



NOAA/NESDIS Commercial Data Program (CDP) and Radio Occultation (RO)

Overview of the Commercial Strategy and Summary of the Phase 1 RO Analysis of Alternative (AoA)

National Environmental Satellite,
Data, and Information Service

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Products Mapping and Piloting Branch
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NESDIS Approach to Radio Occultation (RO)

- NOAA/NESDIS goal for Radio Occultation is a Hybrid Architecture
 - Commercial Data
 - International Partnership
 - Investigating a NOAA-owned constellation and what it would look like
- NOAA/NESDIS Commercial Data Program currently purchases commercial RO data
 - New “Guidance for NOAA Commercial Data Buys” (Draft)- Provides a framework for NOAA Programs and Offices conducting Commercial Data Buys
- Conducting a RO Analysis of Alternatives Study
 - Identify the hybrid capabilities that will fulfill NOAA requirements as COSMIC-2 degrades.
 - Identify the needs for a NOAA-owned RO constellation and if required



NESDIS Commercial Data Program Overview

Purpose: Acquire and assess value-added commercial *space-based environmental* observation data to support NOAA's mission.

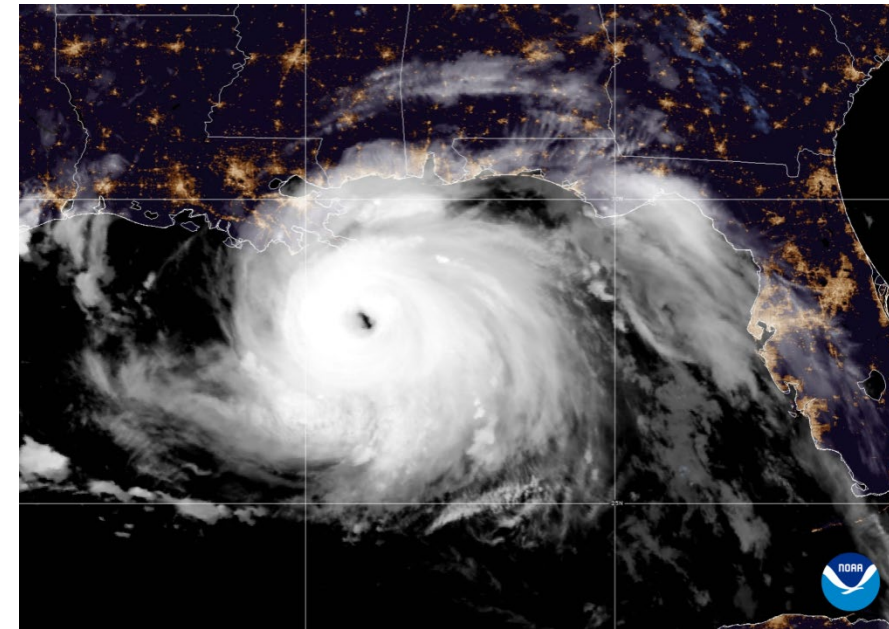
The NESDIS Commercial Data Program (CDP) contains two lines of effort:

Commercial Weather Data Pilots:

Demonstrates the quality and impact of commercial data on weather, climate and space environment applications

Commercial Data Purchases:

Supports operational weather forecast applications



Hurricane Ida making landfall

NESDIS Commercial Data Program Information:

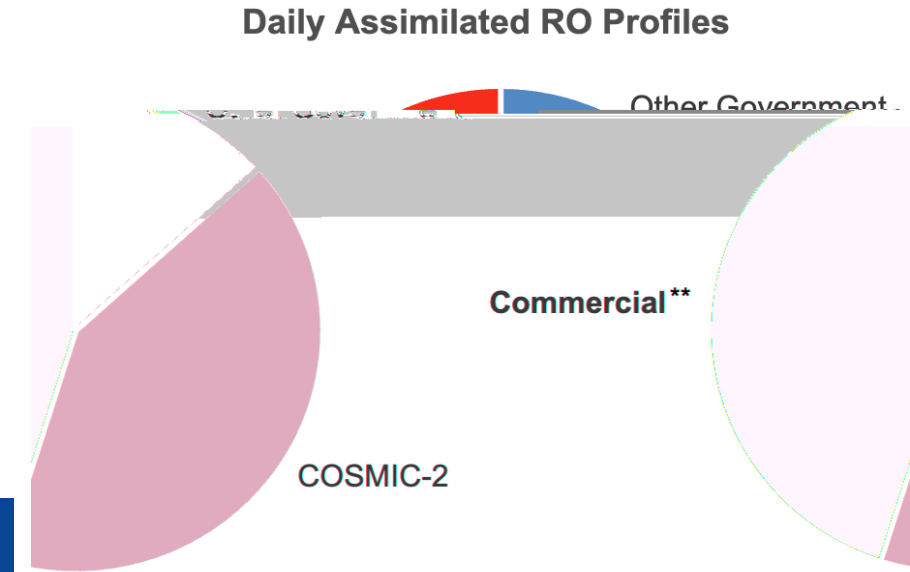
<https://www.space.commerce.gov/business-with-noaa/commercial-weather-data-pilot-cwdp/>

NESDIS CDP Operational RO Data Buys (RODB)

- NESDIS CDP successfully purchases and integrates commercial GNSS-RO data, which is a highly valuable input for operational weather modeling.
- Used in Operational NWP Neutral Atmosphere and Space Weather models

Radio Occultation Data Buy (RODB)-2 IDIQ Delivery Orders:

| Delivery Order | Vendor | RO Profiles per day | Period of Performance | Length | Data Sharing License |
|----------------|-------------------|---------------------|---------------------------|-----------|----------------------|
| DO-1T | PlanetIQ Spire | 500 500 | 6 Apr 2023 – 4 May 2023 | 1 month | Unrestricted |
| DO-2 | PlanetIQ | 3100 | 18 Jul 2023 – 18 Jan 2024 | 6 months | Unrestricted |
| DO-3 | Spire | 3000 | 18 Jan 2024 – 18 Sep 2024 | 8 months | Unrestricted |
| DO-4 | PlanetIQ Spire | 2200 800 | 18 Sep 2024 – 18 Sep 2025 | 12 months | Unrestricted |



COSMIC-2023 Source: NESDIS CDP, ICAO coordinated NOAA (CDP) and ****Commercial data consists of EUMETSAT purchases**

Commercial GNSS-RO data from NESDIS CDP and EUMETSAT purchases now make up nearly half of all RO data assimilated into weather models.



GNSS-RO Data Operationally Assimilated by NOAA

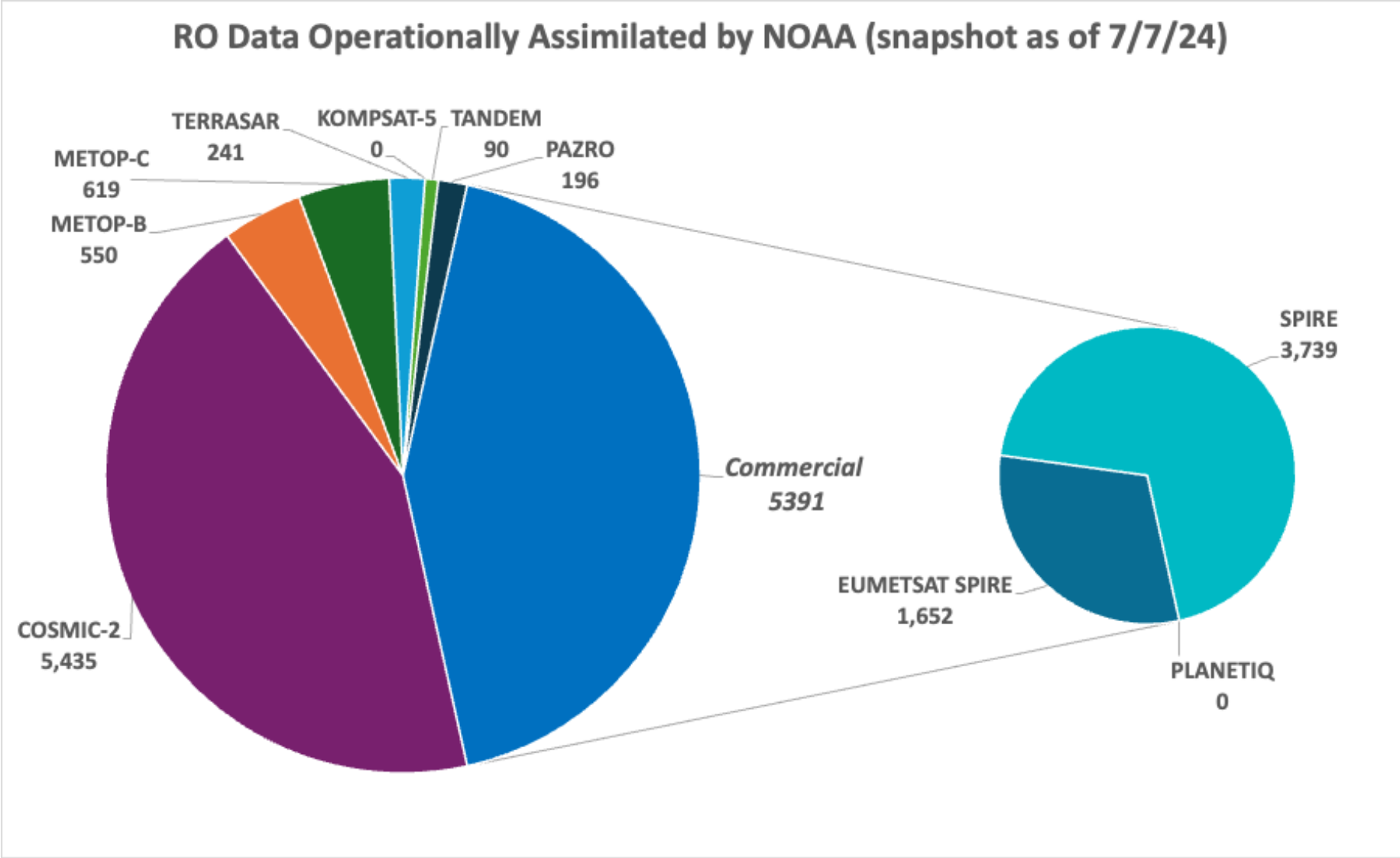


Chart illustrates total RO data assimilated by NOAA as of 7/7/2024.



NESDIS Commercial Data Purchase Impacts

- Benefits of GNSS-RO observations for weather applications:
 - Cost-effective
 - Global coverage
 - Continuous monitoring under all weather conditions
 - Broad applications for space weather and climate prediction
- Enhancements of assimilating GNSS-RO into Numerical Weather Prediction models:
 - 10% forecast error reduction
 - 10-20% tropical cyclone forecast skill improvements
 - Accuracy improvements extend across all forecast lead times

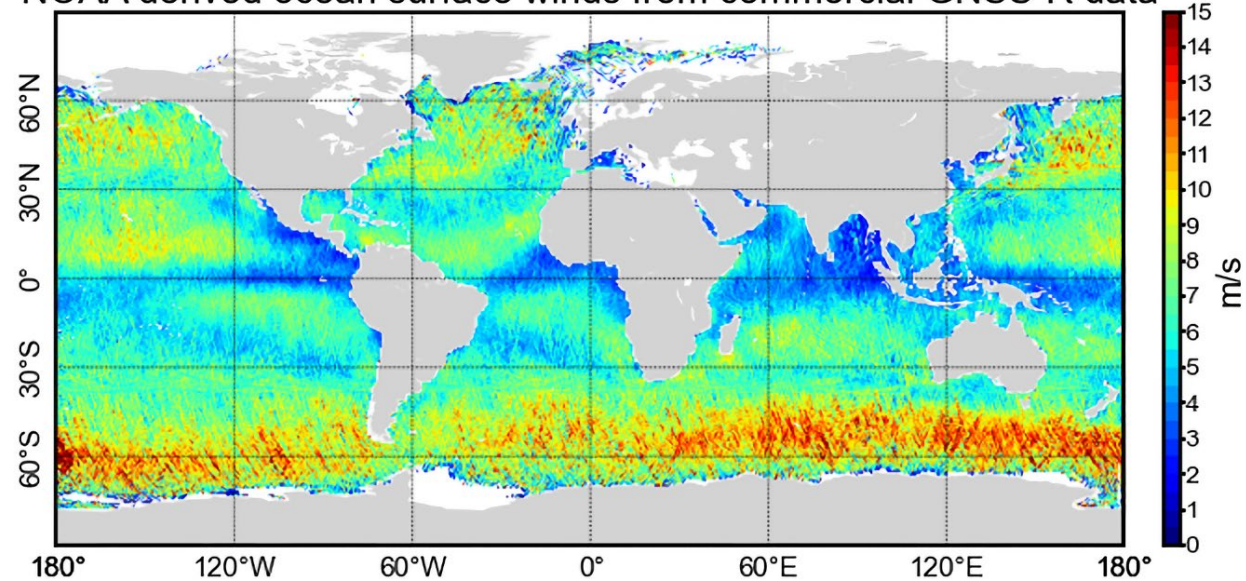


GNSS-RO receivers observe distortion of GNSS signals as they transit the atmosphere. NOAA produces quasi-vertical RO soundings based on bending angles from satellite-based RO open-loop measurements made during a GNSS occultation event.

2023-2024 NESDIS Commercial Weather Data Pilots

- **Space Weather Pilot (ended in 2024):**
NESDIS CDP conducted a successful pilot study of exploiting commercial GNSS-RO data for space weather parameters.
***The final report is now available.*
- **GNSS Ocean Surface Winds (OSW) GNSS Reflectometry Pilot (ongoing):**
NESDIS CDP is executing a pilot study to use commercial reflectometry data to derive **ocean surface wind speeds** and additional environmental measurements.

NOAA derived ocean surface winds from commercial GNSS-R data

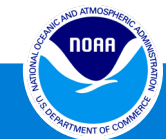


Through a Commercial Weather Data Pilot, NOAA is developing methods for determining ocean surface wind speeds globally using commercial GNSS-R (reflectometry) satellite data.

NOAA Data Sharing License Options

| | | |
|-----------------------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operational Data Purchases | Option 1 | Unlimited distribution rights |
| Data Pilots | Option 2 | Distribution to U.S. Government agencies, National Meteorological Centers (NMC), WMO Met Centers, CGMS members, non profit organizations, Academic entities for non-commercial use with no further distribution |
| | Option 2a | Option 2 plus unlimited distribution after 24 hours |

NESDIS CDP prefers less restricted data sharing options



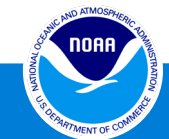
Commercial Weather Data Pilots and Projects

Pilots:

- **Microwave Sounder Pilot:** Awarding a pilot (to begin in Nov/Dec 2024) to
 - Investigate the utility
 - Assess the quality and impact, primarily for the evaluation of atmospheric vertical temperature and moisture profiles measurements.
 - Leverage past microwave research from NASA's TROPICS mission.

Projects:

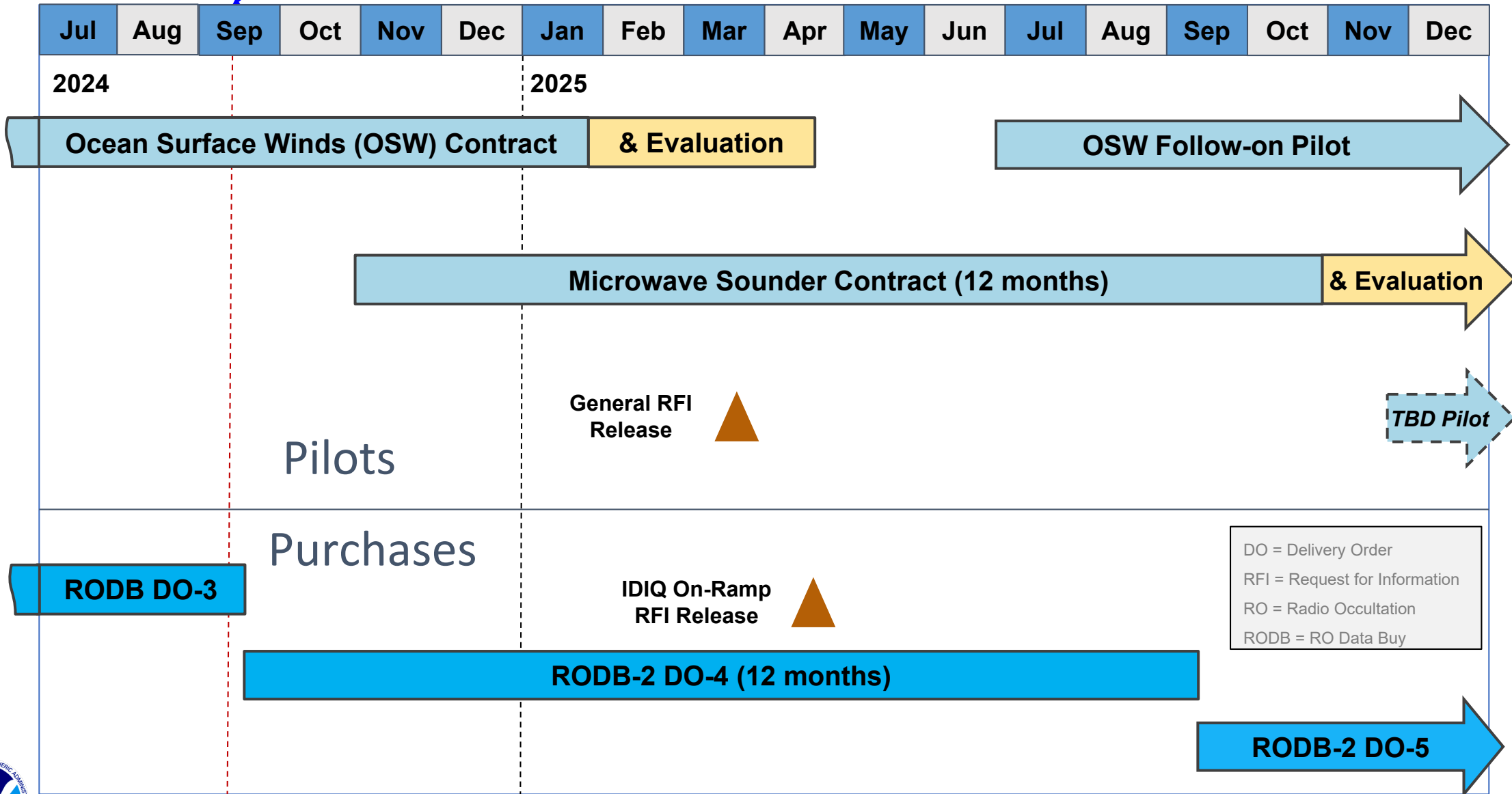
- **HyperSpectral Microwave:** Investigate utility of novel Hyperspectral Microwave technology
 - Leveraging efforts from SAE's own Joint Venture program – results will inform future CDP piloting efforts
- **Polarimetric RO:** Beginning to investigate the utility of PRO profiles to estimate precipitation rates and types
- **Space Weather:** Continued coordination on advancing TEC and Scintillation capabilities



2024-2025 NESDIS CDP Planning

DISCLAIMER: Notional, for planning purposes only, dates subject to change

Today



NOAA Commercial Data Program Community Day

September 26, 2024

1-230pm (EDT)

*Focus: General-
Request for
Information (G-RFI)*

Virtual Event - Register Now



Radio Occultation Analysis of Alternatives (AoA) Phase 1 Overview

Study objectives:

- Identify the gaps in Radio Occultation (RO) coverage as COSMIC-2 degrades, and assess alternatives to meet NOAA's neutral atmosphere (NA) RO requirements through 2036.

Methodology:

- Assessed hybrid architectures composed of:
 - Partner missions
 - Commercial data
 - NOAA constellation
- Assessed performance over time, estimated costs, and risks.
 - Based on Coverage, refresh, and latency requirements.



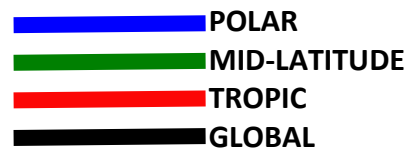
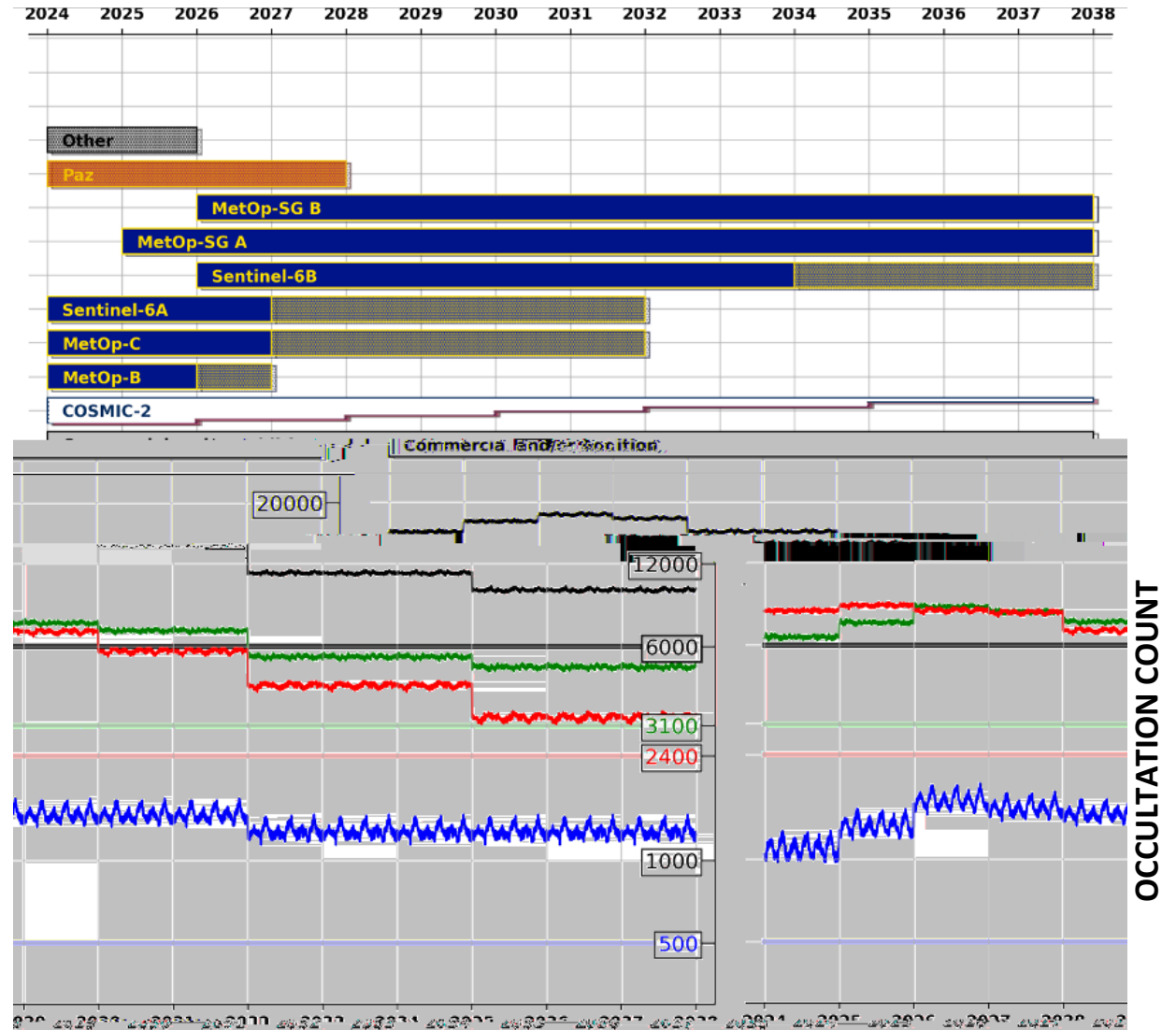
Performance Analysis: Counts Conclusions

Baseline with 4000 commercial augmentation:

- All count requirements will be satisfied through the assessed period with minimal (2,000+) commercially provided RO profiles

Takeaway:

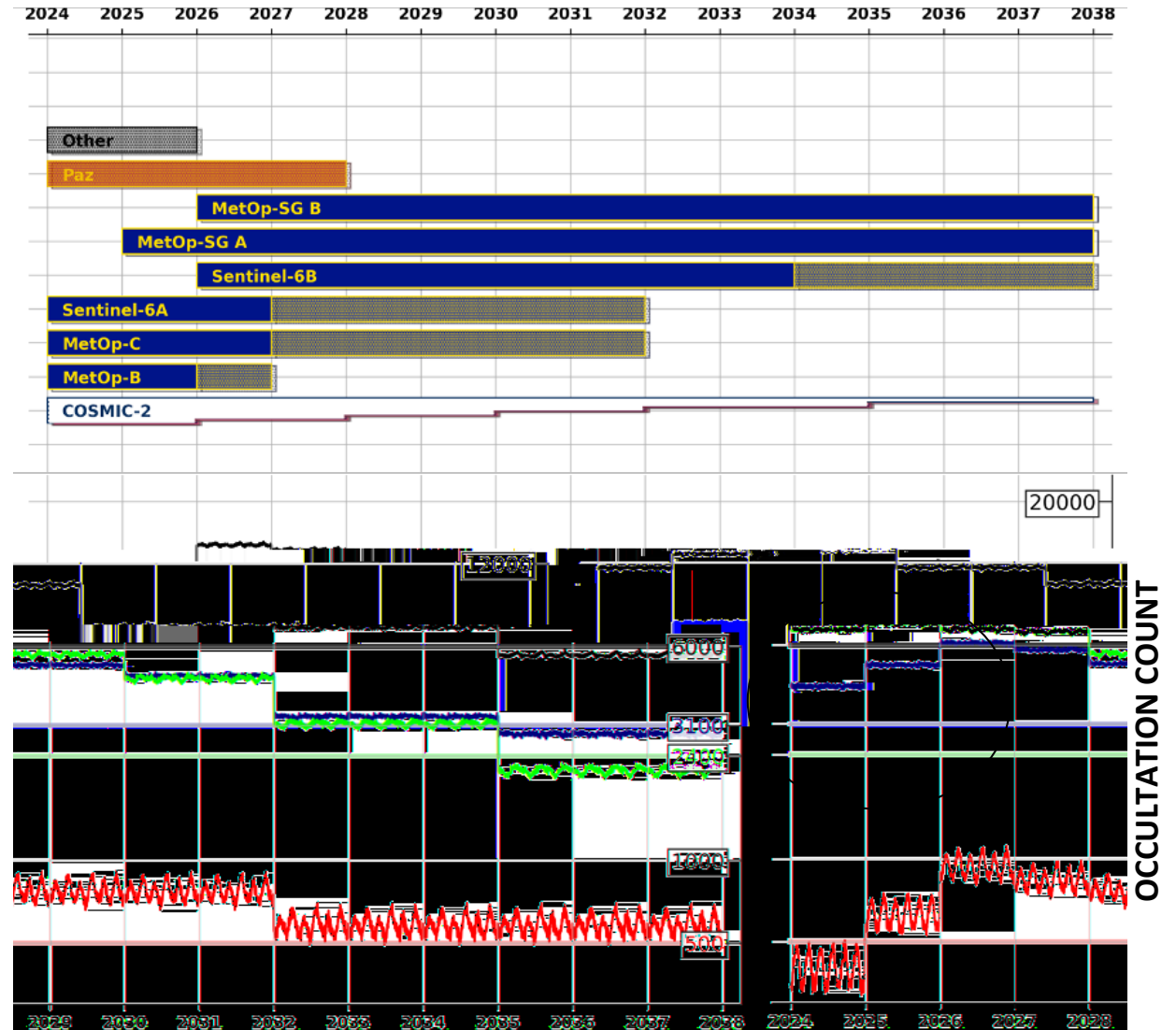
- RO Count requirements are met with commercial augmentation.



Commercially Augmented Baseline (4,000/day)

Performance Analysis: Counts Conclusions

- **Baseline without commercial augmentation:**
 - Global, tropic, and mid-latitude daily RO count requirement is satisfied **until 2035**
 - **Polar** daily RO count will be satisfied when MetOp-SG is launched but is currently failing

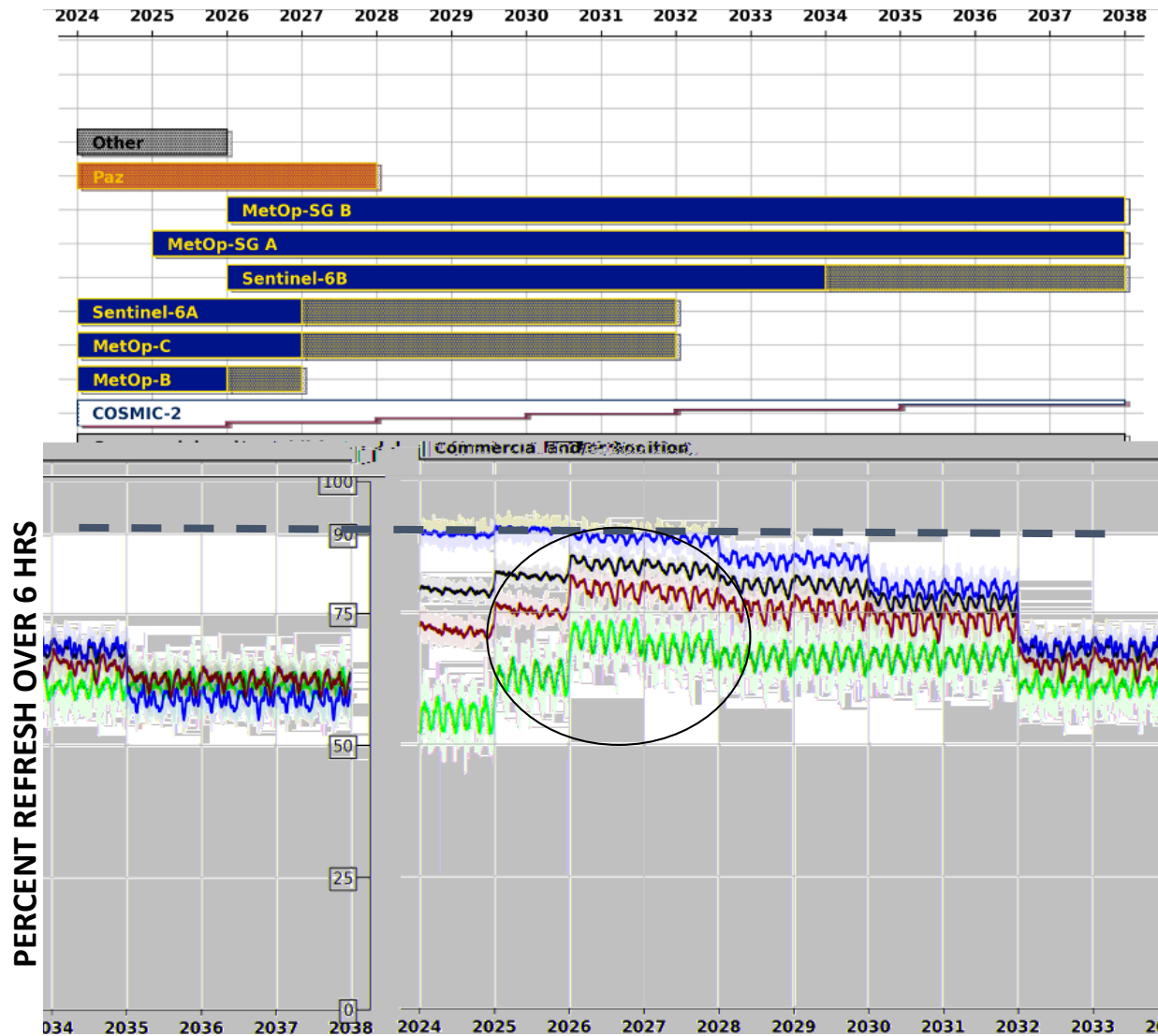


█ POLAR
█ MID-LATITUDE
█ TROPIC
█ GLOBAL

Government Baseline / No Commercial



Performance Analysis: Refresh Conclusions



- Refresh for Baseline and 4000 Commercial
 - Currently the global refresh and uniform distribution requirement in not being met
 - COSMIC-2 carries a similar requirement in the **tropics**, so this meets ~90% performance
- Refresh is highly sensitive to COSMIC-2 loss/degradation, hence the step-function shown

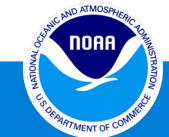
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*Global grid defined as 500x500 km equal area grid between 85°S and 85°N latitude

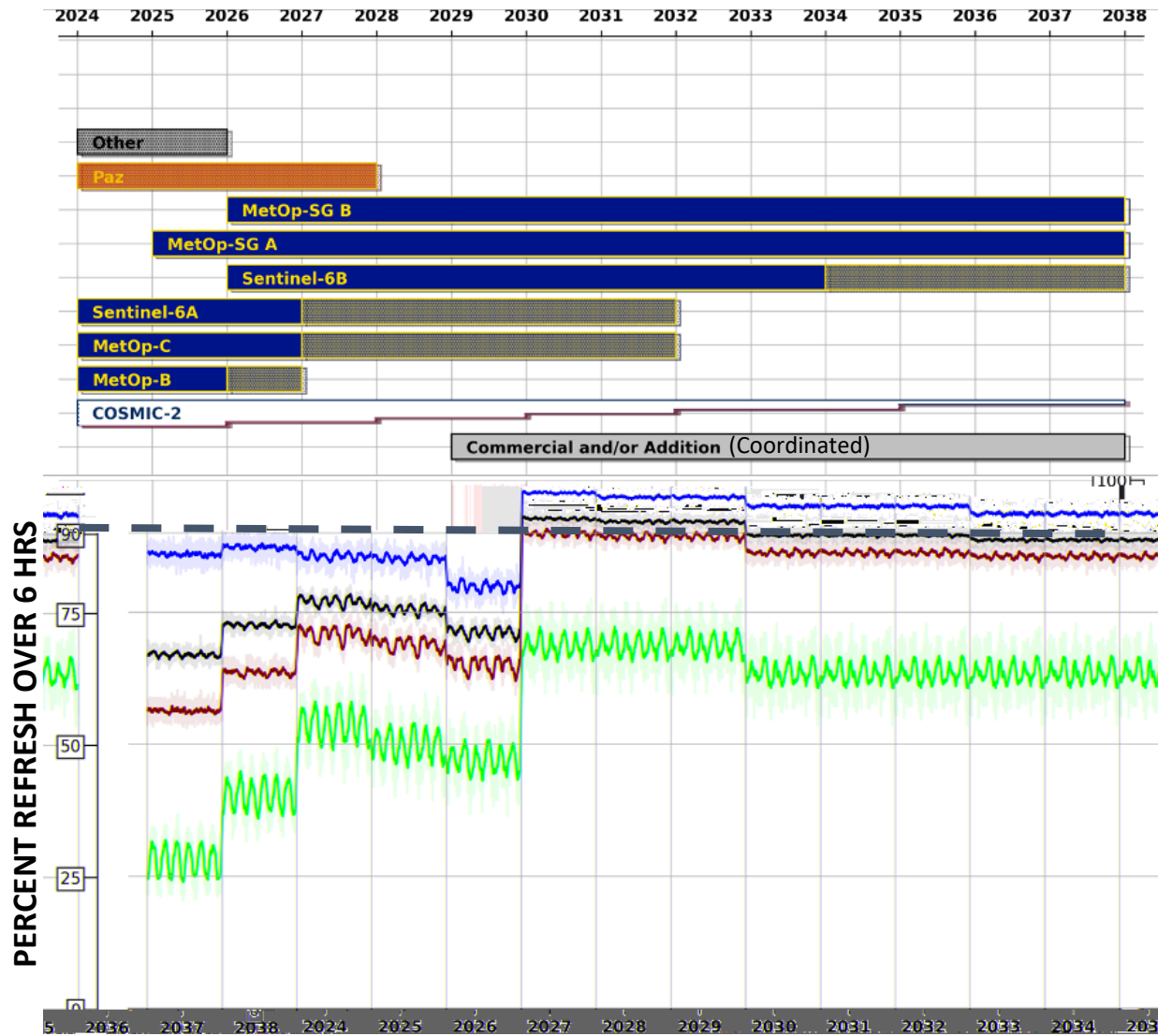
*Polar, mid-latitude, and tropic refresh are not provided requirements and are only shown for relative contribution

Commercially Augmented Baseline (4,000/day)

National Environmental Satellite, Data, and Information Service



Performance Analysis: Refresh Conclusions



- Added dedicated 6 Satellites at low-latitude orbit and 2 Additional Coordinated high-latitude orbit satellites.
 - Could be commercial contribution, LEO planned, NOAA-owned.
- **Coordinated & diverse orbits** are the most effective way to achieve refresh requirements
 - 2029 Launch was for modeling only
- The requirement can be achieved by:
 - (1) Maintain continuity from *coordinated & diverse low-latitude orbits*
 - (2) Increase observations made from *coordinated & diverse high-latitude orbits*

Dedicated 6x30° + 2x~98° (SSO)

- █ POLAR
- █ MID-LATITUDE
- █ TROPIC
- █ GLOBAL

*Global grid defined as 500x500 km equal area grid between 85°S and 85°N latitude

*Polar, mid-latitude, and tropic refresh are not provided requirements and are only shown for relative contribution



Key results

Key results:

- RO observing system is sensitive to the loss of COSMIC-2 in tropics and mid-latitudes
- Counts per day requirement is much easier to meet than refresh requirement
 - Count requirements can be met by partners and commercial
- Uniform distribution requirements and refresh cannot be met by partners and commercial
- **NOAA-owned constellation in *low-inclination orbit* in addition to a coordinated and diverse constellation in *high-inclination orbit* would meet requirements by 2028-2031.**
- **Will continue this AoA analysis with a Phase 2 in FY25.**

Phase 2 Next Steps

- Better understand the impact of NWP forecasts from deviations in RO capabilities
 - OSSE's, model sensitivities
 - Leverage ROMEX Results
- Expand partnerships
- Expand scope of study to include all of the products produced from an RO constellation, including
 - Ionospheric TEC
- Optimize the modeled constellations

Questions?

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NESDIS Commercial Data Program Information:

<https://www.space.commerce.gov/business-with-noaa/commercial-weather-data-pilot-cwdp/>



Bullpen Slides



NOAA/NESDIS Commercial Data Program Background

- In 2016, NOAA began the NESDIS Commercial Data Program with a Radio Occultation Data Pilot.
- In 2020, awarded 1st Commercial Data Buy (RODB-1)
- Today, NOAA uses commercially available Radio Occultation (RO) data to respond to the demand for environmental information and satisfy observational requirements.
- Derive Neutral Atmosphere and Ionospheric products from Global Navigation Satellite System RO (GNSS-RO)
- Exploring non RO-based commercial space-based environmental monitoring data sources



Methodology of Study

Performance Analysis

One-year propagation **simulation of 101 use cases** executed

Sensors modeled based upon capabilities demonstrated in operations (or advertised for future missions)

Payload Analysis

Detailed investigation into **published performance parameters** and SWAP values

Cost Analysis

Standard cost models
Historical/actual costs
Estimates from partners
Open source data

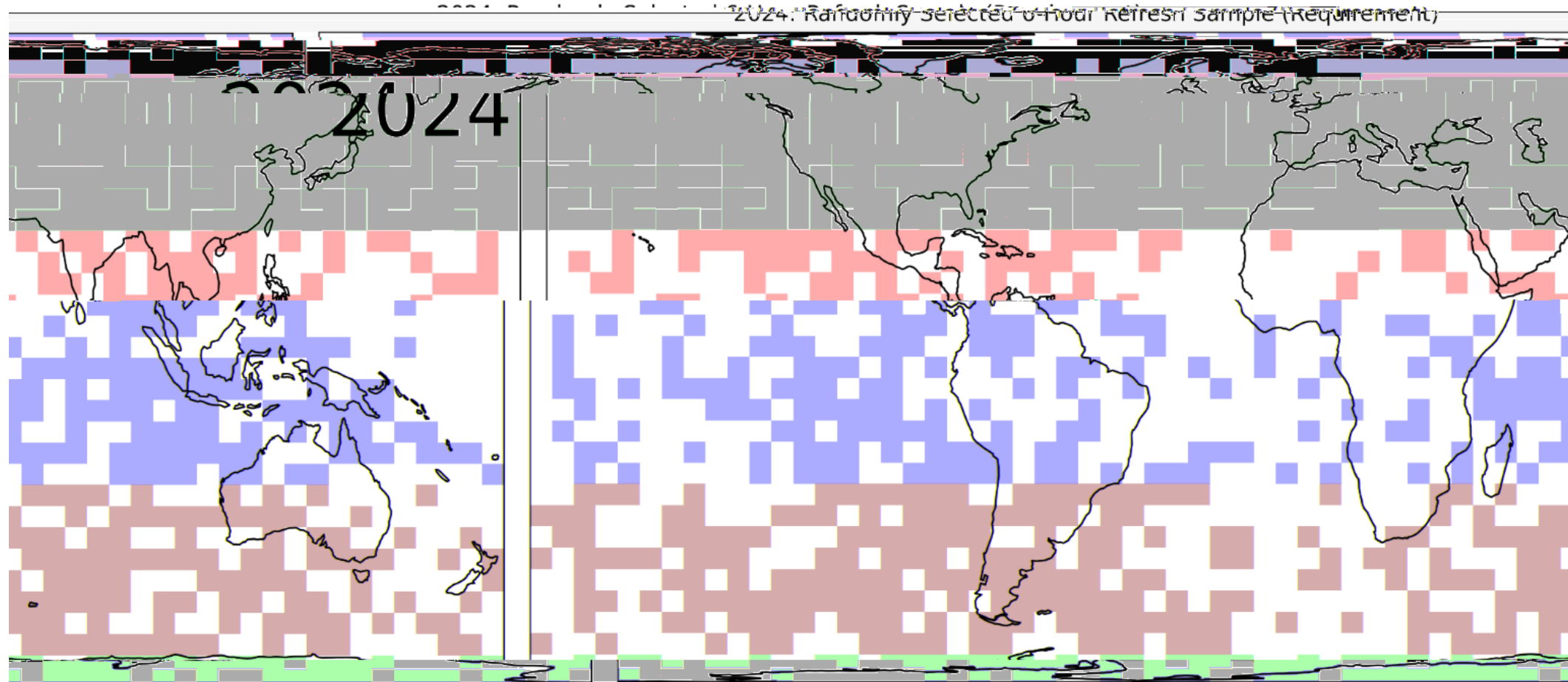
Risk Analysis

Risk ratings determined through **NASA Risk Management Handbook criticality methodology**

Evaluation Matrix

Takes into account all factors analyzed, provides a rating scale to compare alternatives

Partners + 4k Commercial, No COSMIC-2



Note: If something seems visually off about these cells “not moving” over the course of years, it’s because of the approach taken to model them; for expedience, only one year worth of data was modeled for every satellite on an arbitrary date. Various configurations by year were then combined based upon flyouts. This presents a small modeling error in that the ascending node of the GNSS satellites should be moving ~1-2 degrees per year. This is only meaningful over the course of one year if an observing satellite has very slow precession, which only occurs at pure polar orbits (~90 degrees).