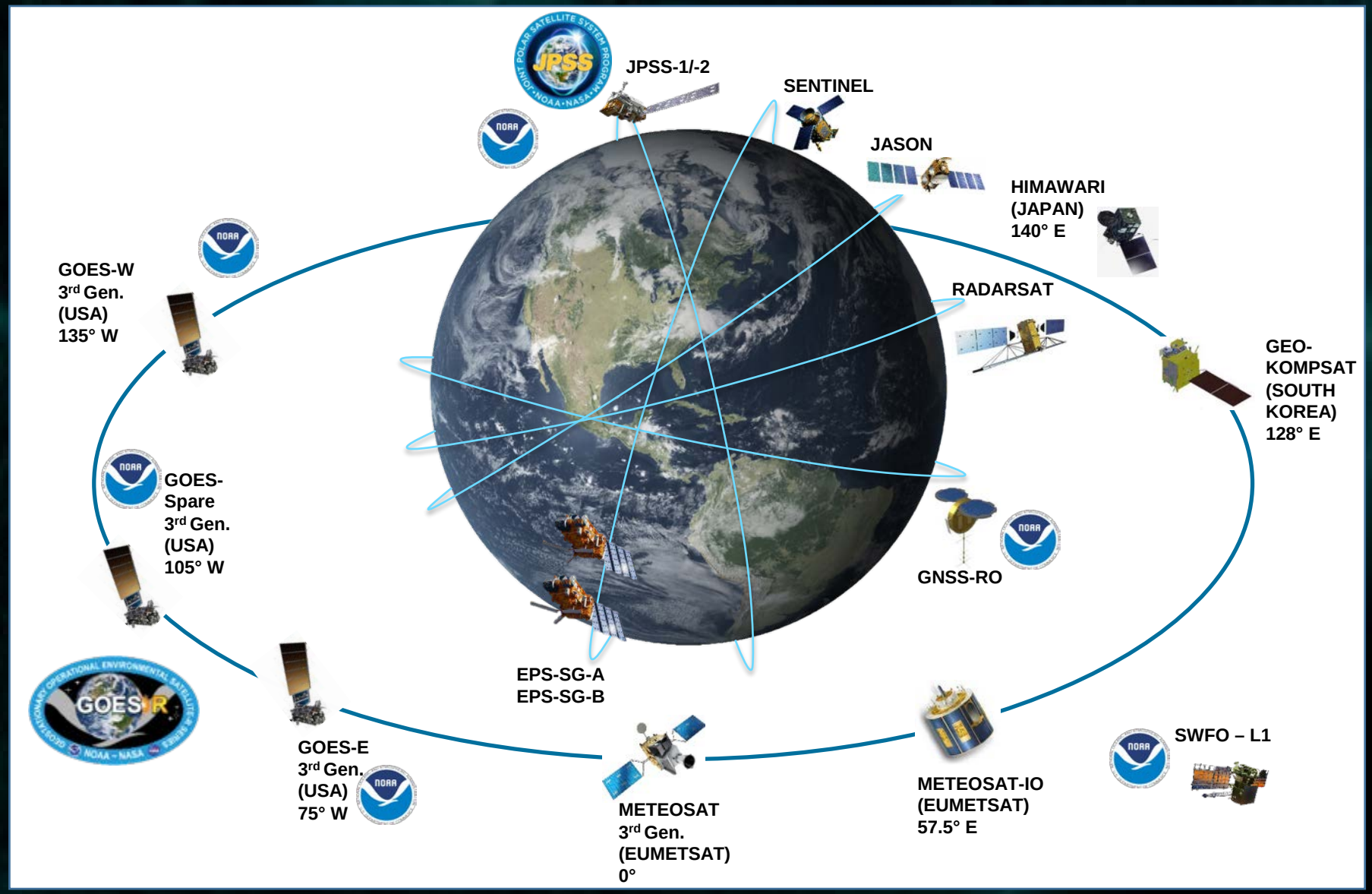
COSMIC-2 Spacecraft in STP-2 Launch Stack



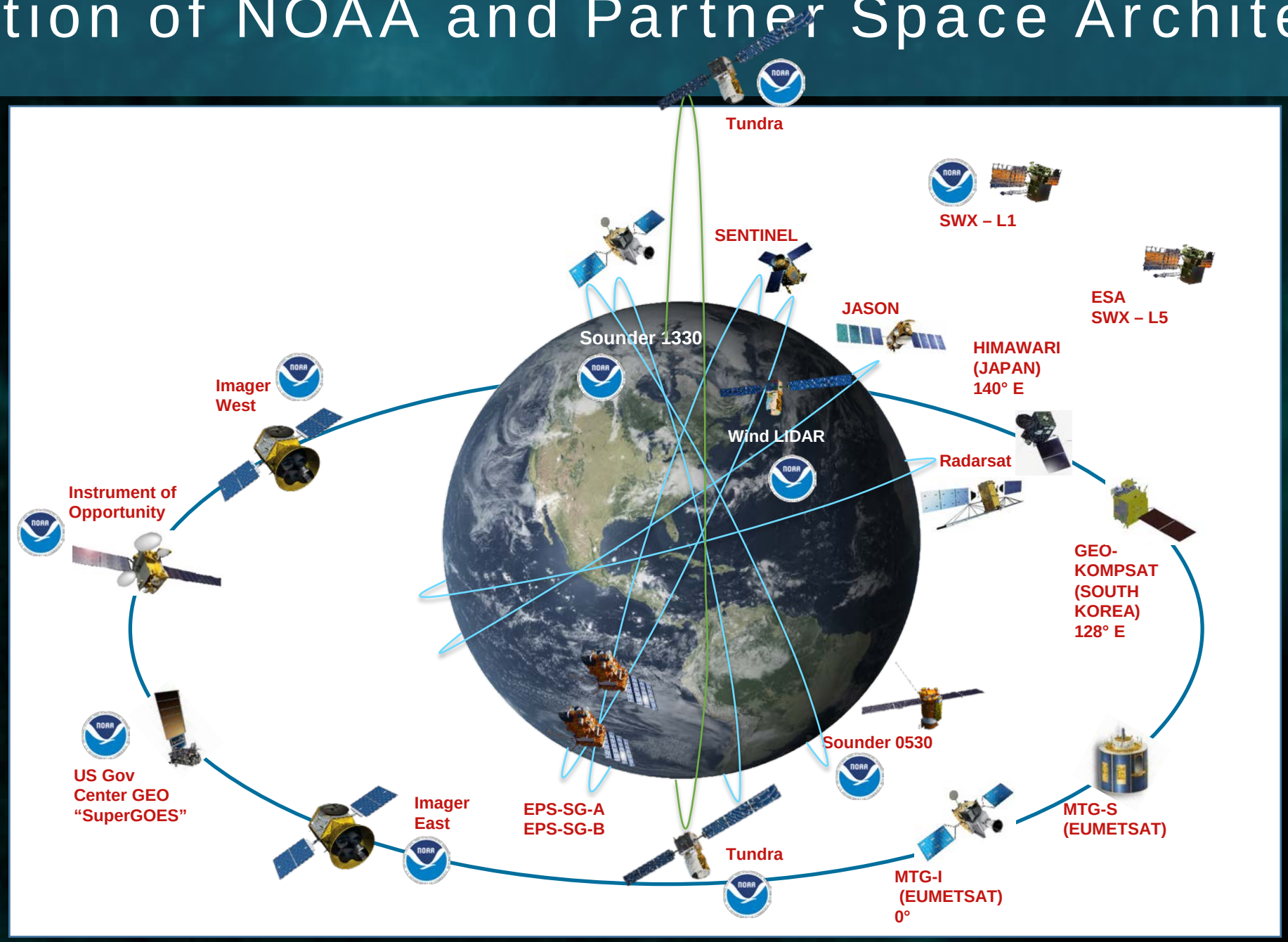
COSMIC-2 RO Coverage



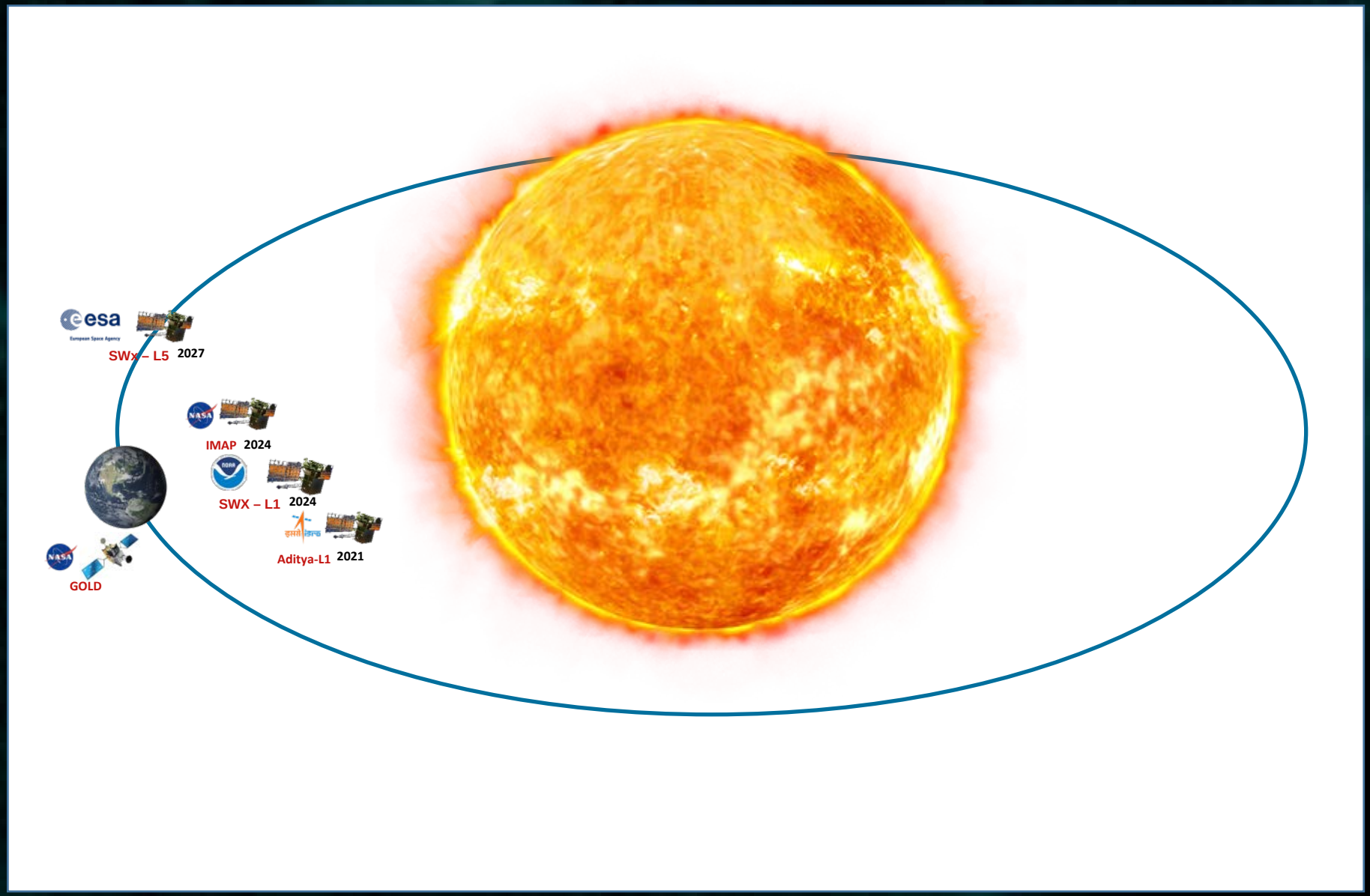
Near-Term Observational Capability



Evolution of NOAA and Partner Space Architecture

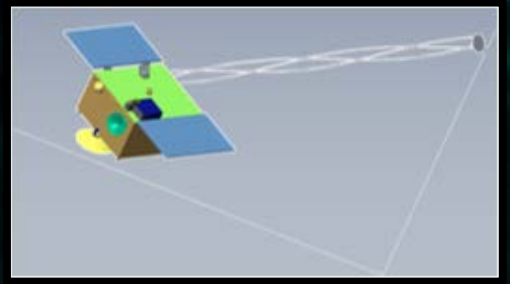


Evolution of Space Weather Architecture



Starting Point – 2025 Program of Record

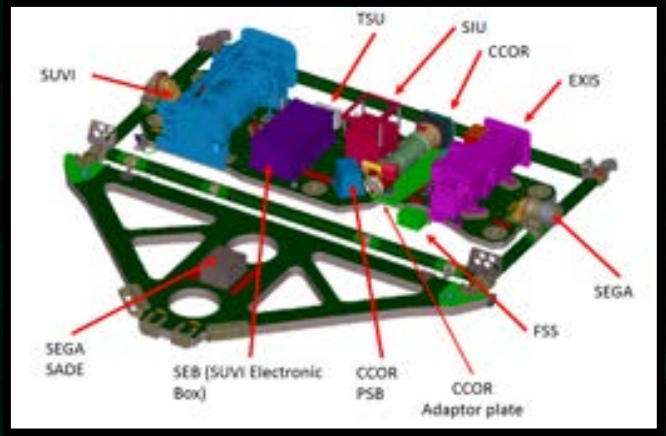
3-Axis Stabilized ESPA Class Spacecraft



Compact Coronagraph (CCOR)

GOES-U Solar Pointing Platform (SPP)

CCOR + SUVI + EXIS



2025 NOAA Space Weather Observing Program of Record
Starting point for Infrastructure Workshop

SWFO – L1 platform
GOES – U
COSMIC-2
GOLD
Metop – C, SG A1, SG B1
ESA – L5 (2027)

What's next for 2030 and beyond?

Space Weather Operations and Research Infrastructure Workshop

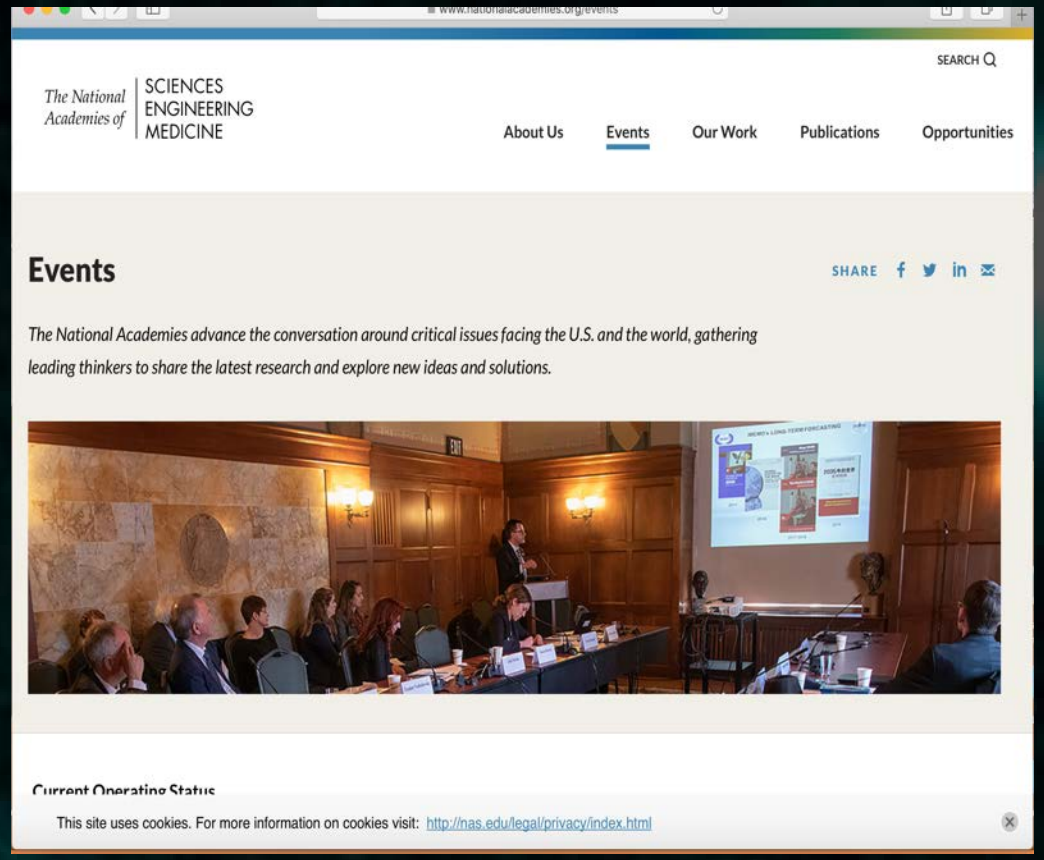
- National Academies via an appointed ad hoc committee will conduct a workshop that will consider options for continuity and future enhancements of the space weather operational infrastructure. Objectives include:
  - Review current and planned U.S. and international space weather-related observational capabilities;
  - Discuss space weather observational needs;
  - Identify programmatic and technological options to ensure continuity of the baseline, the Program of Record (POR), giving particular attention to options to extend the Space Weather Follow On (SWFO) program; and
  - Consider options for technology, instrument, and mission development to support in situ and remote sensing space weather observations from either ground- or space-based vantage points, the latter including L-1, L-5, L-4, L2, 1Au coverage, sub-L1, Tundra, GEO, GEOtransfer, and LEO among others.

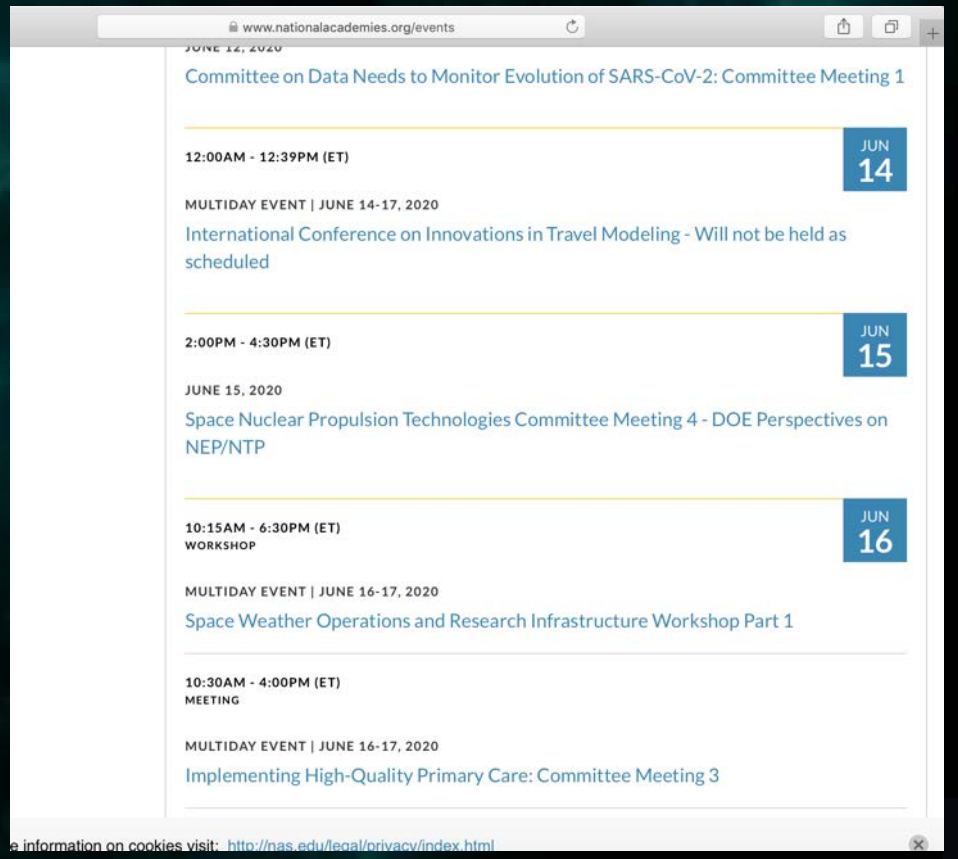
Space Weather Operations and Research Infrastructure Workshop - Status

- The NASEM has approved the Space Weather Operations and Research Future Infrastructure Workshop
- The NASEM has selected an ad hoc organizing committee
- Meetings of the organizing committee have developed the agenda and space weather experts' participation
- The initial workshop is to be conducted in two stages:
  - Stage 1 – 16-17 June, 2020 (virtual)
  - Stage 2 – 10-11 September (in-person and/or virtual)
- A follow on workshop (NASA and NSF supported) will be held to address out-of-scope issues encountered in the first workshop

Space Weather Operations and Research Infrastructure Workshop – NAS Posted Link

https://www.nationalacademies.org/events





THANK YOU!

For more information visit: **www.nesdis.noaa.gov**

CONNECT WITH US!

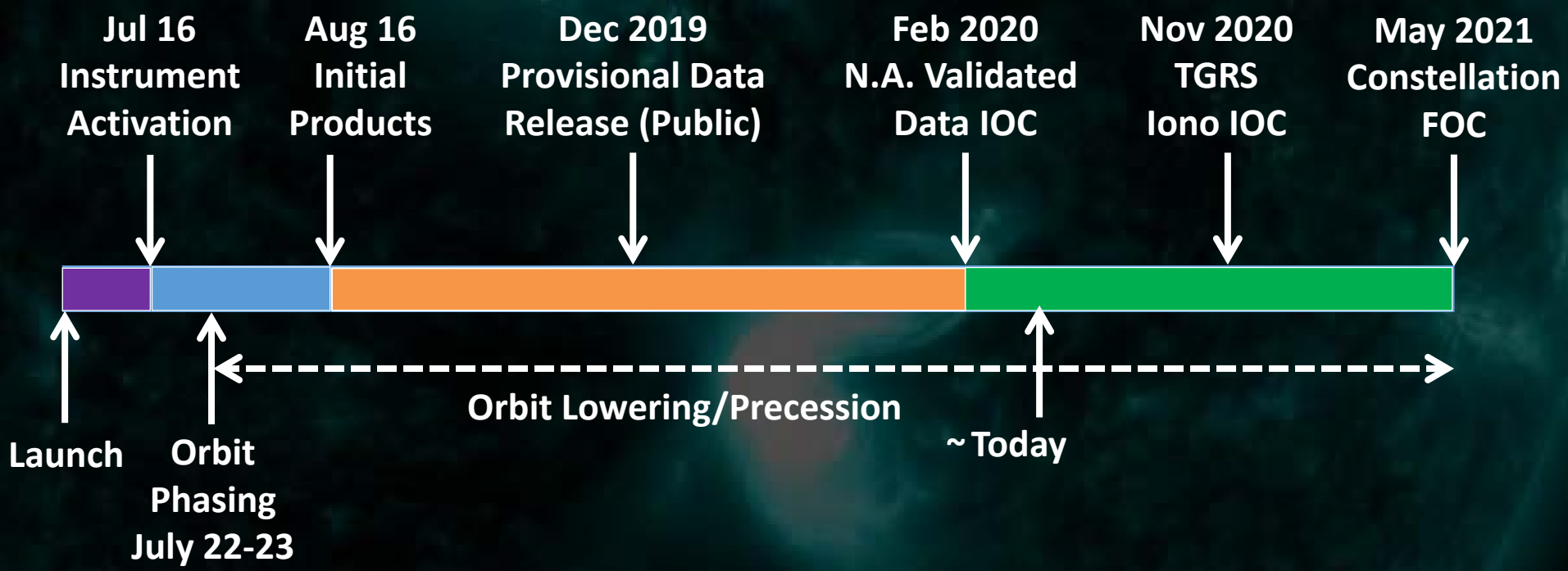
NOAASATELLITES

@NOAASATELLITES

@NOAASATELLITES

NOAASATELLITES

COSMIC-2 Data Release Timeline



- Launch and early orbit operations
- Checkout and commissioning
- Weather cal/val
- Weather operations

IOC = Initial Operational Capability
FOC = Full Operational Capability
N.A. = Neutral atmosphere
Iono = Ionosphere