GOES Updates

GOES-U Launch

- GOES-U is being prepared for a June 25th, 2024 launch
    - Spacecraft is at Cape Canaveral / Astrotech
    - Launch Vehicle: Falcon Heavy
    - Launch Site: LC-39A
- GOES-U will be designated as **GOES-19**

Operations Post Launch

- GOES-19 will undergo checkout in 89.5W location
- Following Post Launch Testing & Handover → 79.2W
    - Co-located with GOES-16 @ 79.5W
- GOES-19 operational late March 2025
- GOES-16 will go into storage
- Future of GOES-14 and -17 in discussion

GOES End of Life – Inclination Drift

The Geo Program is evaluating the potential to increase the operational life of the GOES-R series spacecraft by ceasing North-South Station-keeping (NSSK) as spacecraft approach end of life

- Significant amount of fuel can be saved on NSSK, both in storage or in operational mode, extending the life of the mission. Protects against alternative: coverage gaps in event of GeoXO delay for any reason
- Has been done in the past on previous missions (e.g. GOES-10, EWSG)
- 5-degrees has been determined to be a 'sweet-spot' between fuel savings and operational/technical complexity
  - Spacecraft will take approximately 6 years to drift to 5 degree inclination
- East-West station-keeping is maintained; Spacecraft performs yaw-steering to maintain 'normal' E-W scan pattern

Earliest operational implementation would be on GOES-16 in late 2029 (in storage location, current EoL projected to be Q1 2033), followed by GOES-18 and GOES-19 in 2030s

- Spacecraft will appear to perform a thin figure-8 relative to ground track around nominal equatorial slot
  - Results in adjustments to imager field of regard and user facing RF comms coverage areas
- Testing to be performed on GOES-17 in near term

ABI Field of Regard Comparison at Max Inclination

Equatorial GOES-E
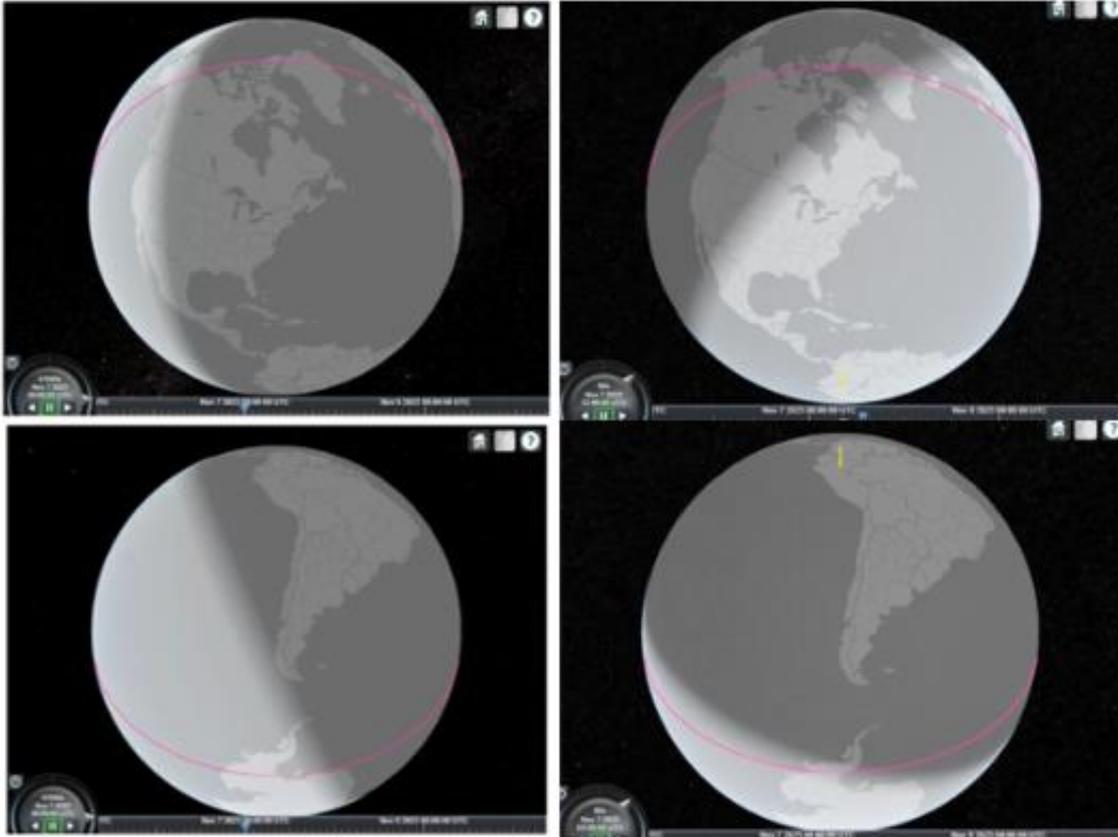
Maximum Reduction in Northern Coverage (GOES-E @ -5 Deg Inclination

Maximum Reduction in Southern Coverage (GOES-E @ +5 Deg Inclination

Red Line denotes observable earth from nominal inclination
Due to fixed grid remapping, no additional observable area will be available

User Facing Comms Summary

- As part of the coordination of potential RF aux comms impacts of performing inclination float, Geo Program has been coordinating with the OSPO Direct Services Branch to assess impacts to Auxilliary Communications Services on **User Facing** Interfaces
    - User Facing Auxilliary Communications Services links include:
        - **Data Collection System (DCS)**
            - DCPR Uplink (Data Collection Platform to Geo)
            - DCPR Downlink (Geo to User Direct Readout)
            - DCPC (Geo to Data Collection Platform) - Not Currently Utilized / Receiver in Development
        - **GOES Rebroadcast (GRB)**
            - GRB Downlink (Geo to User Direct Readout)
        - **High Rate Information Transmission / Emergency Managers Weather Information Network (HRIT/EMWIN)**
            - HRIT/EMWIN Downlink (Geo to User Direct Readout)
        - **Search and Rescue Satellite-Aided Tracking (SARSAT)**
            - SARSAT Uplink (Device to Geo)
            - SARSAT Downlink (Geo to Direct Receive)

- Supporting OSPO SPSD/DSB in coordination and risk assessment in event inclination float implemented for operational GOES spacecraft

RF User Comms Impact Summary

Potential impacts of inclination float on user facing auxiliary communications can be broken into three categories based on user site location

- A) Locations well within coverage area
  - Sites with > 10 deg of elevation to equatorial GOES
  - Primarily driven by receiver / transmitter antenna patterns / margin
    - Omni-directional systems not impacted (i.e. SARSAT Uplinks, some DCPR)
    - Highly directional antennas may experience decrease in link margin without tracking

- B) Locations near Northern / Southern Edges of Coverage Area
  - Sites with < 10 deg of elevation to equatorial GOES
  - Same primary drivers as A, but low elevation angle sites should consider local obstacles (terrain, buildings, etc)
  - During a portion of day, sites will be outside "official" coverage area from spacecraft

- C) Locations at Northern / Southern Edges of Coverage Area
  - Sites near 5 deg elevation (< 5 deg not "officially" covered by GOES)
    - Represented by the lines at left
  - These sites will be outside of official coverage area for half of the day
  - Greatest risk of loss of coverage

+5 Deg N

Equatorial

- 5 Deg S
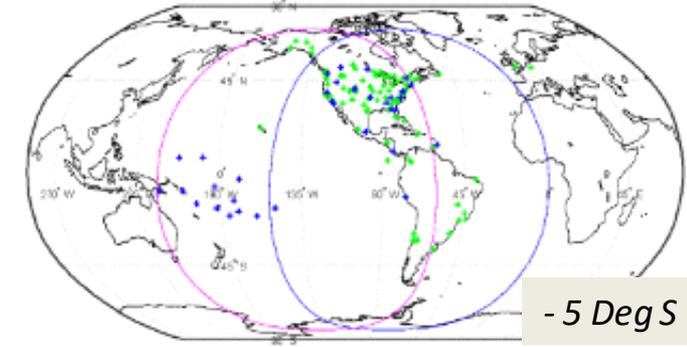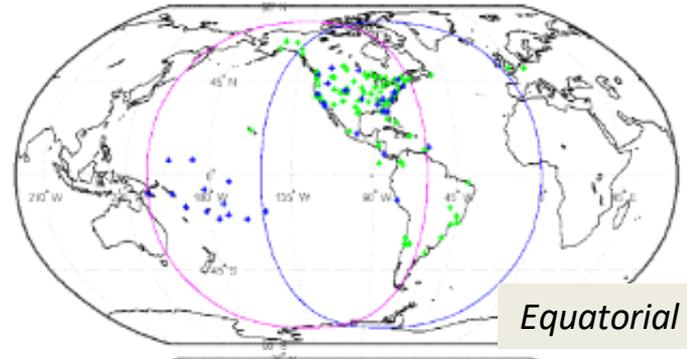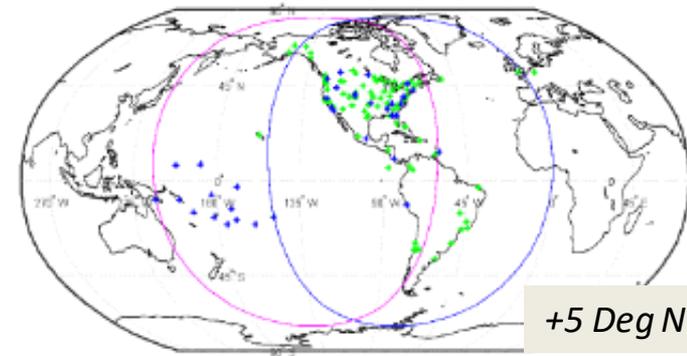
GeoXO Constellation

GEO-West
Visible/Infrared Imager
Lightning Mapper
Ocean Color
+ DCS

GEO-Central
Hyperspectral Infrared Sounder
Atmospheric Composition
Partner Payload

GEO-East
Visible/Infrared Imager
Lightning Mapper
Ocean Color
*+ DCS*

GeoXO Updates

Lifecycle Updates

- Mission Definition Review (MDR): December 2024
- Preliminary Design Review (PDR): FY2025
- Critical Design Review (CDR): FY2027
- Initial Launch Capability (ILC): FY2032

Procurement Updates

- Imager (March 2023) & Sounder (September 2023) Contracts Awarded
- Spacecraft RFP Released (September 2023) & Responses Received / In Evaluation

Spectrum Updates

- NTIA Stage 1 Certification Approved April 2023
- NTIA Stage 2 Certification Submitted October 2023 → Anticipated Cert Late 2024
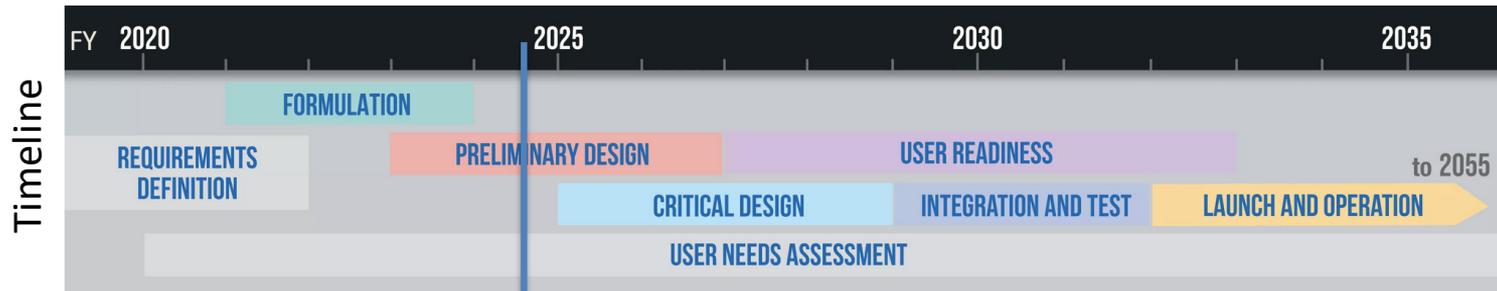
GeoXO Spacecraft Orbit Locations

| Satellite Orbit Location	Location
East (GeoI)	75° W
West (GeoI)	137° W
Central (GeoS)	105° W
Storage Location 1	94° W
Storage Location 2	92° W
Check-out	88° W

GeoXO Instruments

GOES-R provides Visible/Infrared Imagery, Lightning, and Space Weather data:

– Essential for short-range forecasting, issuing severe weather watches and warnings, and monitoring hazardous environmental conditions including tropical storms, severe storms, damaging winds, snow, ice, flooding, fog, fires, smoke, and volcanic ash

– GOES-R Imagery, Lightning, and Space Weather data included in User Facing Comms

GeoXO will continue and improve Imagery and Lightning data and add new observations:

– **Hyperspectral IR Sounder** for numerical weather prediction and local nowcasting

– **Ocean Color Instrument** for monitoring dynamic coast/ocean features, ecosystem change, water quality, and hazards

– **Atmospheric Composition Instrument** for monitoring air quality and the linkage between air quality, weather, and climate
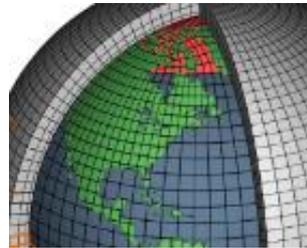
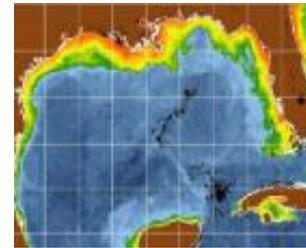– No space weather instruments → SWO
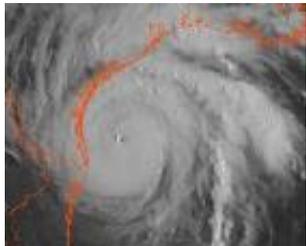
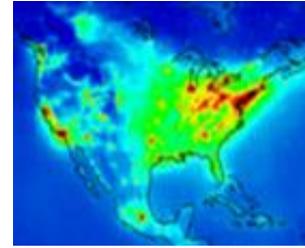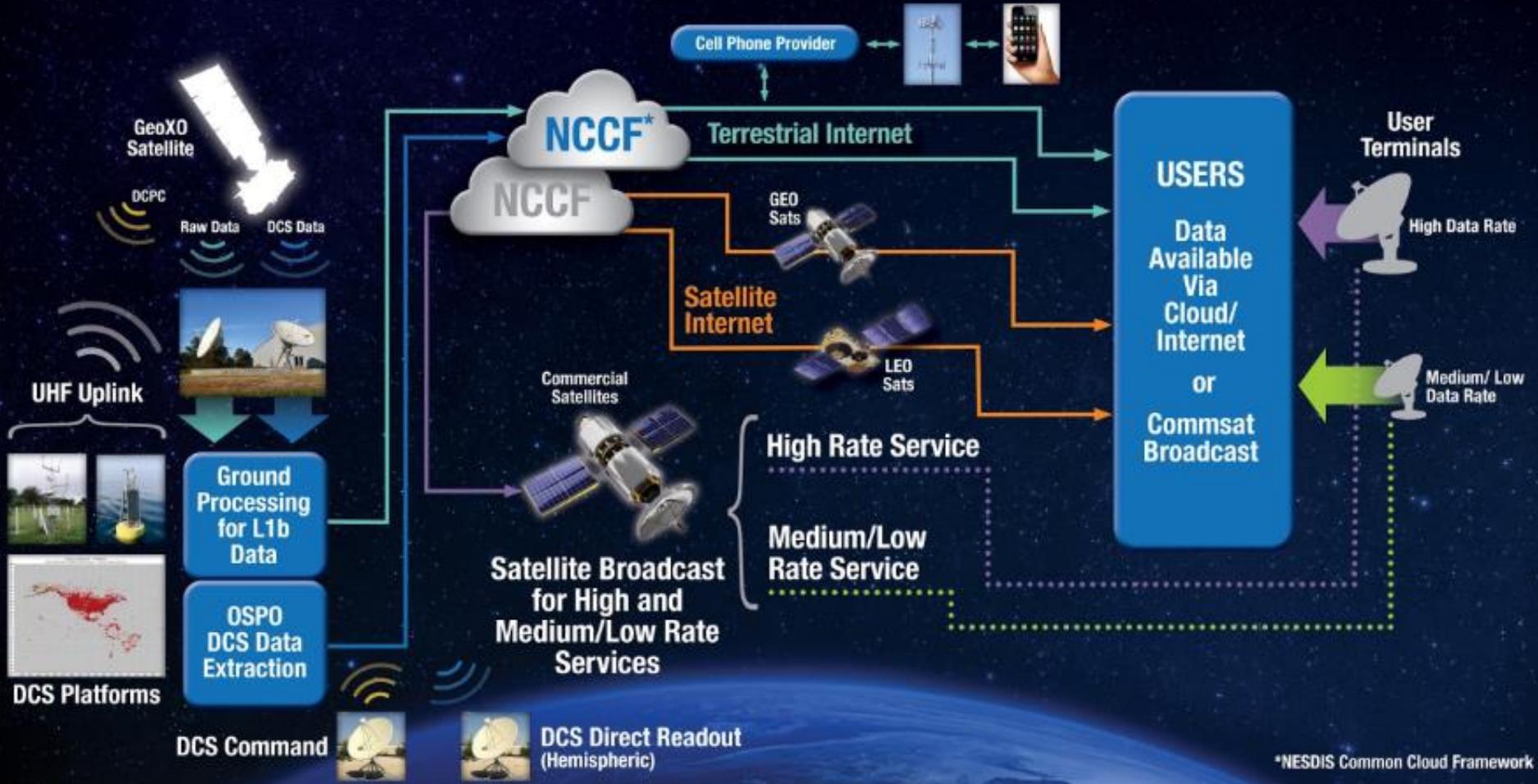**Vis/Near-IR Imagery** **Lightning Mapping**

IR Sounding **Ocean Color** **Atmo. Composition**

GeoXO Data Distribution

GeoXO User Facing Comms Overview

	GOES-R Series	GeoXO Series
Data Collection System (**DCS**)	Data Collection Platform Report (DCPR) - UHF Data Collection Platform Command (DCPC) - UHF Hemispherical Direct Readout – L-Band*	Data Collection Platform Report (DCPR) - UHF Data Collection Platform Command (DCPC) - UHF Hemispherical Direct Readout – L-Band**
GOES Rebroadcast (**GRB**)	Hemispherical L-Band	Cloud Dissemination & Commercial RF (Band TBD)
High Rate Information Transmission (**HRIT**) / Emergency Managers Weather Information Network (**EMWIN**)	Hemispherical L-Band	Cloud Dissemination & Commercial RF (Band TBD) – No GeoXO Transponder
Search and Rescue Satellite Aided Tracking System (**SARSAT**)	GEOSAR via GOES	Not included in GeoXO Spacecraft – Served by MEOSAR Constellations

Hemispherical: > 5 deg ground elevation angle to spacecraft

*GOES-R L-Band Downlink Center Frequency 1679.9 (U.S. Domestic) 1680.2 (International)
**GeoXO L-Band Downlink Center Frequency 1691.9 (U.S. Domestic) 1692.2 (International)

Frequency Plan for GeoXO
User Facing Communications

GeoXO User Facing Communications Center Frequencies

FREQUENCY (MHz)	DIRECTION	Description
401.7, 401.85, 402.0, 402.4; 401.7-402.4	E-S E-S	DCS Pilot & DCPR Uplink
2032.775; 2032.825	E-S	DCPC Uplink
468.775; 468.825	S-E	DCPC Downlink
1691.9 (U.S. Domestic) 1692.2 (International)	S-E	DCPR Downlink (DRGS)

GOES-R vs. GeoXO User Facing Communications

GeoXO High Rate Service
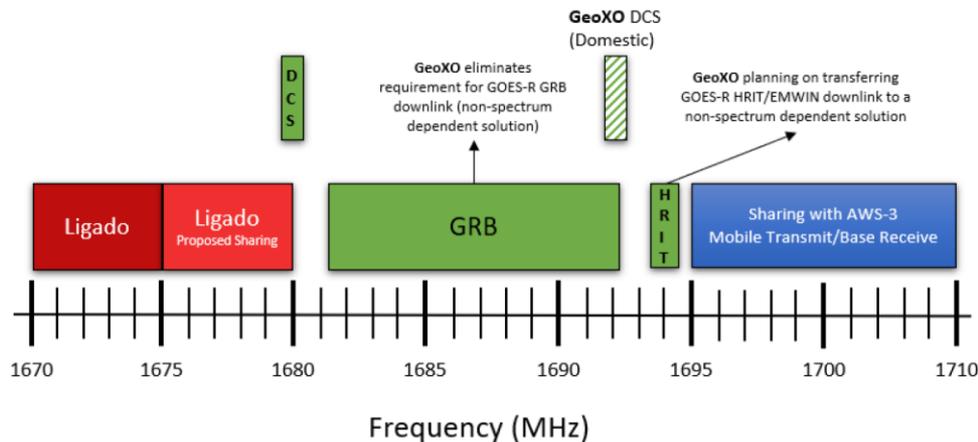
GOES-R

GOES Rebroadcast (GRB)

- Instrument data collected via GOES
- Downlinked to NOAA, Processed
- Uplinked as the GRB
- Distributed L-Band Hemispherical Broadcast
  - Dual Circular Polarization, 31 Mbps
- L1b Imagery (ABI), Lightning (GLM), Space Weather/Solar Instrument Data

GeoXO

GeoXO High Rate Service *(Notional)*

- Instrument data collected via GeoXO
- Downlinked to NOAA, Processed (Cloud TBD)
- Primary Distribution: NCCF
- Selected Products Passed to Commercial Provider, Uplinked to Commercial Communications Satellite
- Broadcast service, TBD Band, **~50 Mbps (TBR)**
  - *Sized based on GRB ABI L1b Continuity*
- Comparable Architectures: Eutmetcast, GNC-A

Typical GRB Receiving Antennas

C-Band GNC-A (El Salvador)

1.8m Ku Eumetcast

GeoXO Medium/Low Rate Service

GOES-R

HRIT/EMWIN

- L-2+ Products from GOES & Partner Satellites
- Tropical Storm Products
- EMWIN alerts, watches, warnings, observations, forecasts and climate products in text and image formats
- 400 kbps data transmission

Professional (L) vs. Homebrew (R) HRIT/EMWIN Antennas

GeoXO

GeoXO Medium/Low Rate Service *(Notional)*

- Equivalent to GOES-R: Configurable product set based on user needs and requirements
- GeoXO products from NCCF + other selected Products Passed to Commercial Provider, Uplinked to Commercial Communications Satellite
- Broadcast service, TBD Band, ~1 Mbps (**TBR**)
    - Not necessarily distinct from High Rate, but need to balance efficiency vs. user accessibility

1.25m Ku Eumetcast

NOAA DCS Features on GeoXO

DCS will remain free!

All Current Features!

- UHF Uplink to GeoXO from Data Collection Platforms – 401.701 to 402.09925 MHz in 566 Channels
- Hemispheric L-band Downlink – Received by NOAA or directly by user
- Multiple Communication Protocols – ASCII or Pseudobinary
- Data Access via NOAA web access, open source access (e.g. OpenDCS), or direct receive

New Features Expected Prior to and During GeoXO

- Improved User Web Access and Analytics from NOAA website
- Remote configuration changes via Commanding Capability - UHF transponder signals to Data Collection Platforms (e.g. reset, channel change, etc.)
- Additional Protocol – Open Binary

Potential Features in Development

- Enhanced DCP protocols with improved Error Correction

DCS Commanding Update

There are two efforts underway in parallel to reestablish DCP Command (DCPC) Capability

- Microcom led DCS Command Demonstration
    - End to End Command Capability (User Interface, Modulator, Receiver)
        - More in Skip & Brett's presentations

- Goddard / Geo Program led DCS Receiver Development
    - Focused on portable/fieldable receiver development
        - Evaluating alternate modulation characteristics to enable low-cost receiver

DCS Commanding Update

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Goal is to demonstrate fieldable DCPC receiver and release an engineering reference design for later manufacturer development for GOES-R & GeoXO

Forward Link Development for GeoXO

Goddard Modulator & Receiver - Updates

- Developed and deployed FHSS code for card to card transmission of data (468 MHz only)
    - Bench testing successful with modulator and receiver
- Developed and deployed rack ready modulator system for installation at WCDAS
- Successfully transmitted FHSS modulated signal through WCDAS and GOES-E spacecraft
- Received FHSS signal via WCDAS ground antennas (DCS Pilot) and confirmed receipt on GeoXO receiver (~11/23)
- Reduced symbol rate (started at ~1500 sps, currently at 500)
- Changed DCPC Transponder on GOES-16 from Automatic Level Control to Fixed Gain Mode (02/24)
- Achieved initial synchronization between modulator and receiver → Tuning on-going

Forward Link Development for GeoXO

GeoXO 2-Way Demo (FHSS) – Latest Configuration	
Bandwidth	100 kHz
Number of Hops	60
Hop Dwell Time	0.1 seconds
Hop Frequency Spacing	12.5 kHz (minimum)
Hop Cycle	6.0 seconds
Modulation	(G)MSK
Data Rate	500 bps
Data Whitening	PN9

GeoXO DCPC Modulator Adjacent to Microcom DCPC Modulator

Forward Link Development for GeoXO

GeoXO DCPC FHSS Signal at the WCDAS IFDS
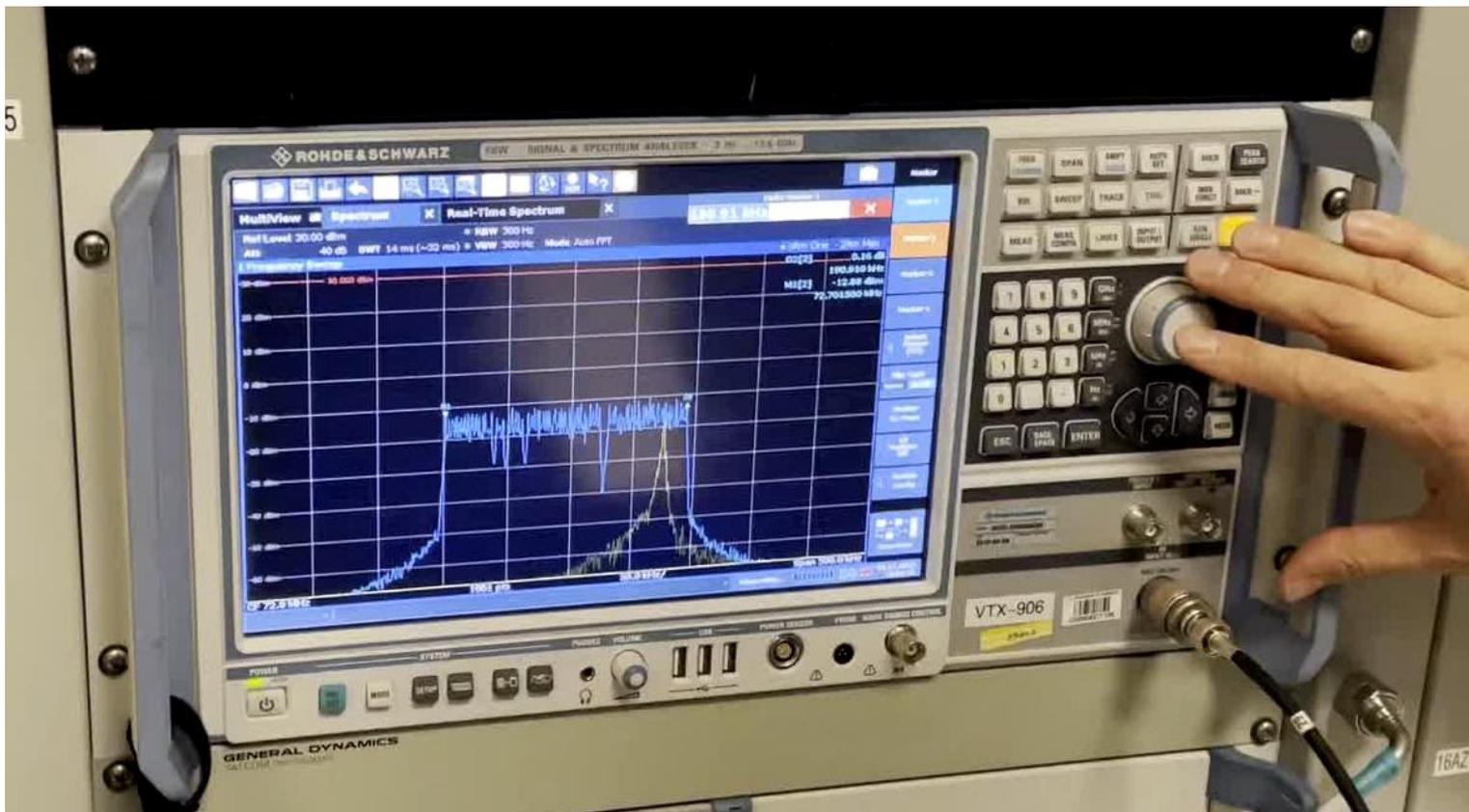
GeoXO DCPC Receiver & Antenna Testing

Forward Link Development for GeoXO

GeoXO DCPC Signal Receipt via "Ideal" Antenna / Amp / Filter @ WCDAS
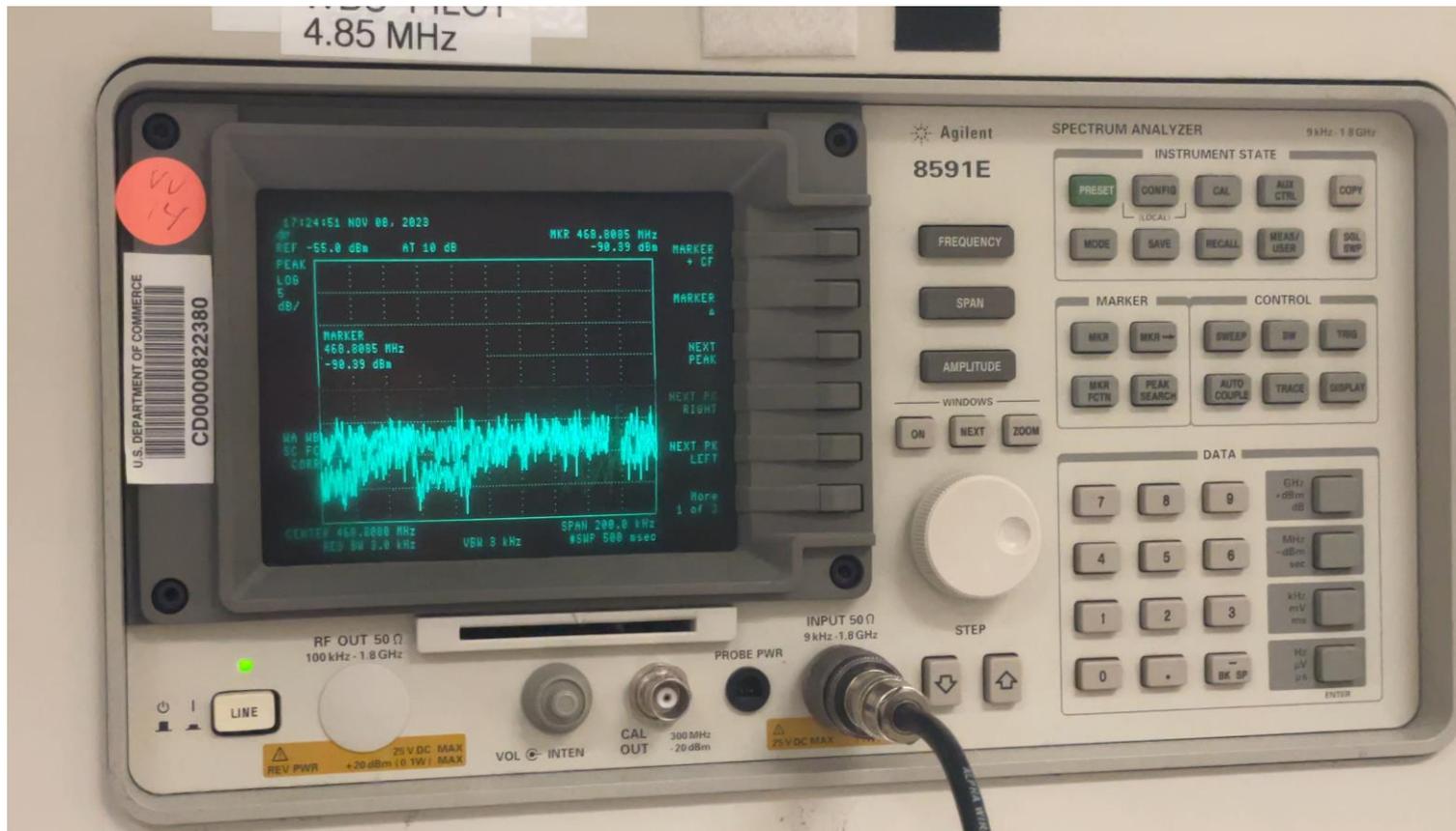
GSFC Receiver Major Tasks

CY2023
- Develop initial proof of concept modulator and receiver ✓
- Integrate Command Handling Card w/ DCP and Ti Receiver ✓
- Perform bench testing of RF link (8/23) and DCP interface ✓
- Integrate proof of concept to WCDAS IF and receiver to DCP to begin end to end proof of concept testing ✓

CY2024
- Continue end to end link testing & tuning **IN PROGRESS**
- Begin initial field testing of proof of concept receiver with NOAA (NOS)
- Field testing of GOES-R receiver with NOAA (NOS & NDBC)
- Expanded field testing with external DCS users (USGS & more) - TBD
- Definition of Engineering Reference Design – Timing TBD

CY2025
- Release of Engineering Reference Design / Transition to DCP Manufacturers

Commercial Command Link Development

Updates

- Geo Program has purchased multiple commercial IoT devices to test in support of alternative DCS command link capabilities
  - **SpaceX Swarm Development Kit w/ M138 Modem**
    - Successfully sent messages to receiver via Swarm cloud interface
    - Next step: Development kit interface to DCP
    - Note: Swarm is currently testing direct-to-device connectivity, although current test is using legacy VHF LEO based system

  - **Orbcomm ST2100 Modem Dev Kit (uses Inmarsat GEO link)**
    - Hardware on hand

  - **CLS Argos Meloa Modem (Argos DCS Leo)**
    - Hardware on hand
    - Performed initial hardware familiarization

Commercial Link Example

SpaceX / Swarm Evaluation Kit @ NOAA National Ocean Service
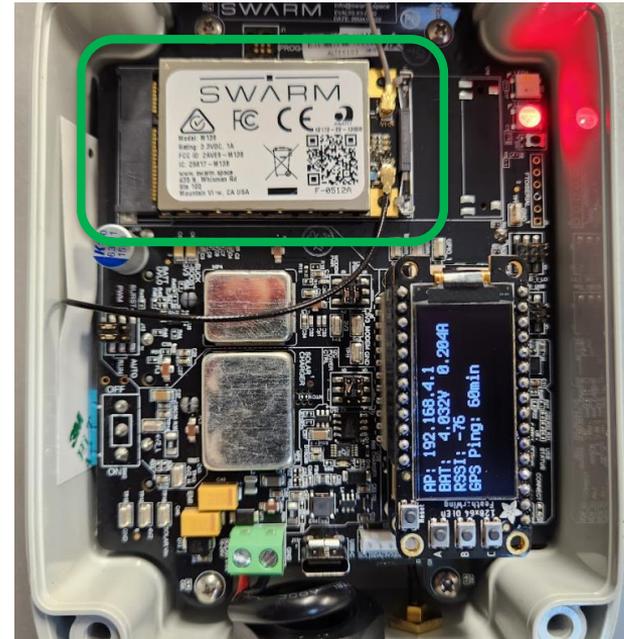
Swarm M138 Modem (PCIe Form Factor) Installed in Evaluation Kit

Project Overview Schedule

Milestones / CY	2023			2024				2025				2026				2027
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1

GeoXO Fwd Link Review Point

GOES-R DCS Forward Link Full Functionality (Mod & Receiver)

GeoXO Milestones: MDR · Flt PDR · Msn PDR · Flt CDR · Msn CDR

User Engagement: F23 STIWG · S24 STIWG · F24 STIWG · S25 STIWG
- Release Commitment Document
- Commitment Stats Update 1
- Update 2
- Cutoff
- Fwd Link Commitment Period

Requirements Updates
- GeoXO PLR, MRD, IRDs + DCS Program Docs
- A/R: GeoXO PLR, MRD, IRDs, DCS
- GOES-R GS to DCS IRD Updates

Fwd Link Receiver
- Prototype Development (GSFC)
- Prototype Test
- Engr Ref Design (ERD): Define, Procure, Build
- User Field Tests
- Final ERD Released
- Mfg Certifications
- A/R: ERD Updates

Fwd Link Modulator
- Prototype Development (GSFC)
- Op. Definition
- Install (Wallops)
- Prototype Test (Wallops)
- May be able to utilize existing modulator (Microcom or GSFC) vs. procurement of "operational" units

Commercial Fwd Link
- Market Research
- Procurement
- STIWG Update
- Expanded Field Trials
- STIWG Updates
- Procurement
- Arch. Design Definition
- Architectural Design Release
- Field Trials (NOS)

BACKUP SLIDES

GOES-R vs. GeoXO
RF Data Relay & Distribution Services
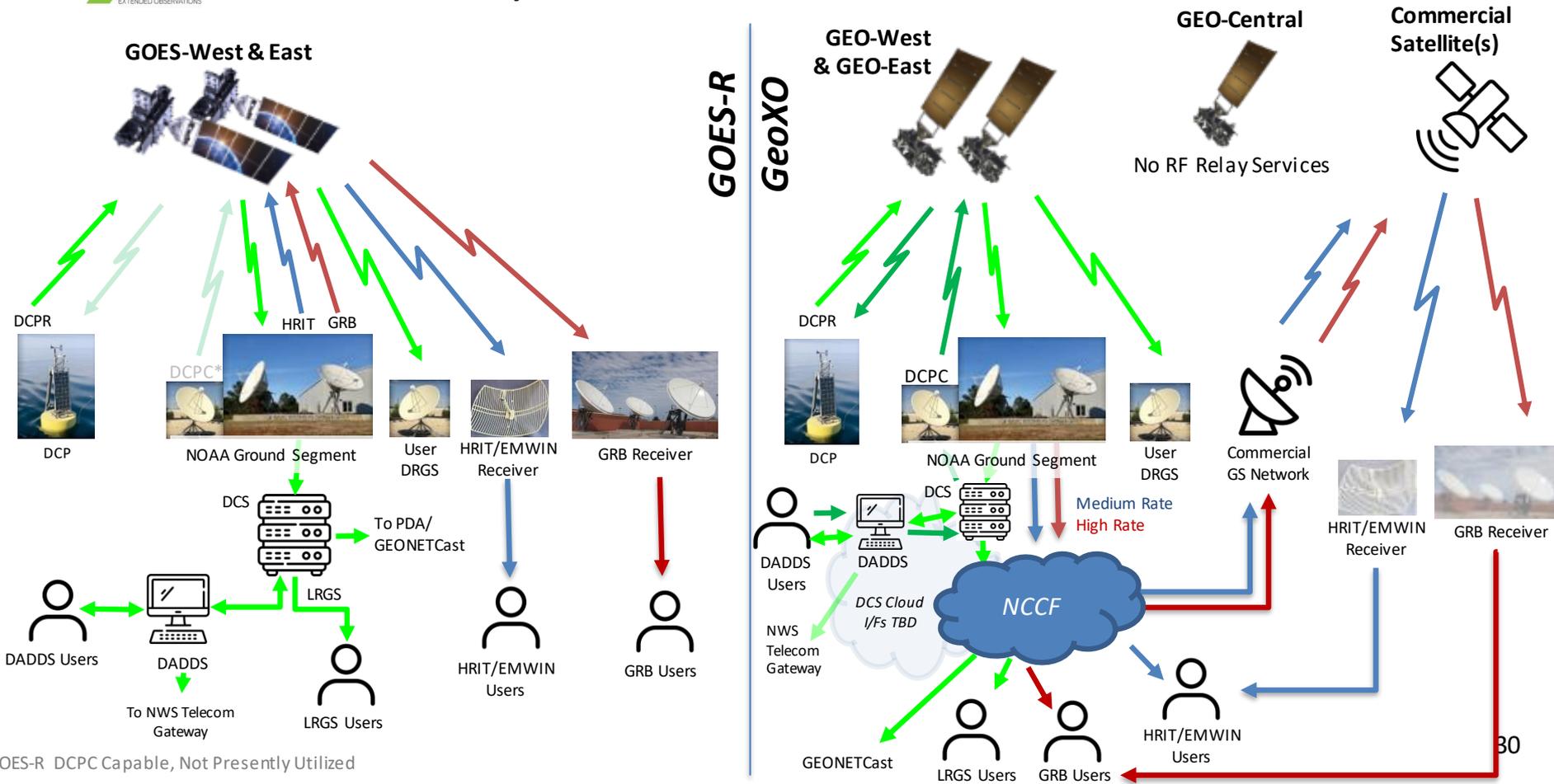
*GOES-R DCPC Capable, Not Presently Utilized