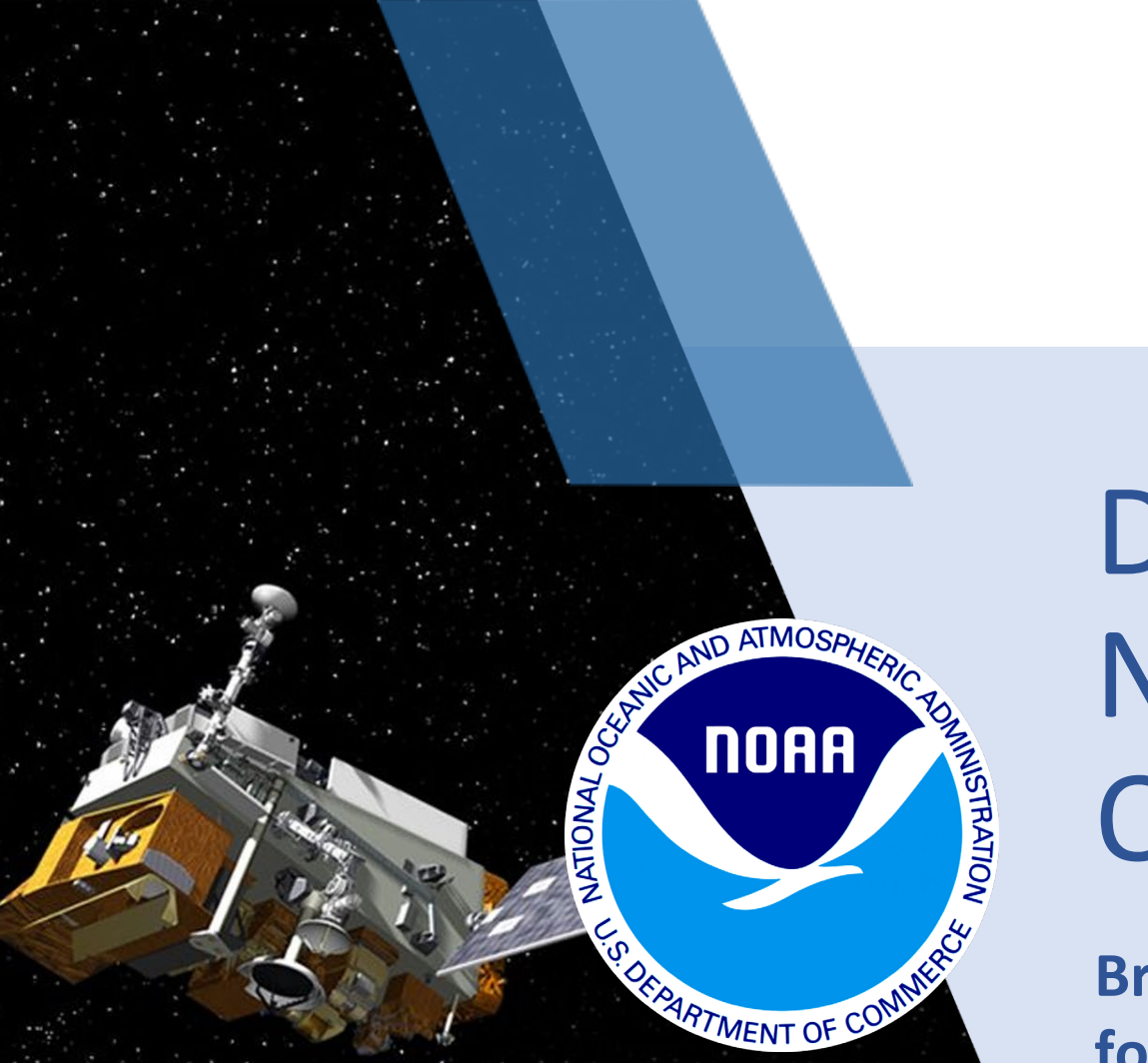


National Environmental Satellite, Data, and Information Service

JULY 15, 2021

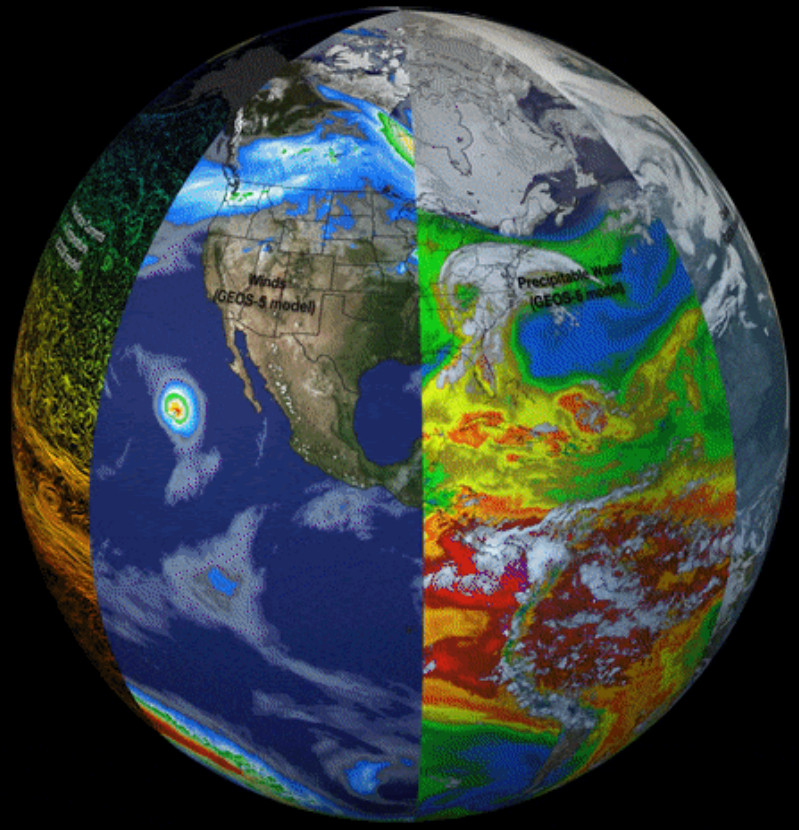
Developing NOAA's Next-Gen Earth Observation Capability

Briefing to NOAA's Science Advisory Board / Priorities for Weather Research

Vanessa Griffin, Office of Systems Architecture and Advanced Planning (OSAAP)

Our Vision:

Provide a truly integrated digital understanding of our Earth environment that can evolve quickly to meet changing user expectations by leveraging our own capabilities and partnerships.



Today's Space Architecture

Today's space-based observation architecture is highly capable – but not adaptable.

Large, capable satellites require:

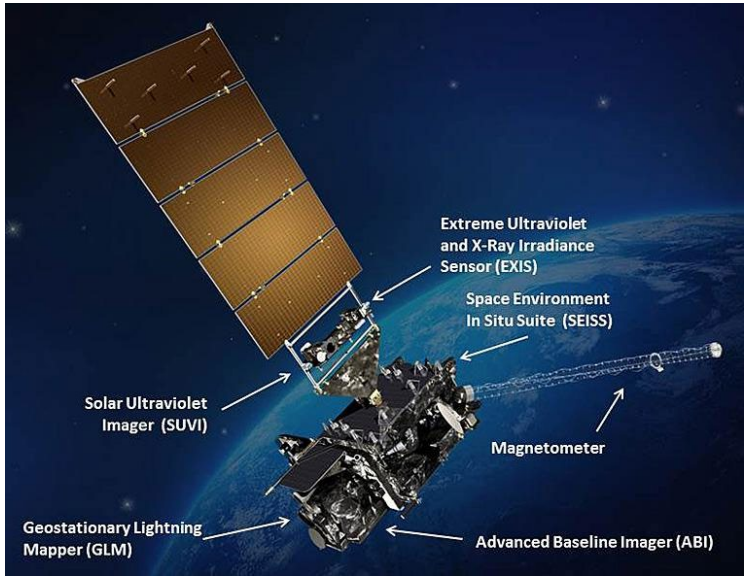
- Very low risk for each satellite
- 10+ years in development

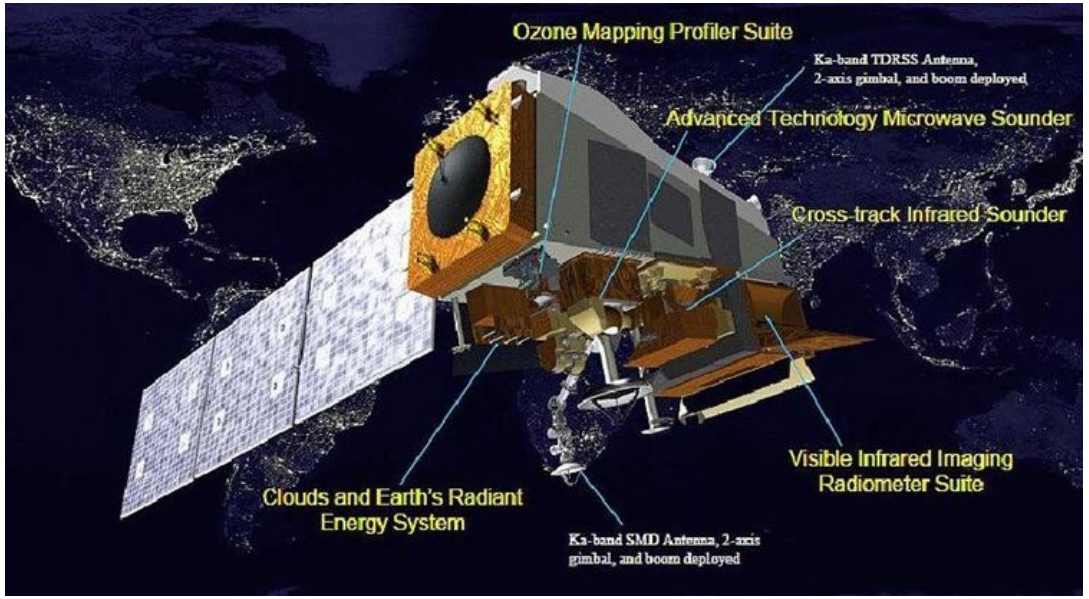
Very low risk requires:

- Locked up funds
- High cost for top end of assurance scale

Long development requires:

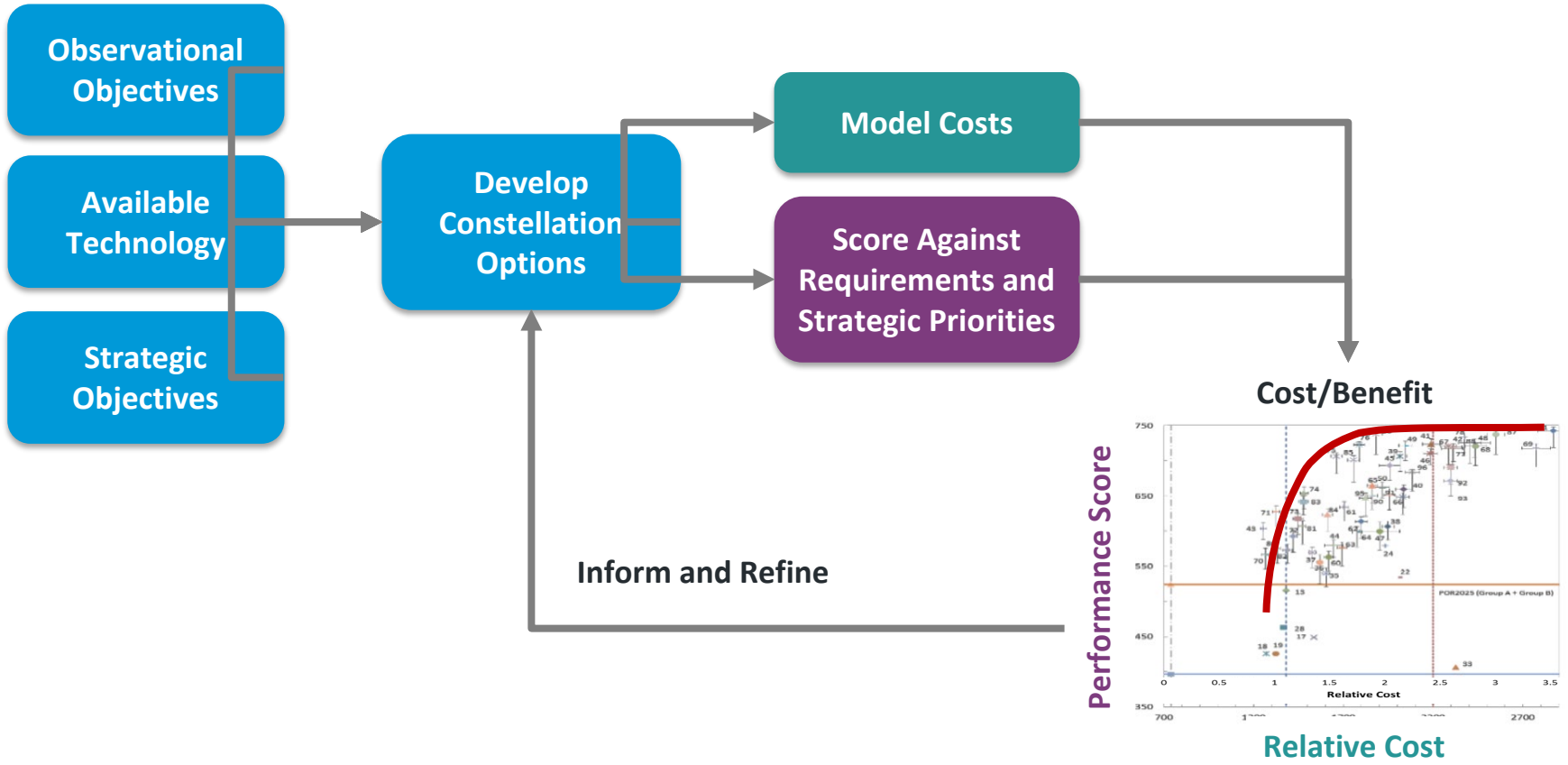
- Inability to exploit tech advances





2018 Architecture Study Informing Our Next-Gen Decisions

NSOSA identified the most cost effective space segment architectures for performing the NOAA mission beyond the POR to 2050.



High-Value Frontier Attributes

Mix of higher-impact observations

- Small & medium platforms
- Enhanced imagery & high-altitude coverage

More agility

- Disaggregated
- Onramps to new technology

New business models

- Data purchases, ride shares, & hosted payloads

NOAA's Next-Gen Earth Observation Strategy

Integrated, Adaptable, and Affordable: Orbits, Instruments & Systems

LEO

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

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.

Space Weather

Reliably monitoring space weather from all applicable orbits (L1, GEO, LEO, HEO, L5) to protect the nation's valuable, critical infrastructure. New capabilities at L5 and high earth orbit can provide additional insight & 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.

Trends Shaping Our Next-Gen Architecture

New business models: Joint Venture, other transactional authority, data buys

Commercial capability: Rapid pace of innovation, cheaper launch capability, more satellites

Ground & data system to match space capability: DACS, NCCF & NGES

Partnerships w/ private industry, other agencies & strategic partners: Obtaining global data

Engaging our users: user needs are evolving as quickly as the climate changes (e.g., demand for more ocean science)

Joint Venture – Leveraging Partnerships

Current

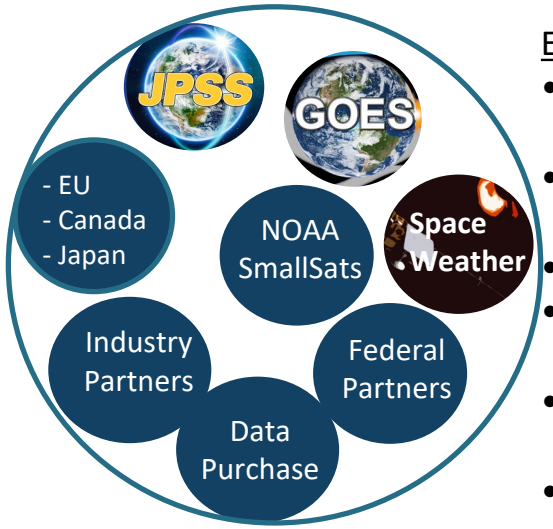
NOAA launched Low Orbit

NOAA launched Geostationary

Partner Satellites

- EU
- Canada
- Japan

2030-2050



Enterprise Architecture

- Partially disaggregated Low Orbit
- Mixed US government Geostationary
- Partner Satellites
- Mixed resolution, update rates
- NOAA launched, rideshare, and payload
- Data buys

Joint Venture

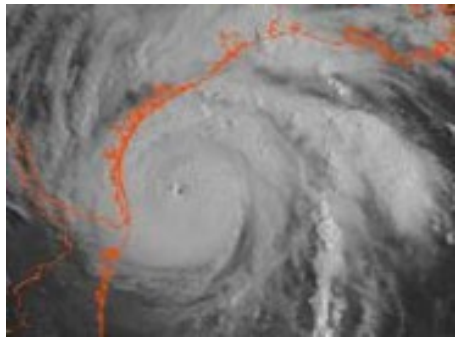
Leverage capabilities being developed by other federal partners & industry - to provide high return on funds

- Exploit partner data
- Exploit partner technologies
- Partner to supplement other agencies' initiatives to meet NOAA needs
- Initial Concept Development to operationalize new data & technology

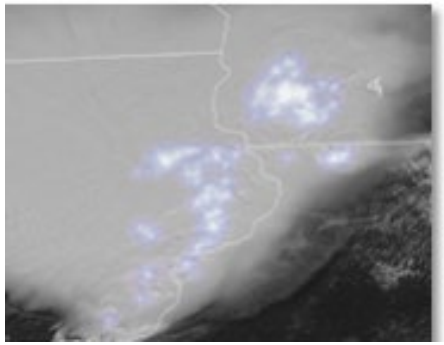
NOAA's Future Observation System in GEO

- In addition to maintaining today's 24/7 now-casting, GeoXO advances NOAA's observational capabilities to meet new mission requirements and supports the World Meteorological Organization's vision for 2040
- GeoXO observations will provide a comprehensive understanding of the atmosphere, oceans, and weather through 2050, including potential new capabilities (depending on budget):
  - **Improved nighttime monitoring of severe weather and hazards** with a Day/Night Imager
  - **Better forecasts with improved numerical weather prediction and nowcasting** with IR Sounder
  - **Enhanced monitoring of ocean health and productivity** with Ocean Color Instrument
  - **Reduced health impacts from poor air quality** with Atmospheric Composition Instrument

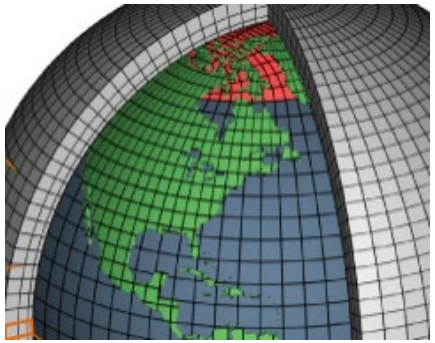
Vis/Near-IR Imagery



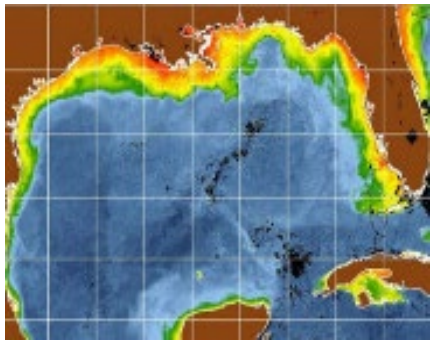
Lightning Mapping



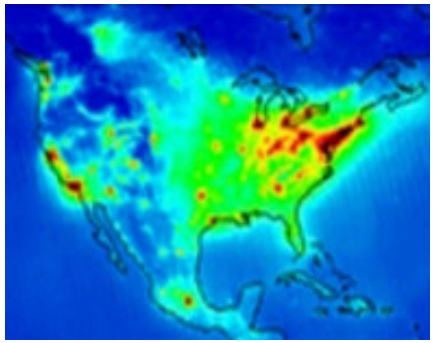
IR Sounding



Ocean Color



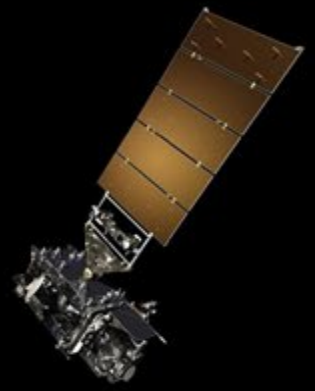
Atmo. Composition



GeoXO Constellation

GEO-West

Visible/Infrared Imager
Lightning Mapper
Ocean Color
Space Weather Suite*



GEO-Central

Hyperspectral Infrared Sounder
Atmospheric Composition
Partner Payload

GEO-East

Visible/Infrared Imager
Lightning Mapper
Ocean Color
Space Weather Suite*

**Space Weather Program to define and fund plans*

Highly Diverse LEO Observations

Foundational Products: Satellite Radiances and Satellite Imagery

NESDIS Level Requirements – Geophysical Products

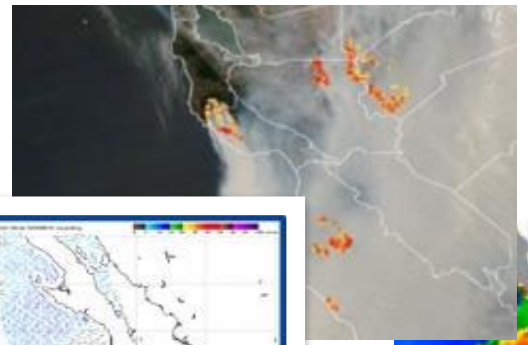
Atmosphere	Cryosphere	Land	Ocean, Fresh Water & Coasts

Analytical

Climate & Weather

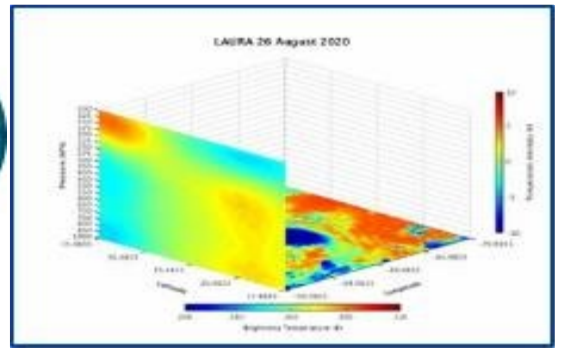
Ocean, Fresh Water & Coasts

Multipurpose VIS/NIR/IR Imagery

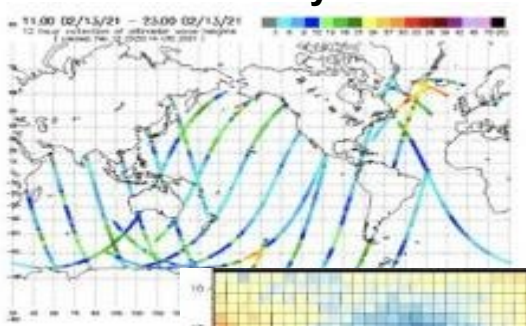


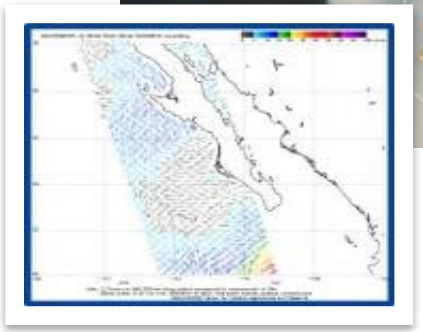
UV Imagery

Soundings from IR/MW/RO

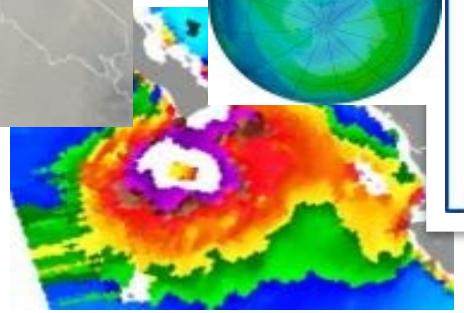


Altimetry

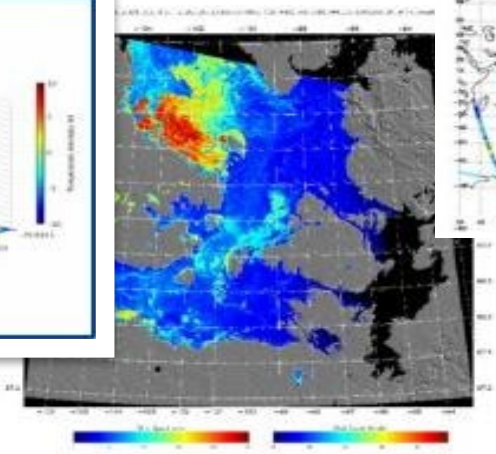




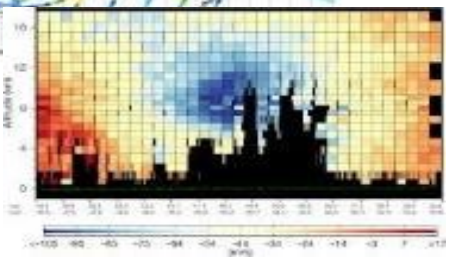
Scatterometry



MW Imagery



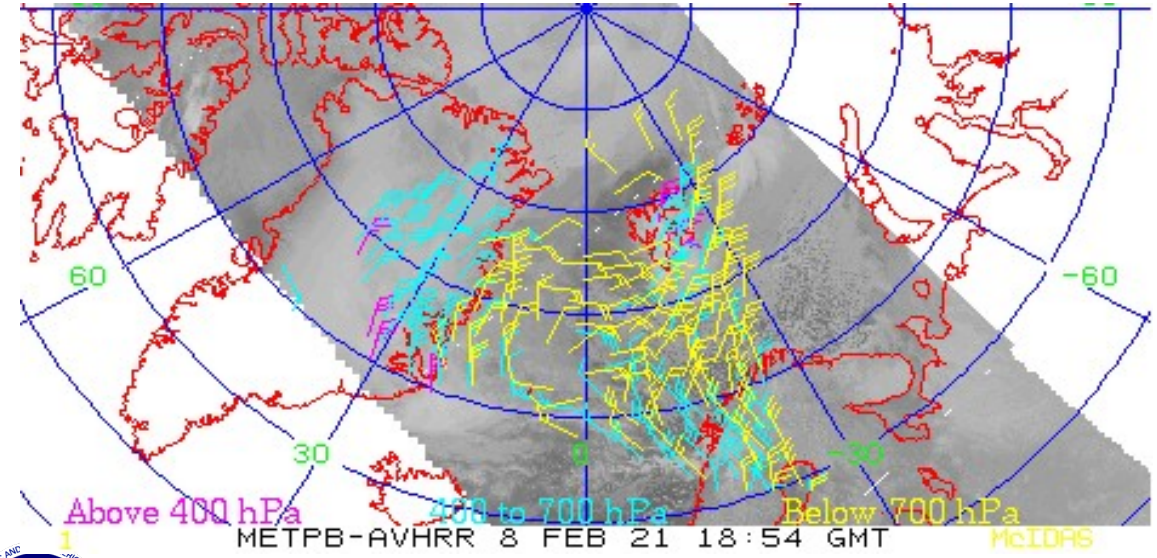
RADAR Imagery

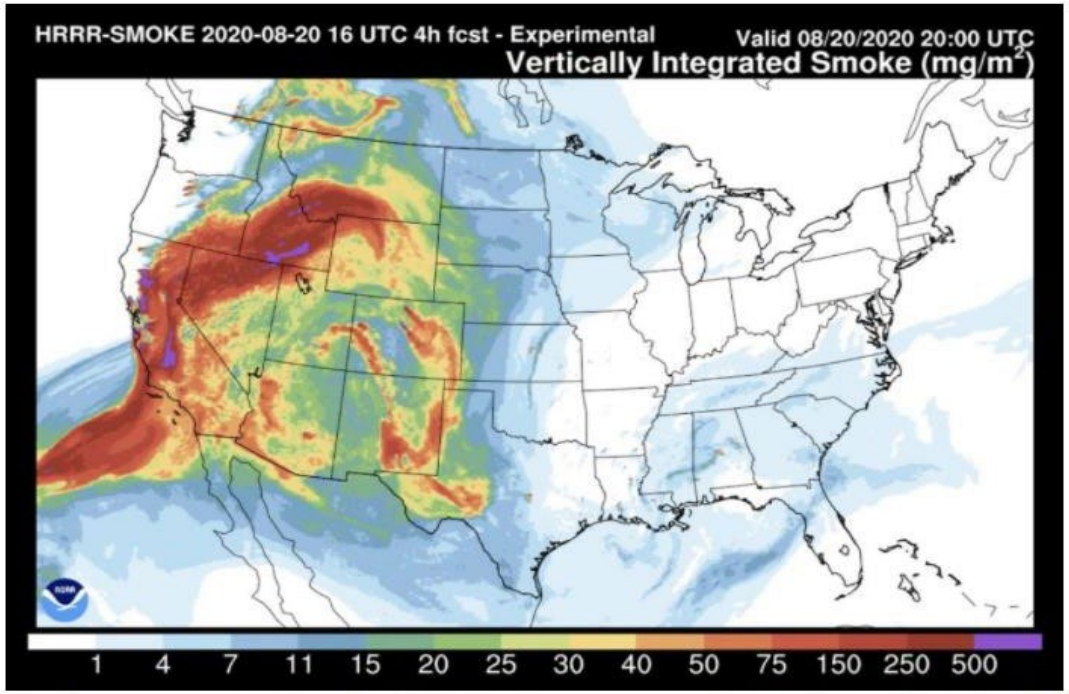


LIDAR

NESDIS LEO Approach: Mission Concepts to Augment Global Measurement Capability

- Launch satellites more frequently to **enhance refresh and augment global observations collected from earth observation satellites**, beginning in mid to late-2020s
- Replenish **critical sounding data**
- NESDIS completed its LEO Milestone-0 Review March 10, 2021





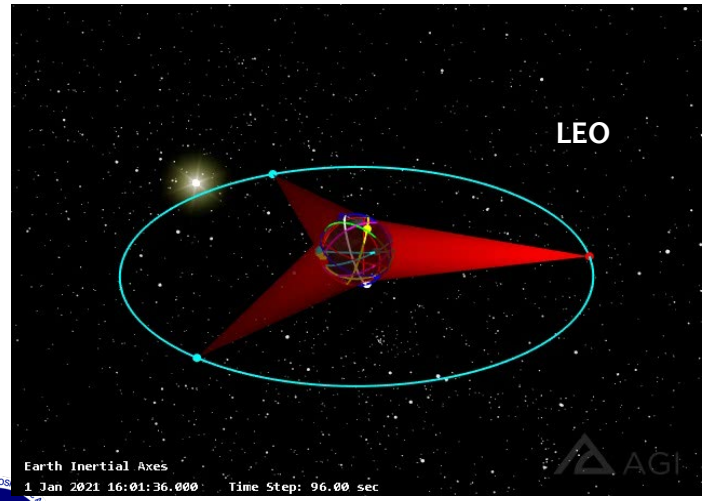
Vertically integrated smoke plot showing HRRR-Smoke forecast on August 20, 2020 valid at 20:00 UTC. The High Resolution Rapid Refresh Smoke model uses a suite of fire products from JPSS satellites.

- Capture **3D winds, ocean surface vector winds, precipitation data**, and **low-light imagery**
- **Hybrid approach**: data from NOAA satellites, strategic partners, and commercial providers

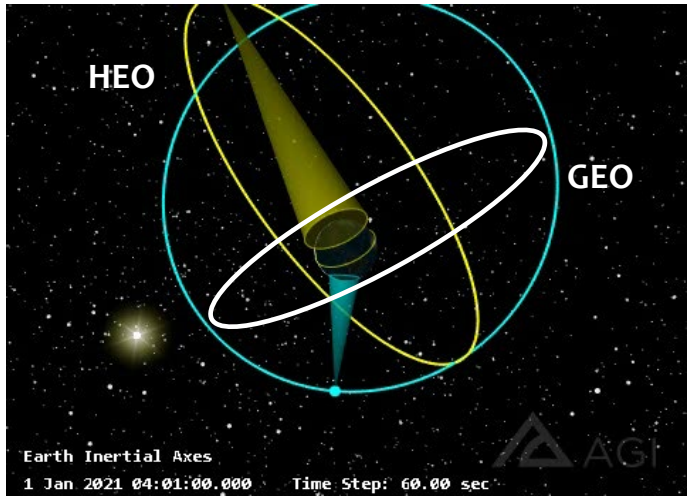
Space Weather Observations Program

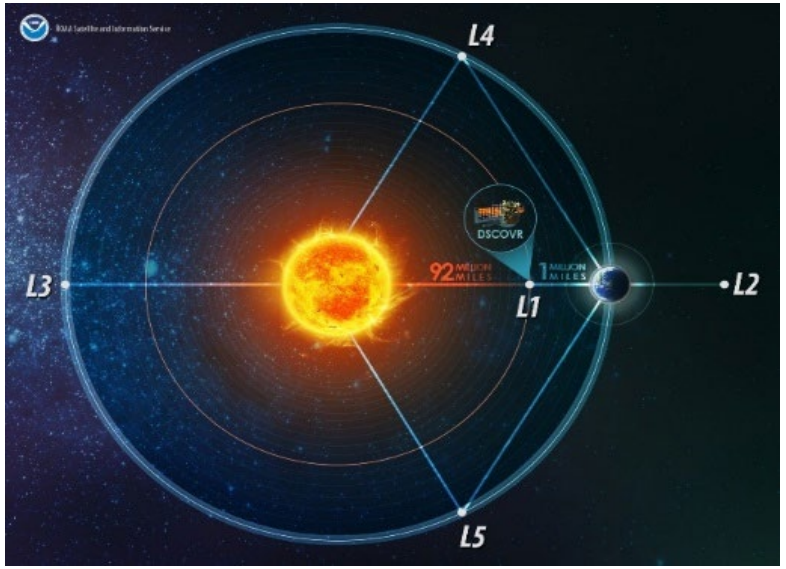
The Space Weather Observations (SWO) Program will need a comprehensive observational capability for several orbital vantage points.

Thermospheric and ionospheric objectives will require in situ measurements from LEO as well as imaging capabilities from GEO.



For the magnetosphere, in situ measurements from GEO and HEO can be combined with auroral imaging.





Coronal and photospheric imagery from L1 and L5 can be used for stereoscopic analysis. In situ plasma/field data will drive heliospheric models.

SWO Program Plans & Partnerships

SWO will implement:

- Continuity of current **L1** space weather measurements
- Continuity of current **geostationary** space weather measurements
- Additional measurements as recommended by NSOSA

SWO will leverage partnerships, including:

- NASA, DoD, EUMETSAT partnerships for **LEO** space weather observations
- European Space Agency (ESA) agreement for enhanced capability at **L5**
- Discussions with Canadian Space Agency (CSA) for **HEO** auroral imaging
- International participation in Space Weather (Follow-On) Antenna Network
- NASA-NSF-NOAA Decadal Survey to recommend future technology infusion

Advancing Data Science and Information Services

TODAY'S GROUND SERVICE

- **Single system data services**
- **Limited computing power**

Data Collected & Transmitted from Single Observation System

Delivery to NOAA Users

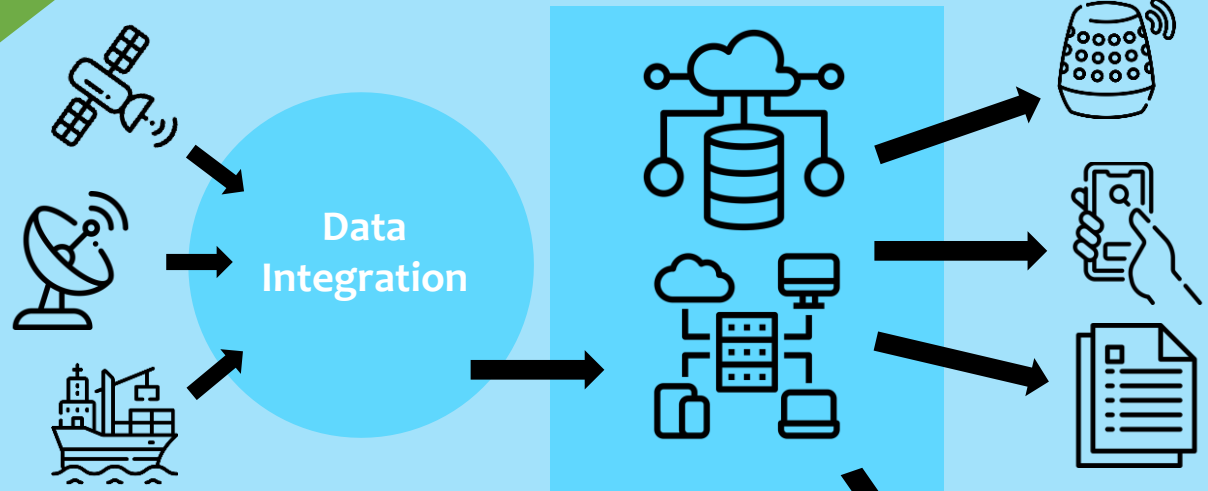
Development of Products & Services

Forecasts, Warnings, Watches

NOAA is moving to a ground system that matches our agile space-based observation systems.

TOMORROW'S GROUND SERVICE

- **Secure ingest for all data types**
- **Powered by AI, data science**
- **High performance computing capability, cloud transition & hosting for data storage, stewardship & access**



Data Collected & Transmitted from Multiple Sources: International, Commercial, USGS Partners

Cloud-based Data Stewardship, Supercomputing Capability

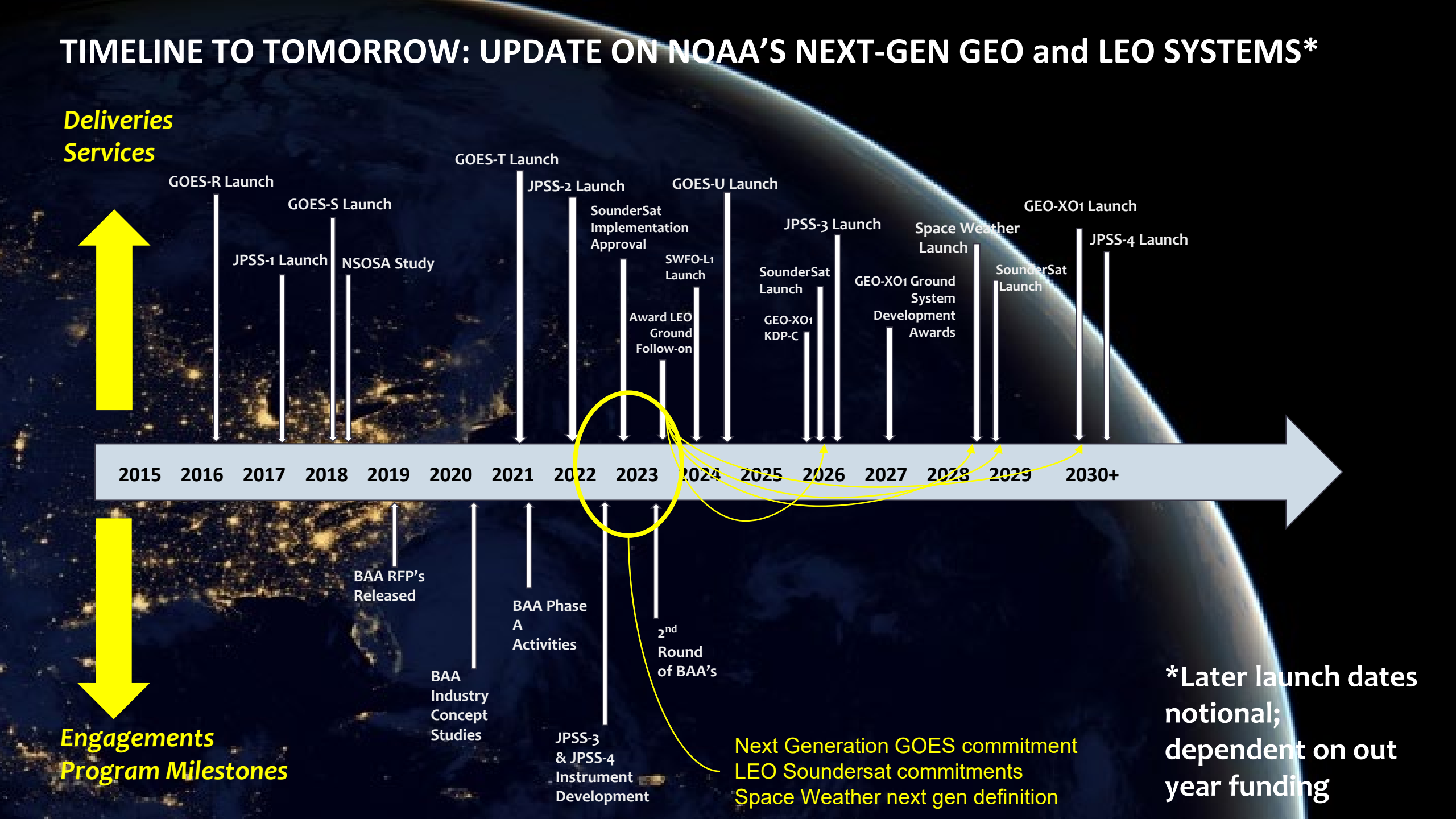
Development of New Products & Services Delivered in New Ways to More Users

Co-located Earth system data available for ***Data-Driven Science***

NESDIS POR to Next Generation Architecture

BACKUP SLIDES

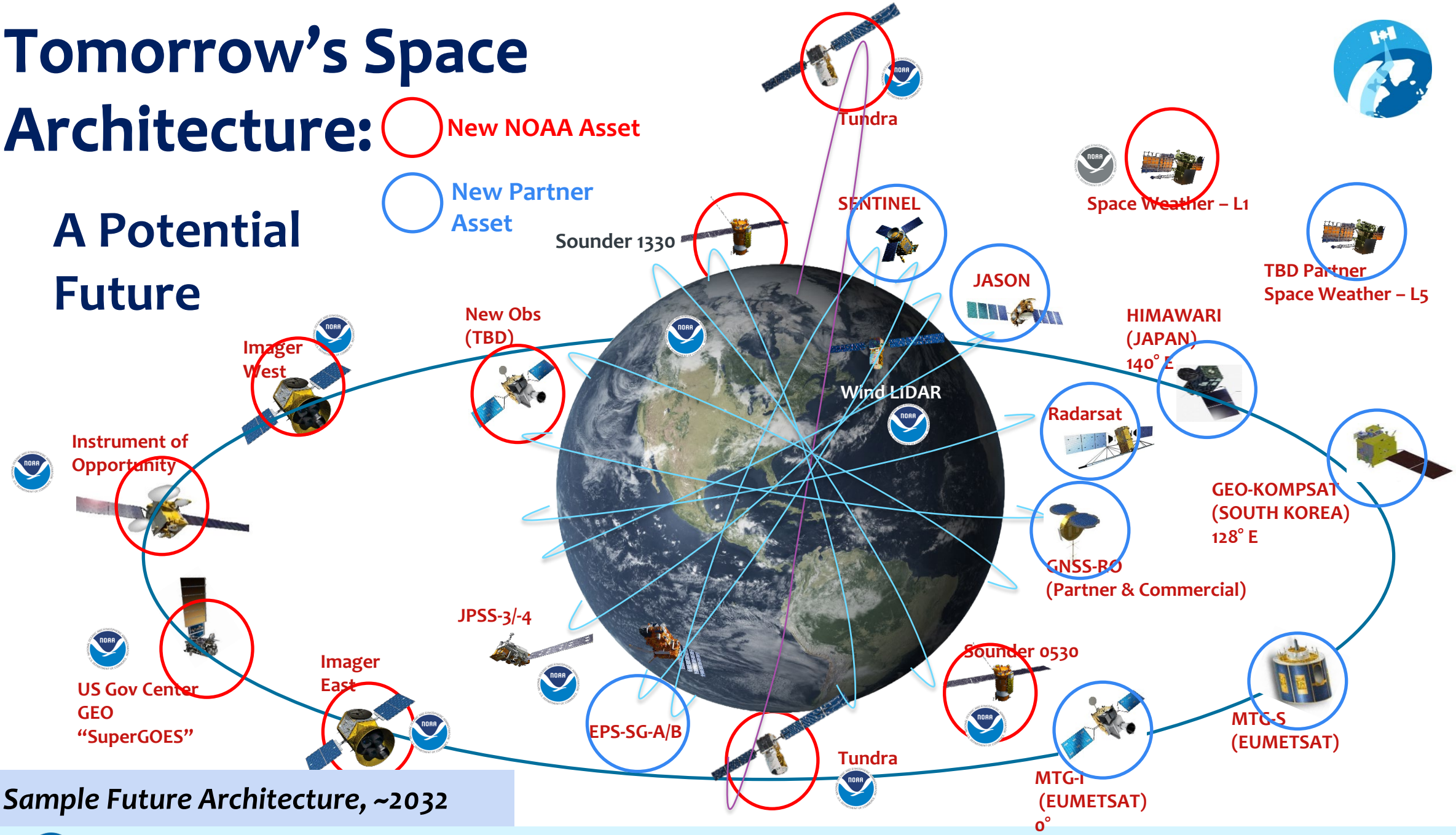
TIMELINE TO TOMORROW: UPDATE ON NOAA'S NEXT-GEN GEO and LEO SYSTEMS*



*Later launch dates notional; dependent on out year funding

Tomorrow's Space Architecture:

A Potential Future



Sample Future Architecture, ~2032

New Business Models with Commercial Sector

Industry Concept Studies: 32 studies worth $17.3 million to study temperature and moisture sounder instruments and mission concepts in LEO, and instruments, missions and spacecraft in GEO

Ongoing BAA Study Cycle: Regular cadence of industry studies to make use of expertise and innovation and fill out remainder of LEO constellation

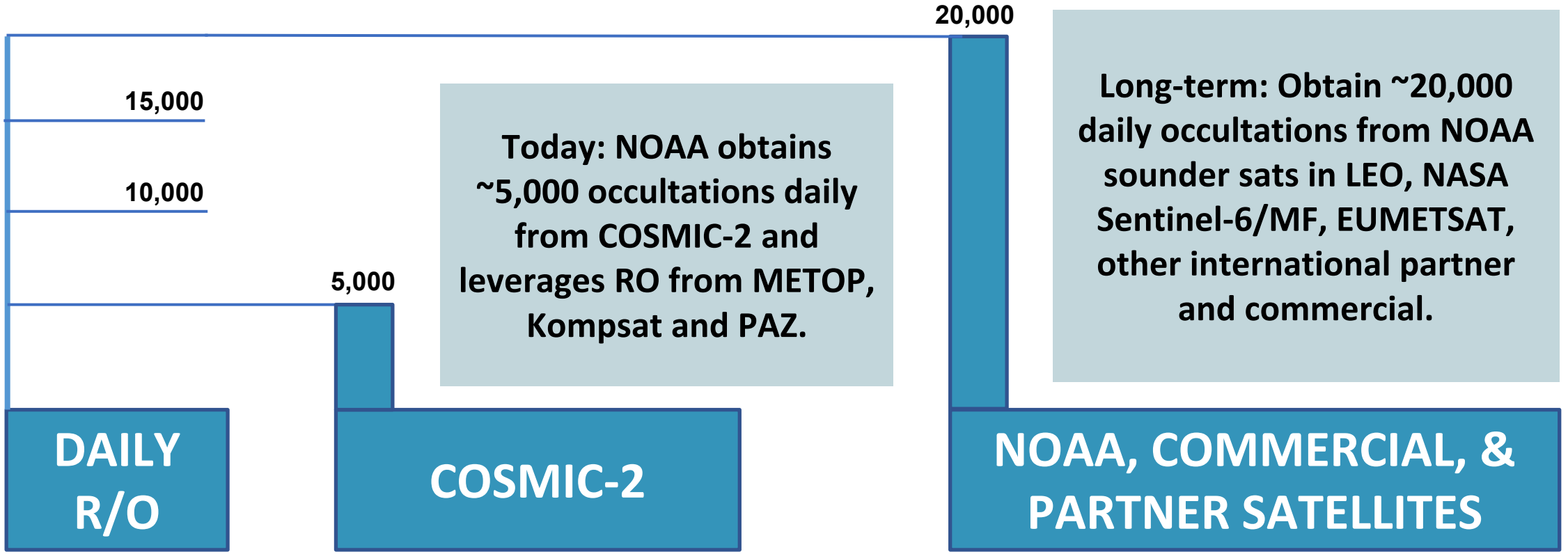
Commercial Weather Data Purchase: Contracts awarded for operational Radio Occultation (RO) data purchase

Commercial Weather Data Pilots: Completion of Round 2 in RO, exploring other data types available commercially

NESDIS Ground Enterprise Study: NSOSA-model analysis to inform next-gen ground system decisions

NOAA's Long Term R/O Objectives: 20,000

NOSC endorsed IROWG-6 goal of 20,000 occultations a day. NSOSA established threshold of 5,000 globally distributed occultations daily at highest quality and availability. Remaining daily observations more flexibility in performance, availability and geographic distribution.



Near Term Commercial Data Objective: Obtaining 5,000 Daily Occultations

- When fully operational, COSMIC-2 to provide ~5,000 high-quality daily RO soundings – a threshold established by NSOSA.
- NOAA will continue to leverage “missions of opportunity“ to fill out polar regions.
- Initiated commercial RO data for operational use.

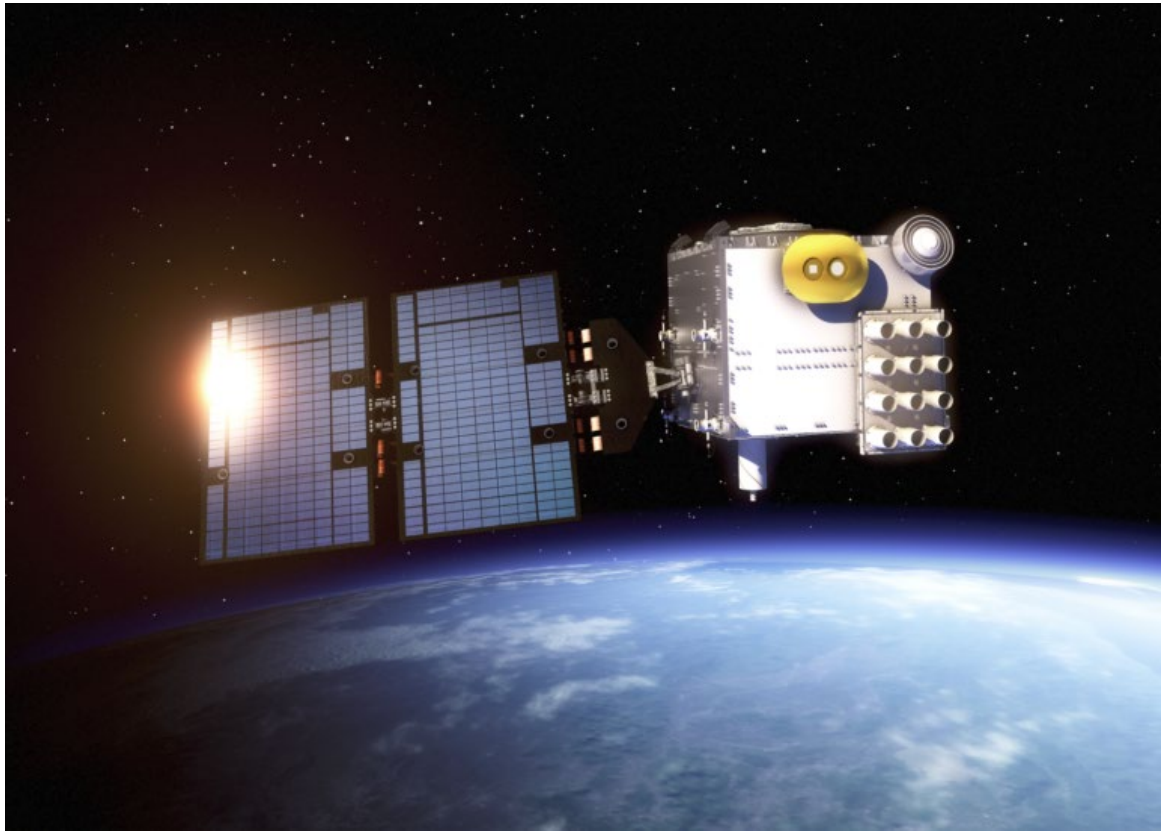


Image credit: Surrey Satellite Technology Ltd.

Long Term Commercial Data Objective: Augmenting High-Quality RO

- NOAA to continue operating a base of NOAA LEO satellites dedicated to soundings, including high-quality RO
- Other NOAA satellites, ongoing partnership with EUMETSAT, to provide “backbone” set of global measurements to satisfy threshold requirements
- NOAA to augment this base with high-quality RO data from other international partners coming online in 2020s (JasonCS/Sentinel-6 follow-on) and commercial data when available