# NASCTN CBRS Sharing Ecosystem Assessment: Coastal Dynamic Protection Area

## Test Plan Community Brief

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*Additionally, we thank the NASCTN steering committee and its member agencies for their support and access to considerable talent to approach this very important and complex study.*

# Outline

- National Advanced Spectrum and Communications Test Network
  - Mission
  - Framework
- Sharing Ecosystem Assessment Project
  - Background
  - Coastal dynamic protection area
  - Modeling
  - Site selection
  - Sensor architecture
  - Data products
  - Example analysis
  - State of the project

# National Advanced Spectrum and Communications Test Network (NASCTN)


*NIST hosts NASCTN Program Office and a core team to ensure rapid response, access to key skills, consistency, and knowledge management.*

NASCTN is a multi-agency, chartered organization that includes DoD, NASA, NIST, NOAA, NSF, and NTIA.

The purpose of NASCTN is to improve opportunities for successful spectrum sharing through accurate, reliable, and unbiased measurements and analyses.

**Through its members, NASCTN provides:**

- **Robust test processes** and **validated measurement data** necessary to develop, evaluate and deploy spectrum sharing technologies
- Best practices for spectrum sharing **metrology, testing, measurement, and data analysis** to improve quality of information provided to the spectrum community
- **Access** to testing capabilities, spectrum test data, analyses, and reports

# National Advanced Spectrum and Communications Test Network (NASCTN)

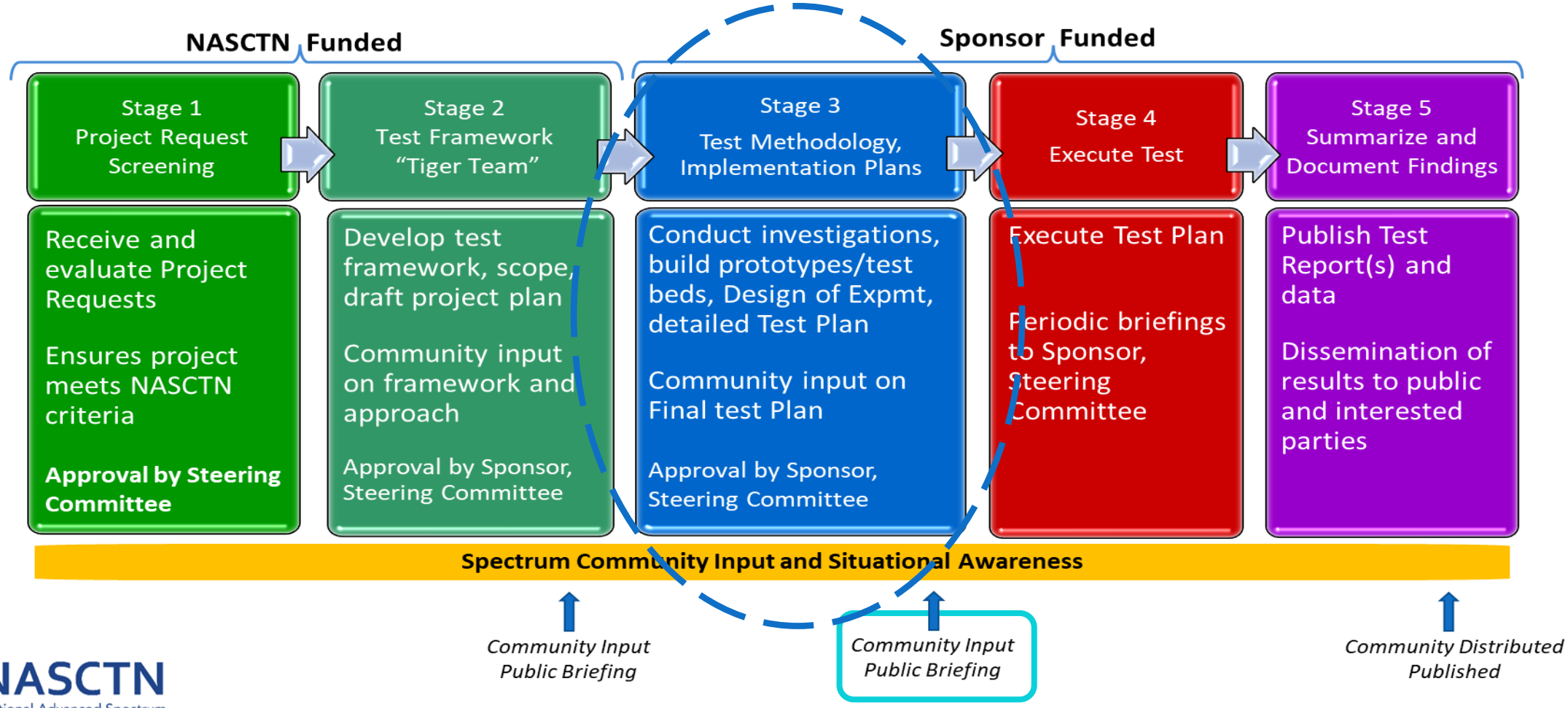

NASCTN:

- Develops Test Plans with independent technical experts
- Identifies and facilitates access to appropriate test facilities
- Executes and validates scientifically rigorous test methodologies
- Delivers detailed test methods and data with transparency, validity, and reproducibility
- Protects all controlled information (proprietary, sensitive, classified)

NASCTN does not make policy recommendations

# NASCTN 5-Stage Framework

NASCTN projects follow an open, transparent, comprehensive process for developing and executing *independent*, scientifically based test plans, validating test results, and reporting findings. Serves as a common architecture across all NASCTN projects.

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# Test Plan Access and Public Documentation

https://www.nist.gov/programs-projects/cbrs-sharing-ecosystem-assessment

## CBRS Sharing Ecosystem Assessment

### Summary

The objective of this project is to collect the data required for DISA DSO to ascertain the effectiveness of the sharing ecosystem between CBRS systems as managed by Spectrum Access Systems (SASs), and DoD systems as monitored by Environmental Sensing Capabilities (ESCs). The five year project will provide insight into the sharing ecosystem's effectiveness, and track changes in the spectrum environment over time.

### DESCRIPTION

Background: In 2020, FCC auction 105 auctioned licenses in the Citizens Broadband Radio Service (CBRS). CBRS (3.55 GHz to 3.7 GHz) has a three-tiered framework to accommodate shared federal and non-federal use of the band. The DoD 3.5 GHz Transition Plans focus on ecosystem validations, environmental assessments, and continued engagement on refining the CBRS infrastructure. One component was identified for submission to NASCTN, *to evaluate the effectiveness of the CBRS sharing ecosystem to co-exist with DoD radar systems, via independent trusted agent.*

| Framework Stage | Information |
|---|---|
| Stage 5: Summarize Findings | |
| Stage 4: Test Execution | |
| Stage 3: Test, Metrology, and Implementation Plan | NASCTN CBRS SEA Task1 Draft Test plan - September 2024<br>Task 1 Test Plan Consolidated Adjudicated Comment Matrix - September 2024<br>NASCTN CBRS SEA Task 1 Draft Test plan - June 2024<br>NASCTN CBRS SEA Task 2 Draft Test Plan - December 2023<br>NASCTN CBRS SEA Task 2 Draft Test Plan - March 2023<br>Test Plan Presentation - March 2023<br>Test Plan Comment Matrix - June 2024 (Word Version) |
| Stage 2: Test Framework | Test Framework developed, Community Outreach event (July 12 2022)<br>Presentation |
| Stage 1: Proposal Screening | Proposal Submitted by DISA DSO. Approved by NASCTN Steering Committee. |

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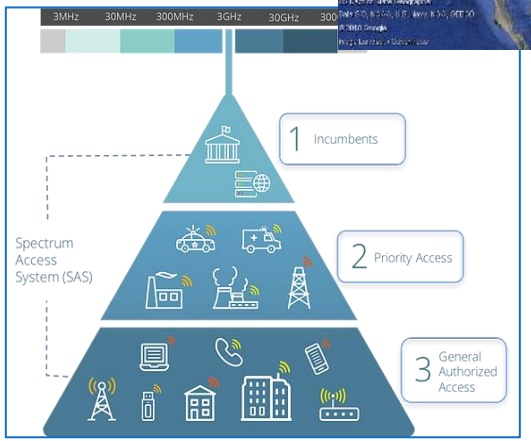
# Citizens Broadband Radio Service (CBRS)

The Citizens Broadband Radio Service (CBRS) is the "first of a kind" shared spectrum ecosystem, implemented nationwide.

- **Shared band, 3 tier approach** - Incumbent, Priority Access License, General Authorized Access
- **Sharing stipulations –** FCC part 96
- **Environmental Sensing Capability (ESC)** detects incumbents and **Spectrum Access Systems (SAS)** coordinates spectrum access
- Sharing is coordinated in **Dynamic Protection Areas (DPA)s:** E-DPA (serviced by ESCs), P-DPA (database/portal based), and GB/Always-On DPA (ground base/always on)


Reference: https://ongoalliance.org/the-technology-behind-spectrum-sharing-the-spectrum-access-system/

**NASCTN Project:** Provide data-driven insight into the CBRS sharing ecosystem's effectiveness between commercial and DoD radar systems, and to track changes in the spectrum environment over time.

# TEST REQUEST: DoD CBRS Sharing Ecosystem Assessment (SEA) program

**Test Request: CBRS Sharing Ecosystem Assessment (SEA)**
Collect data required for DISA PEO Spectrum to ascertain the effectiveness of the sharing ecosystem between CBRS systems as managed by Spectrum Access Systems (SASs), and DoD systems as monitored by Environmental Sensing Capabilities (ESCs). Provide insight into the sharing ecosystem's effectiveness, and track changes in the spectrum environment over time.

**Background**: DoD 3.5 GHz Transition Plans focus on ecosystem validations, environmental assessments, and continued engagement on refining the CBRS infrastructure. One component was identified for submission to NASCTN, *to evaluate the effectiveness of the CBRS sharing ecosystem to co-exist with DoD radar systems, via independent trusted agent*

**4 Key Objectives:**

1. Provide data to determine efficacy of permanent sharing between CBRS systems as managed by SAS systems and ESC systems
    - Attempt to obtain corroborating data from the CBRS community stakeholders
2. Collect power levels in the CBRS band through continuous automated observations
3. Collect emissions in the CBRS band in the vicinity of San Diego, CA and Norfolk, VA
4. Collect emissions in the CBRS band within at least one Always-On Dynamic Protection Area (DPA)

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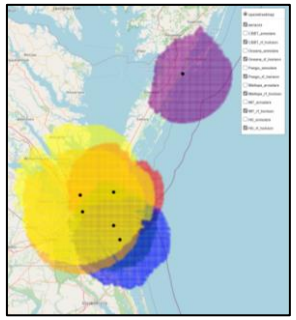
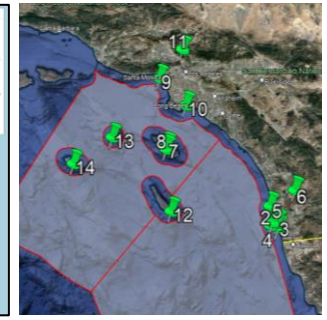
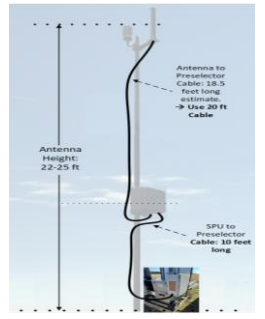
# NASCTN SEA Project Approach

To achieve the 4 objectives, 3 major components were identified:

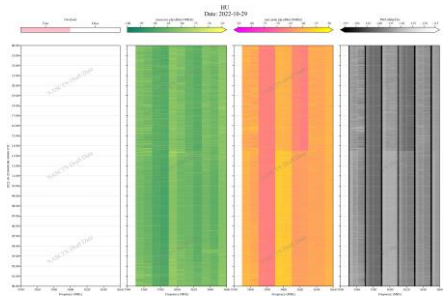
- **Task 1 – Passive Observation in the CBRS Band in Vicinity of Coastal Dynamic Protection Areas (DPAs)**
  - Characterize aggregate emissions within the CBRS band 3550-3700 MHz in the vicinity of at least two Coastal DPAs, with and without DPA activations
  - Assess ecosystem performance to timely respond, and measure increase in background emission due to wireless system deployments over time
- **Task 2 – Passive Observation in the CBRS Band in Always-On DPAs**
  - Characterize aggregate emissions within the CBRS band 3550-3700 MHz in at least one Always-On DPA or ground-based DPA (GB-DPA)
  - Assess ecosystem performance to limit CBRS emissions in the Always-On DPA
- **Task 3 – Long Term Data Analysis and Support**
  - Collection and analysis of Passive Observations throughout sensor deployment
  - Support transfer of data to a DoD data repository

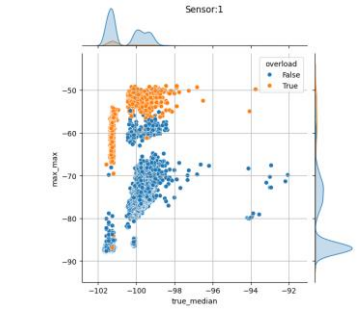









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# Deliverables

- A Final Report & Public Final Briefing
- Data
  - Calibrated and validated sensor measurements and uncertainties
  - Data analysis outcomes from sensor data and modeling
- Code
  - Data analysis code
  - Modeling & simulation code

- Publish to maximum extent, with exceptions for controlled information and sensitive data
- NASCTN will not issue policy recommendations

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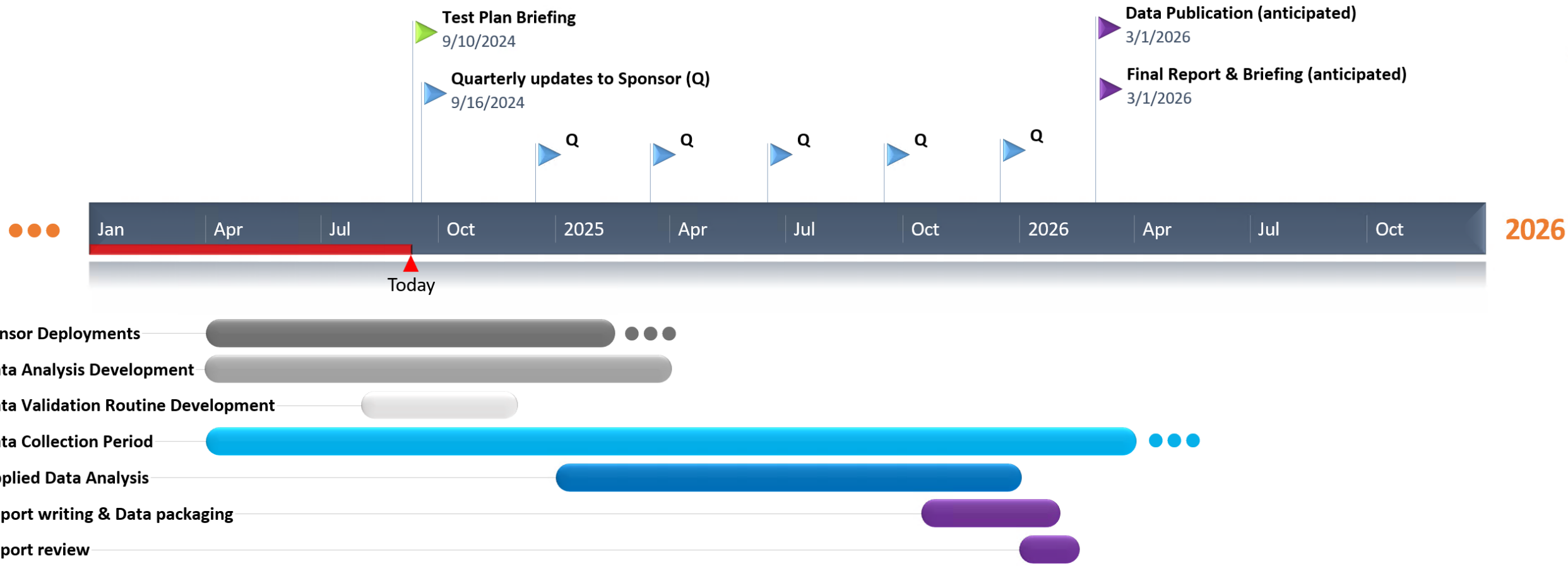
# Timeline

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# Passive Observation: Coastal Dynamic Protection Area



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# Scope: Coastal Dynamic Protection Area (DPA)

**Passive Observation in the CBRS Band in Vicinity of Coastal Dynamic Protection Areas (DPAs)**

- Characterize aggregate emissions within the CBRS band 3550-3700 MHz in the vicinity of at least two Coastal DPAs, with and without DPA activations
- Assess ecosystem performance to timely respond, and measure increase in background emission due to wireless system deployments over time

**Location Focus:**

- East 1 DPA - near Norfolk, VA
- West 13 and West 14 DPAs - near San Diego, CA

**Approach:**

- Autonomous, calibrated, leave behind field systems deployed near the Coastal DPAs
- Modeling and Simulation
  - Identify opportune sensor system siting
  - Evolve understanding of CBRS deployments and SEA sensor measurements

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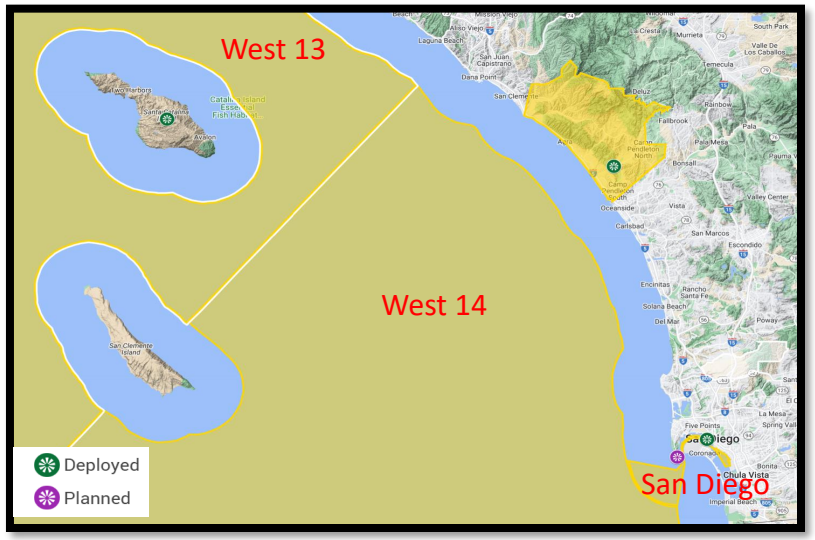
# Outcomes: Coastal Dynamic Protection Area (DPA)

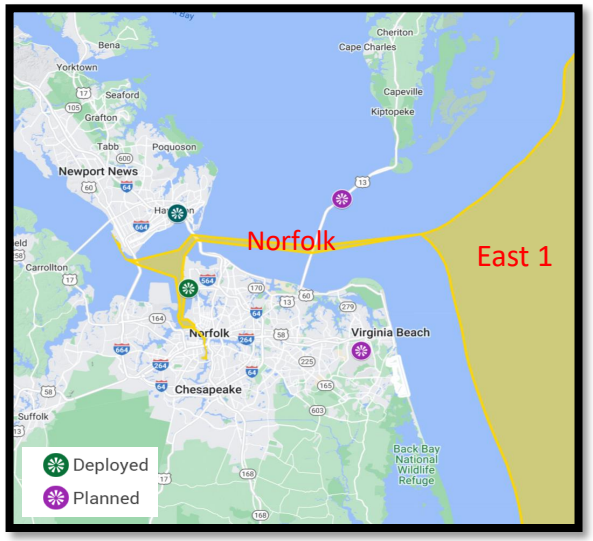
## Anticipated Analysis Outcomes:

1. Quantified emission levels at a set of sensor locations
2. RF emissions change over time
3. Publish data to provide insights into the spectrum sharing effectiveness of the CBRS ecosystem

### E-DPA protection criteria:

- Frequency: 3550 MHz – 3650 MHz
  - Licenses channelized to 10 MHz blocks
- Protection threshold inside DPA: -144 dBm/10MHz
- Reference incumbent antenna
  - Height: 50 m
  - Beamwidth: 3 deg
- DPA neighborhood distances vary by DPA and CBSD category and height




* One sensor will remain in Boulder, CO to both serve as a "non-DPA" baseline sensor as well as a local development sensor to test future software fixes before pushing to remote sensors.

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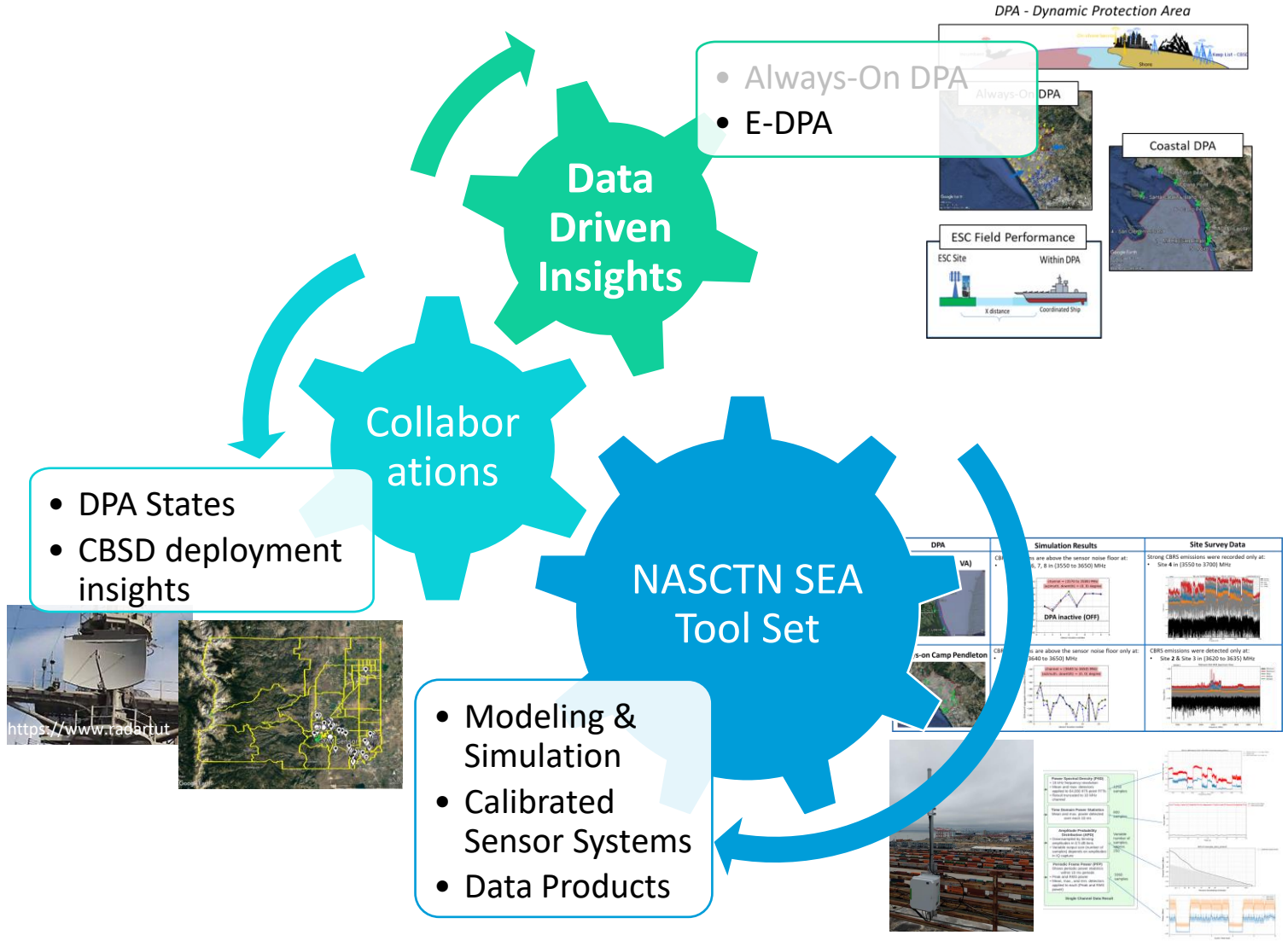
# Overview of Technical Sections

- **Modeling & Simulation**
  - Informed site selection methodology
- **Site Selection**
  - Deployment methodology
  - Current and planned deployments
- **NASCTN SEA Sensor System**
  - Sensor architecture
  - Development evolution/version
  - Characterization & calibration
- **Data Products**
  - Edge Compute Products
  - Sensor data publication framework
  - Example analyses

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# Modeling

# Modeling - Informed Site Selection Methodology

***Objectives***

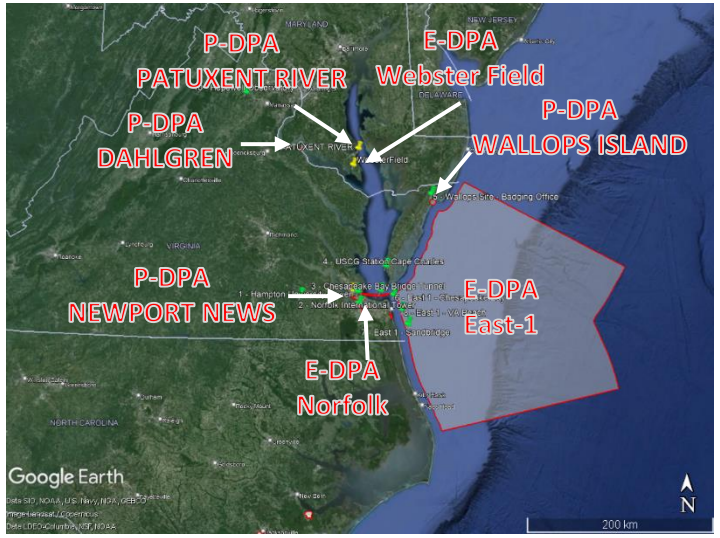
- Utilize modeling as a tool to help informing site selections for NASCTN SEA sensors to measure emissions in the CBRS band
- Estimate aggregate emissions from CBSDs to protection points and candidate SEA sensor locations
  - DPA inactive (emissions from neighbor list CBSD grants)
  - DPA active (emissions from keep list CBSD grants)

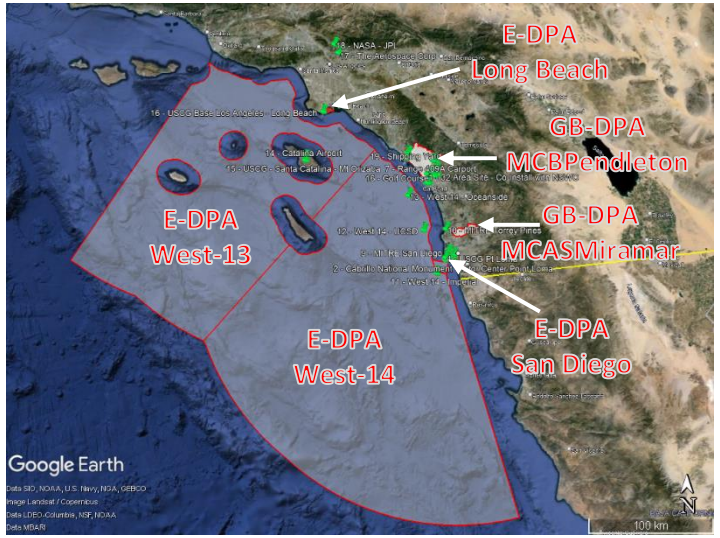
***Approach***

- Leverage obfuscated full activity dump (FAD) data provided by industry to NTIA ITS
- Adapt Wireless Innovation Forum (WInnForum) reference DPA move list algorithm
- Consider recent proposed relaxation of DPA changes (CBRS 2.0)
  - 8 dB EIRP reduction (duty cycle and network loading factor)
  - P.2108 median clutter loss applied to CBSDs with ≤ 6 m AGL
  - ITM median path loss without Monte Carlo simulation
  - Smaller DPA neighborhoods

E-DPA, P-DPA, GB-DPA

Candidate SEA sensor location

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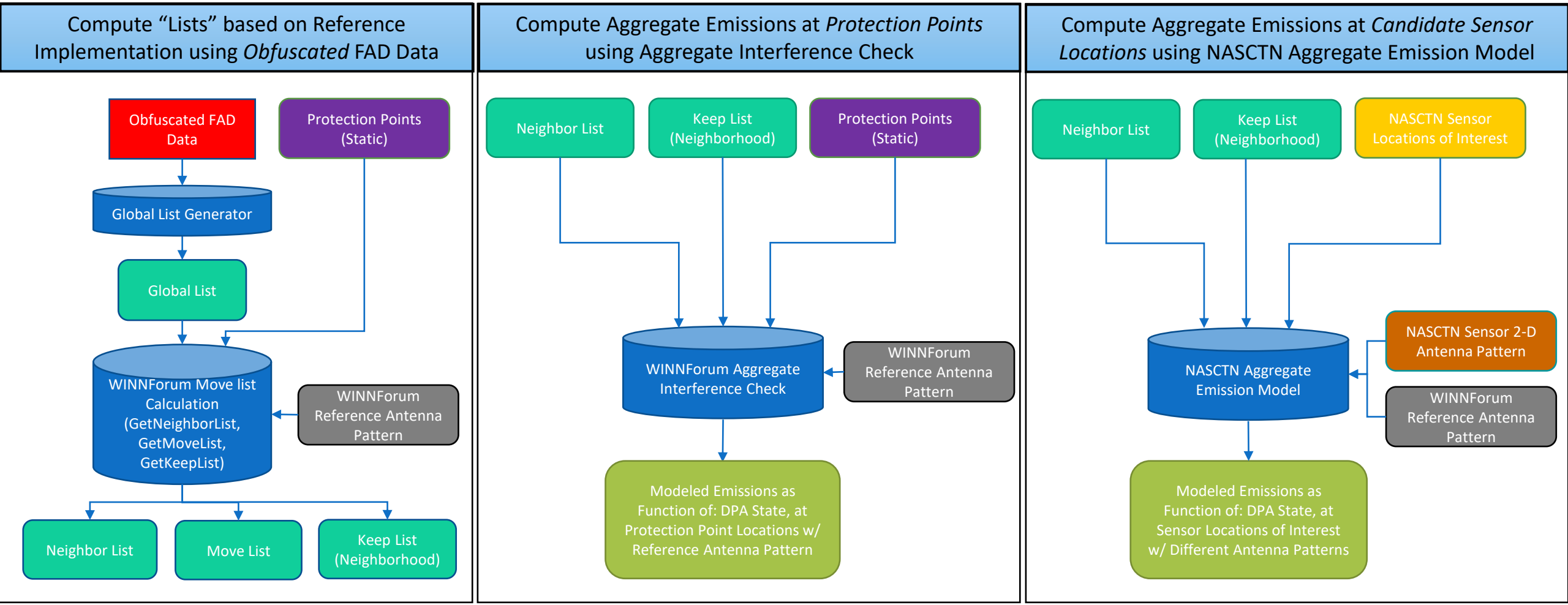
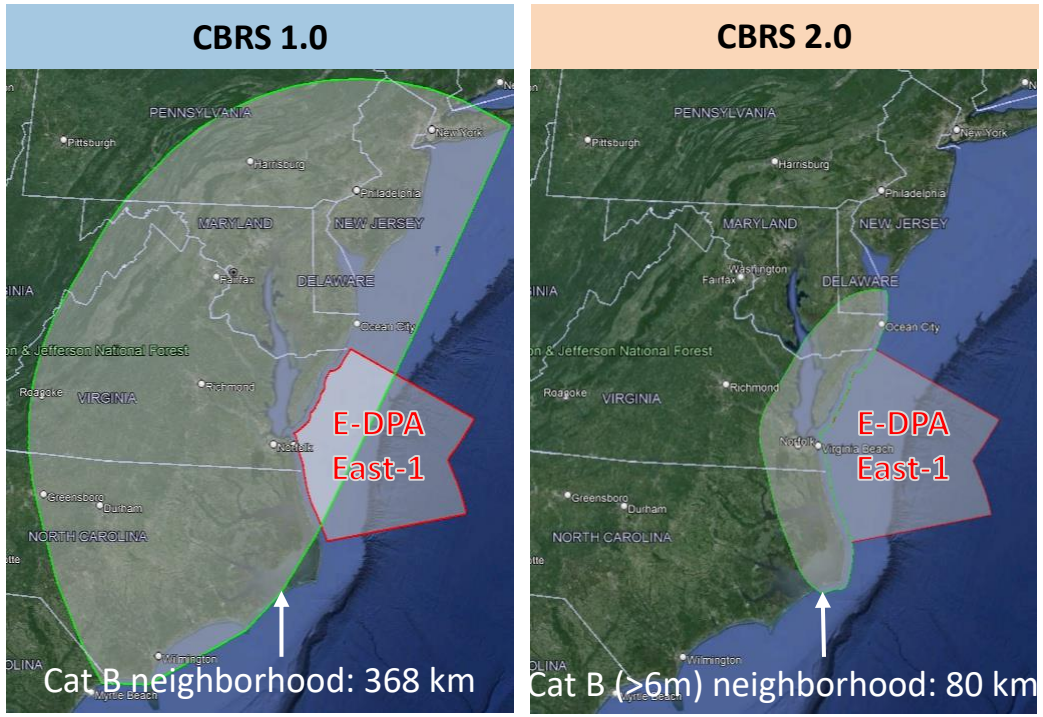
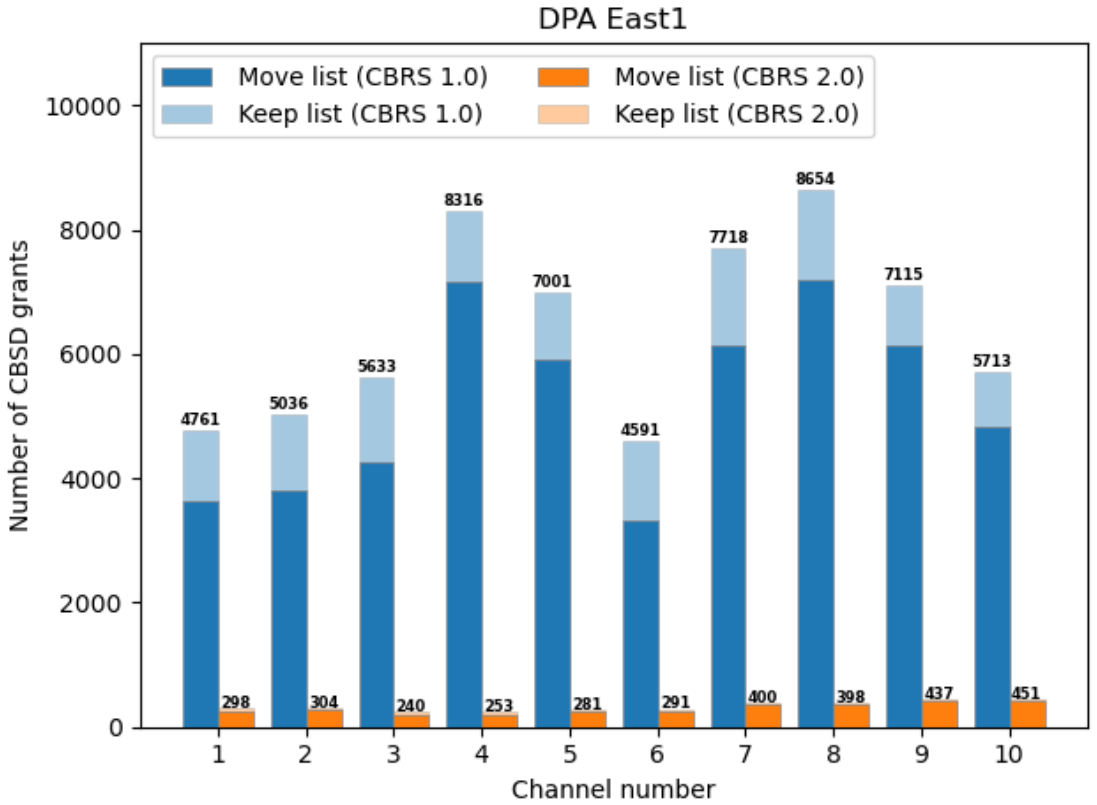
# Modeling Block Diagram



# Example – East-1 Move List & Keep List




- Randomized CBSD deployment generated from 2024-07-01 obfuscated FAD data
- With CBRS 2.0 implementation:
  - CBSD neighbor list sizes have decreased due to smaller neighborhoods
  - CBSD move list sizes have also decreased due to EIRP reduction, clutter, ITM median loss

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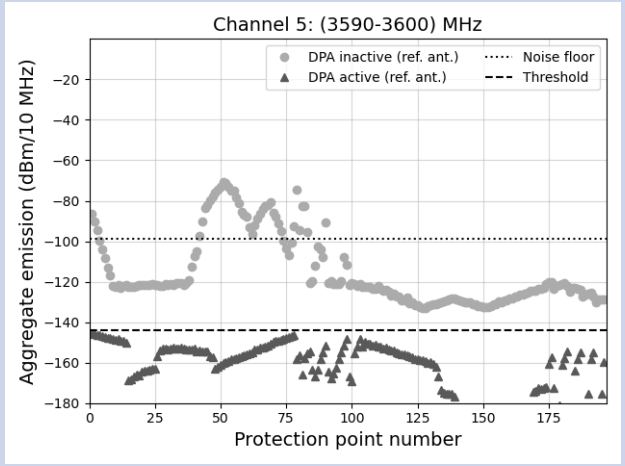
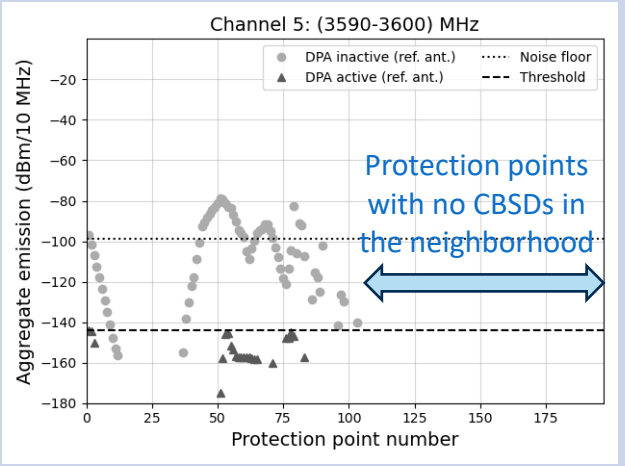
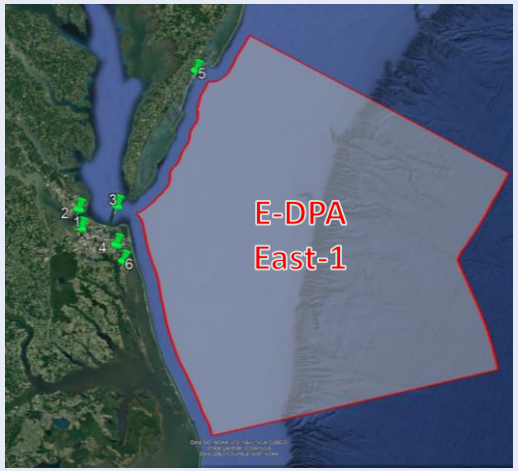
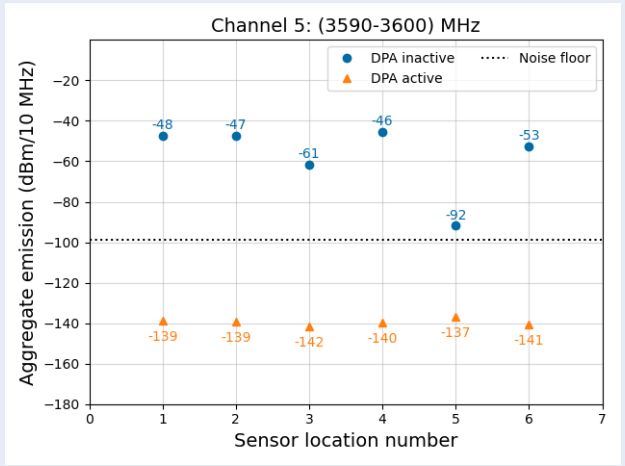
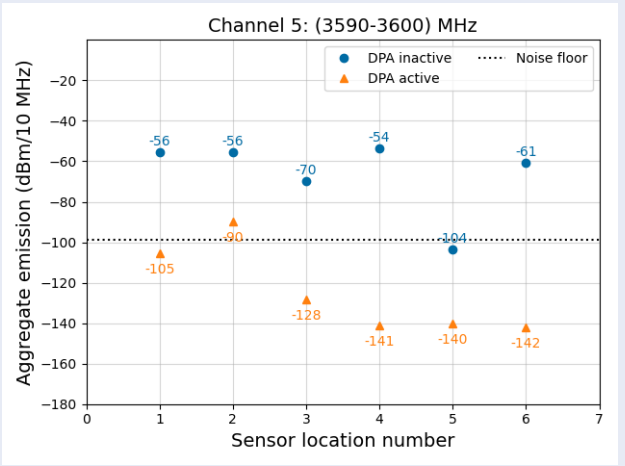
# Example – East-1 Aggregate Emission Calculation

| | | CBRS 1.0 | CBRS 2.0 |
|---|---|---|---|
| Protection Point |  |  |  |
| Sensor Location |  |  |  |

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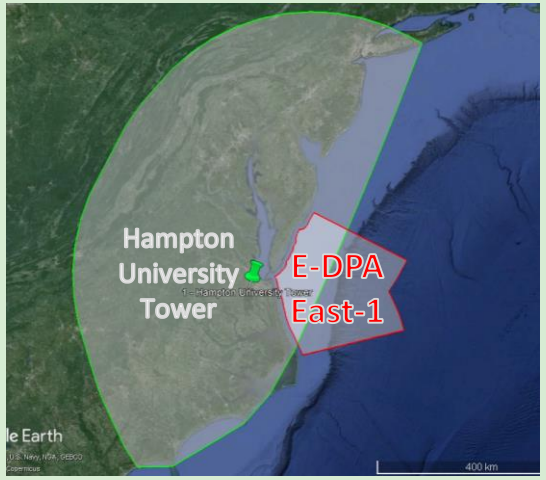
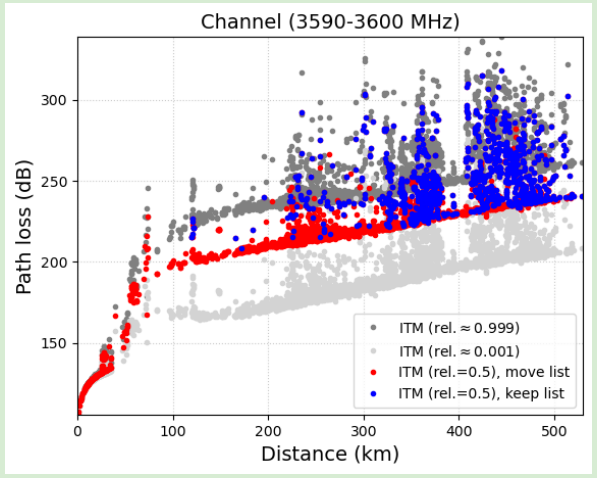
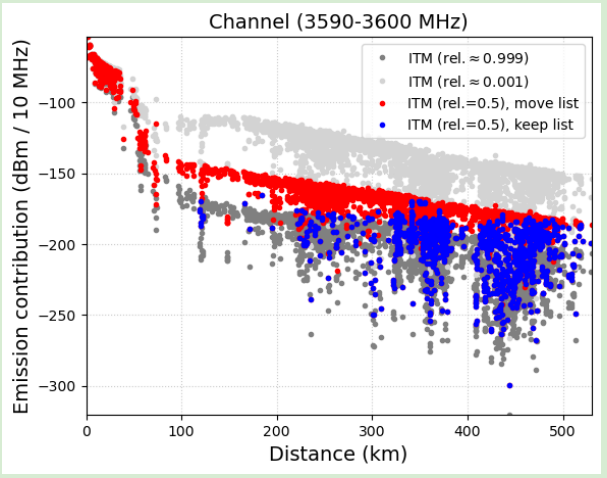
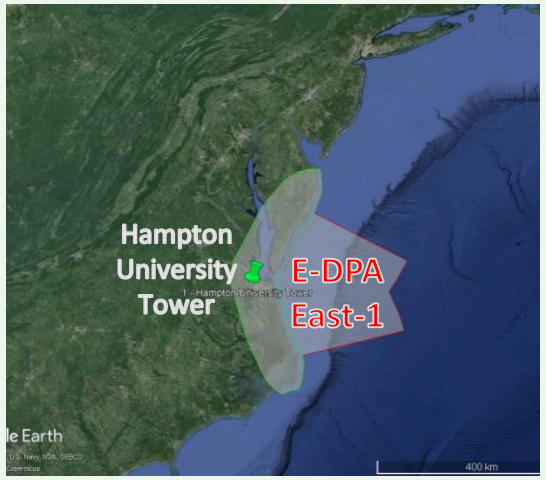
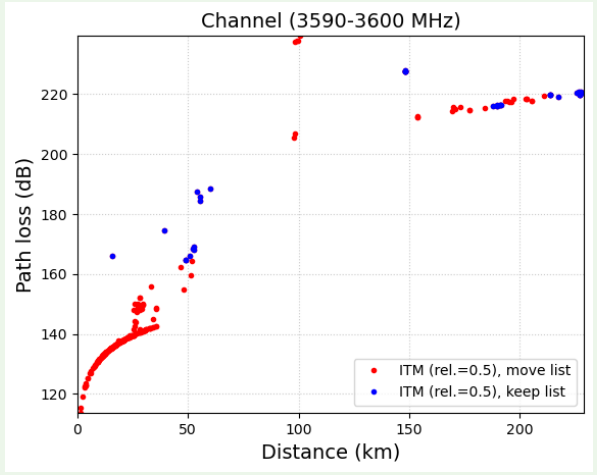
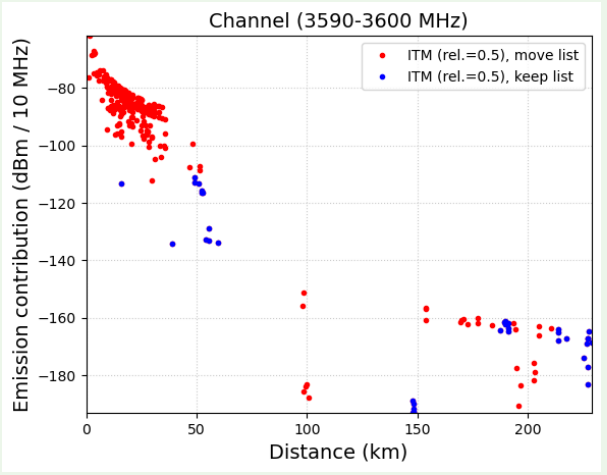
# Example – Hampton University Sensor Location Calculation

| | | Path Loss | Emission Contribution |
|---|---|---|---|
| CBRS 1.0 |  |  |  |
| CBRS 2.0 |  |  |  |

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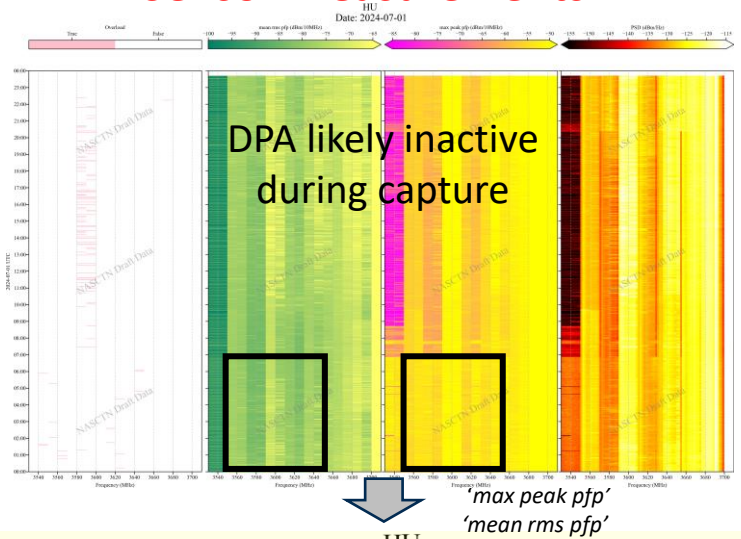
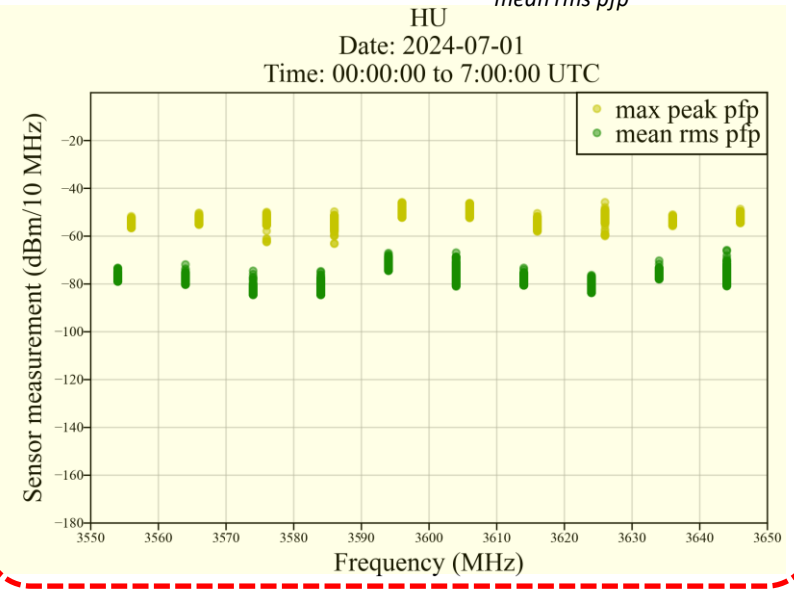
# Correlation between Modeling Results and Sensor Measurements

- Correlate modeling results and sensor measurements at **Hampton University (HU)**
  - Utilize 2024-07-01 obfuscated FAD data
  - Extract sensor measurements on 2024-07-01 (from midnight to 7:00 AM UTC before CPAS starts)
- Understand the offset between modeling results and measurements
  - Provide insights into key technical challenges and assumptions with the current modeling

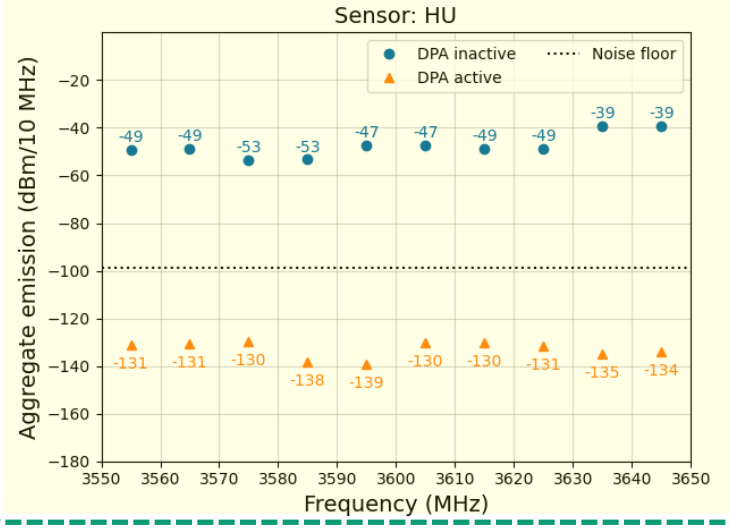
## Sensor Measurements



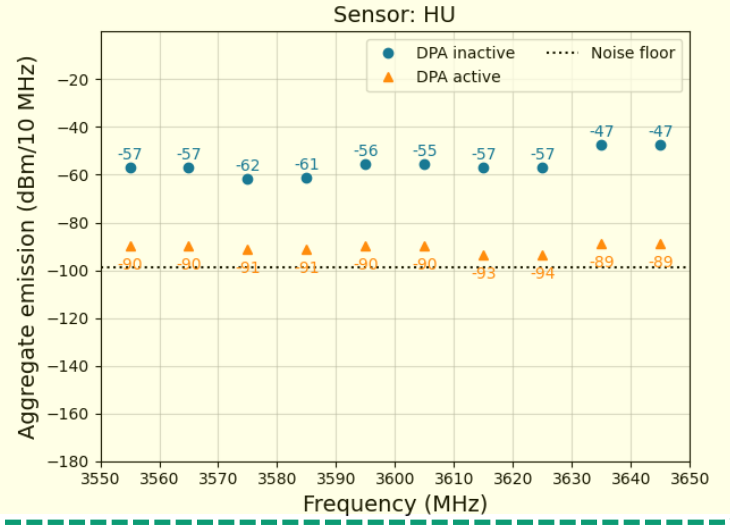




## Modeling Results

CBRS 1.0



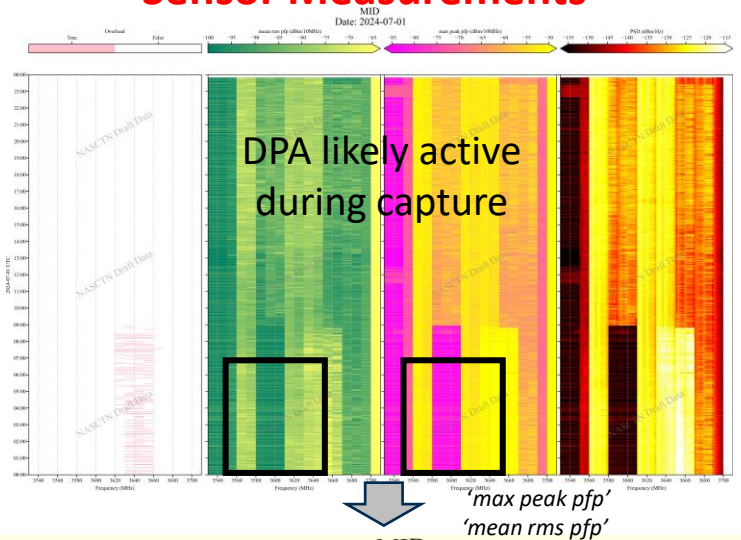

CBRS 2.0



# Correlation between Modeling Results and Sensor Measurements

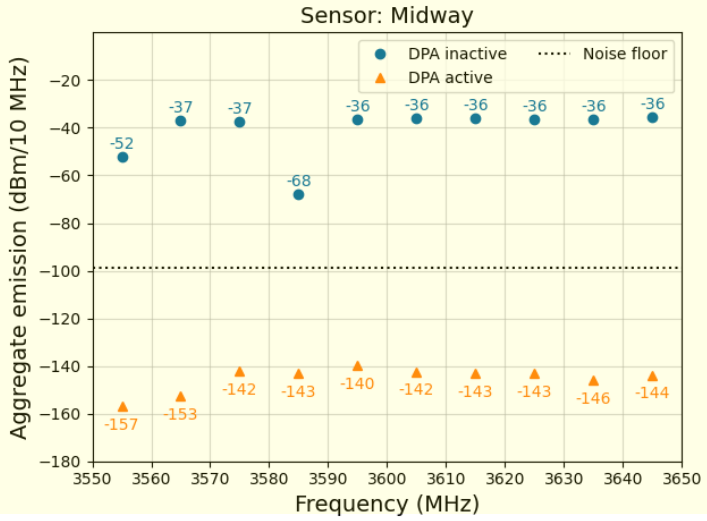
- Correlate modeling results and sensor measurements at **USS Midway Museum, San Diego, CA**

## Sensor Measurements

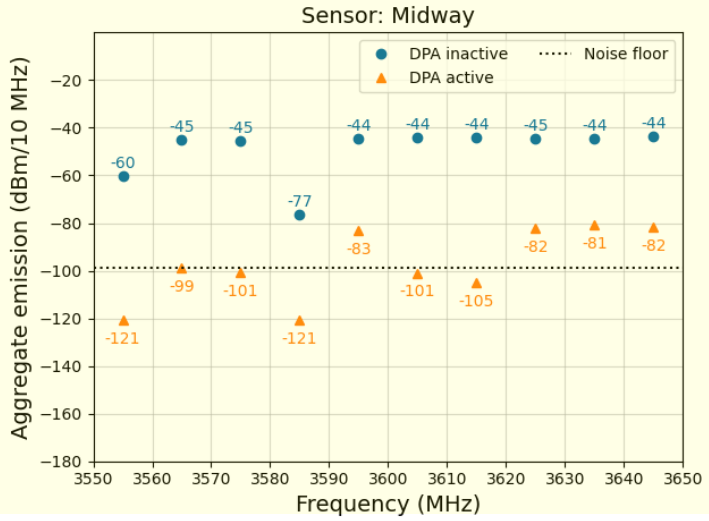


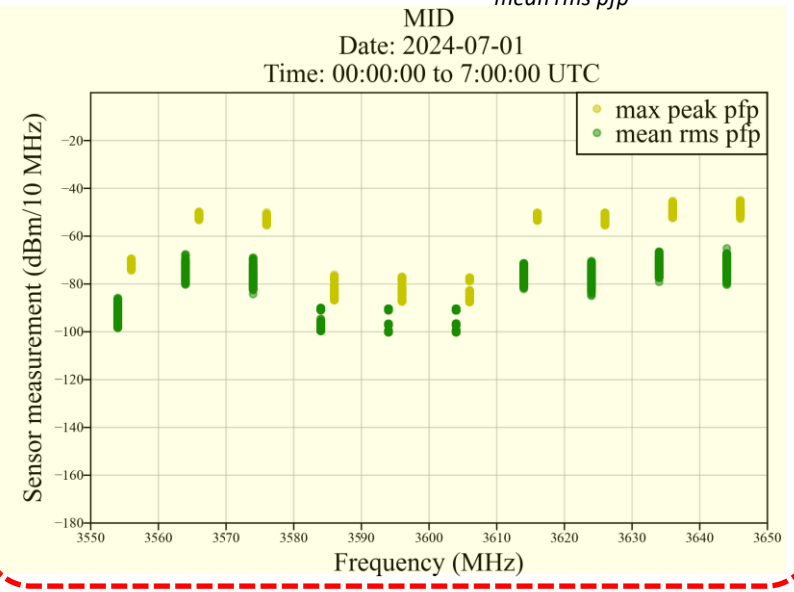

## Modeling Results

CBRS 1.0




CBRS 2.0



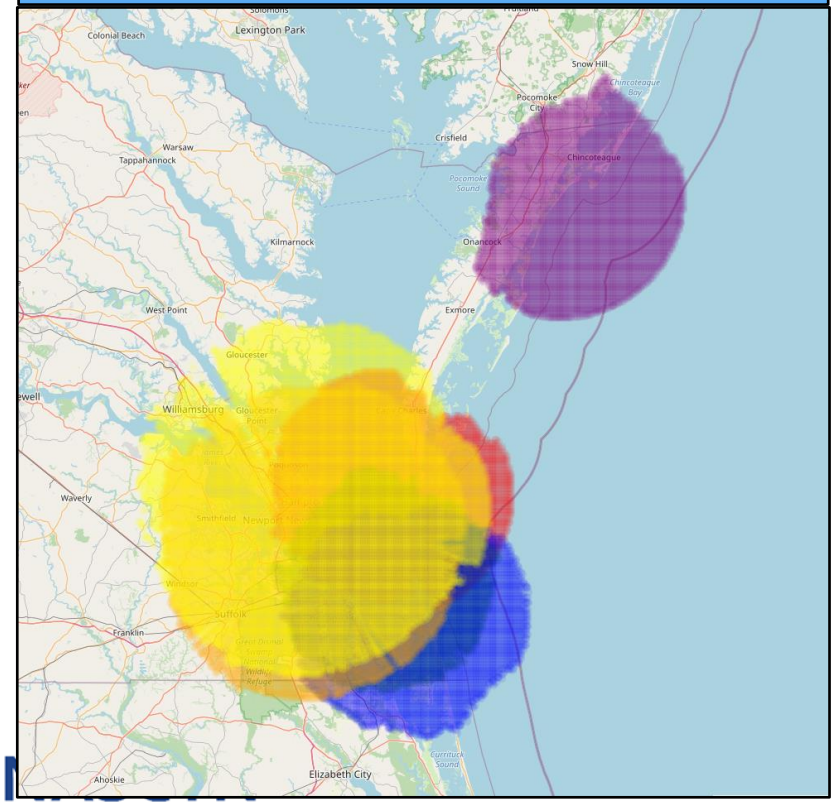



# RF Horizon Modeling Tool

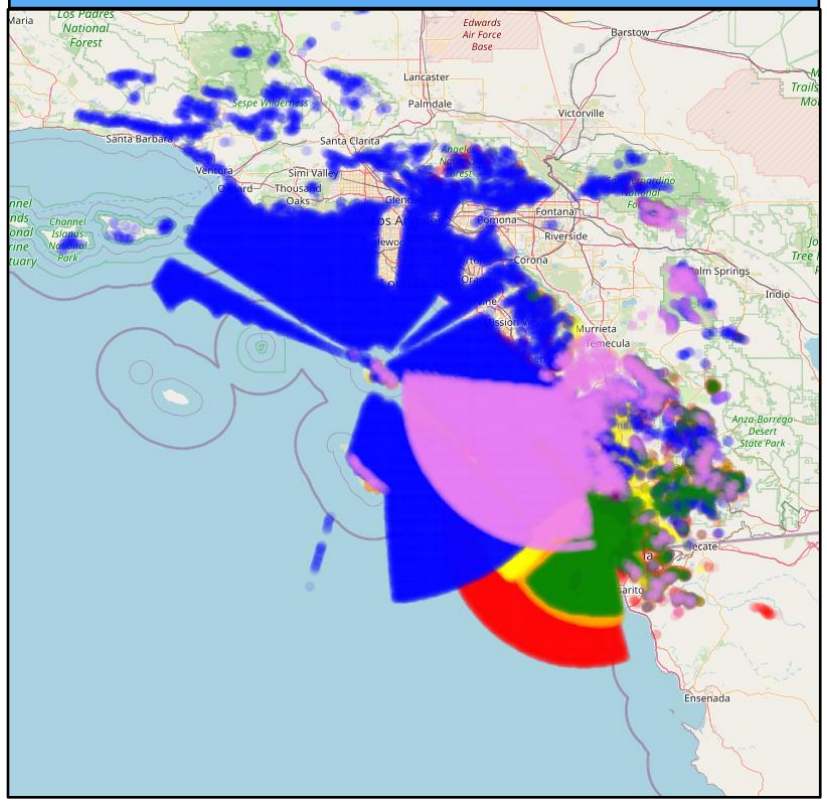
***RF Horizon Coverage Visualization***

- Estimate NASCTN sensor's detection area of CBSDs to inform site selection
- Leverage WInnForum's approach for computing ESC's "whisper zone"
- Adjust parameter configurations suitable for NASCTN sensor design and deployment

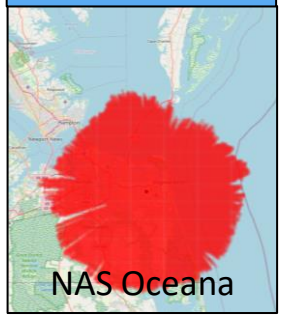
East Coast RF Horizon Coverage



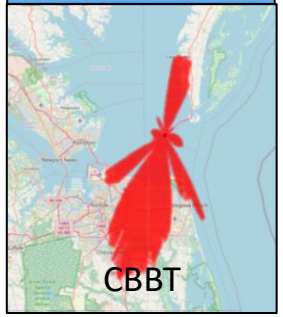

West Coast RF Horizon Coverage



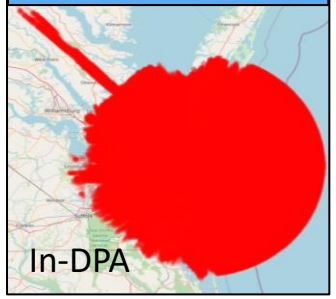

Omni Directional



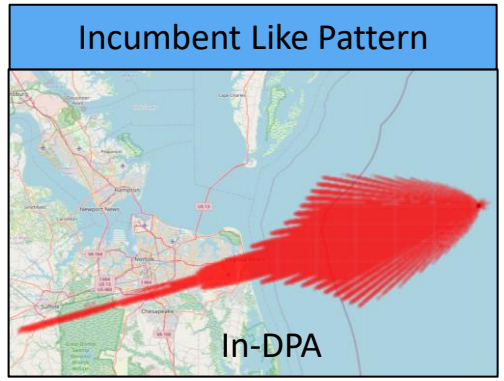

High Gain Directional




WinnForum Reference




Incumbent Like Pattern

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# Modeling Uncertainties and Concerns

| Technical challenges and assumptions |
| --- |
| Derived CBSD deployment from quarterly obfuscated FAD data for each 10 MHz channel |
| ITM P2P propagation model + P.2108 clutter model |
| WInnForum's reference DPA move list algorithm |
| WInnForum's reference aggregate interference check |
| Aggregate emission model for sensor |
| Set of 2-D receive antenna patterns/gains |
| Projected noise floor of sensor |

Deviated from real FAD data (CBSD location, height, maxEIRP, channel occupancy, etc.)

Imperfect representation of real-world environment

SAS implementation variations of reference DPA move list algorithm (?)

Inaccurate aggregate emission calculation due to:

- Unknown CBSD's actual transmit power, on/off state, antenna spatial pattern and orientation, etc.)
- Inaccurate path loss calculation
- Incoherent transmissions of CBSDs
- Sensor measurement may be dominated by a single nearby CBSD in frequency at a given time
- The calculated power is a protection criteria and not an expected measured power

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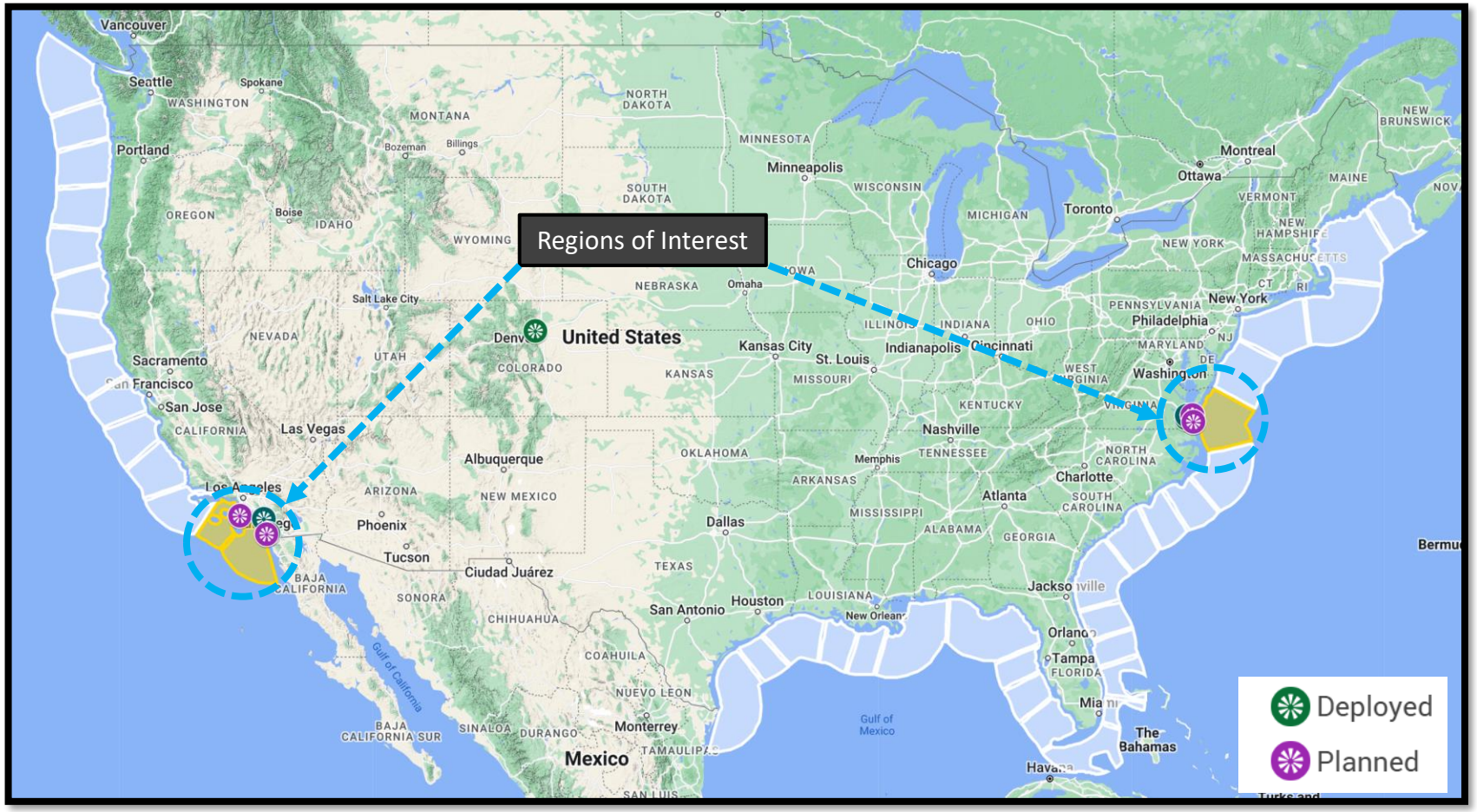
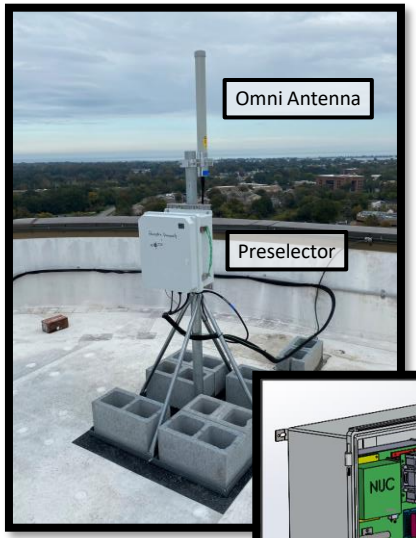
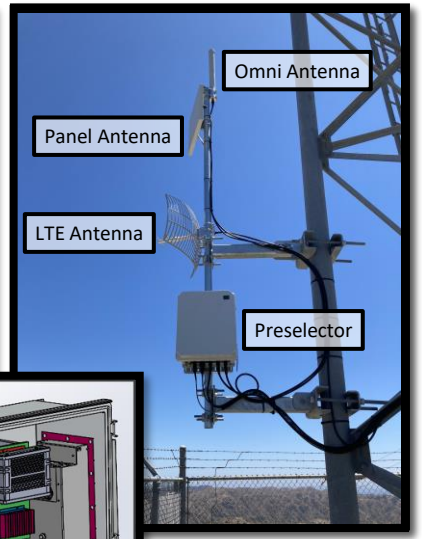
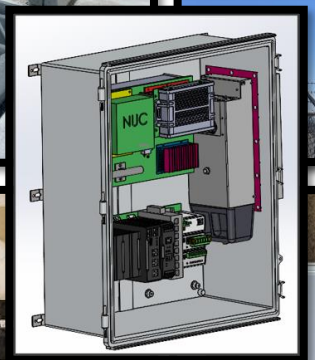
# Site Selection

# Regions of Interest

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# Deployment Methodology


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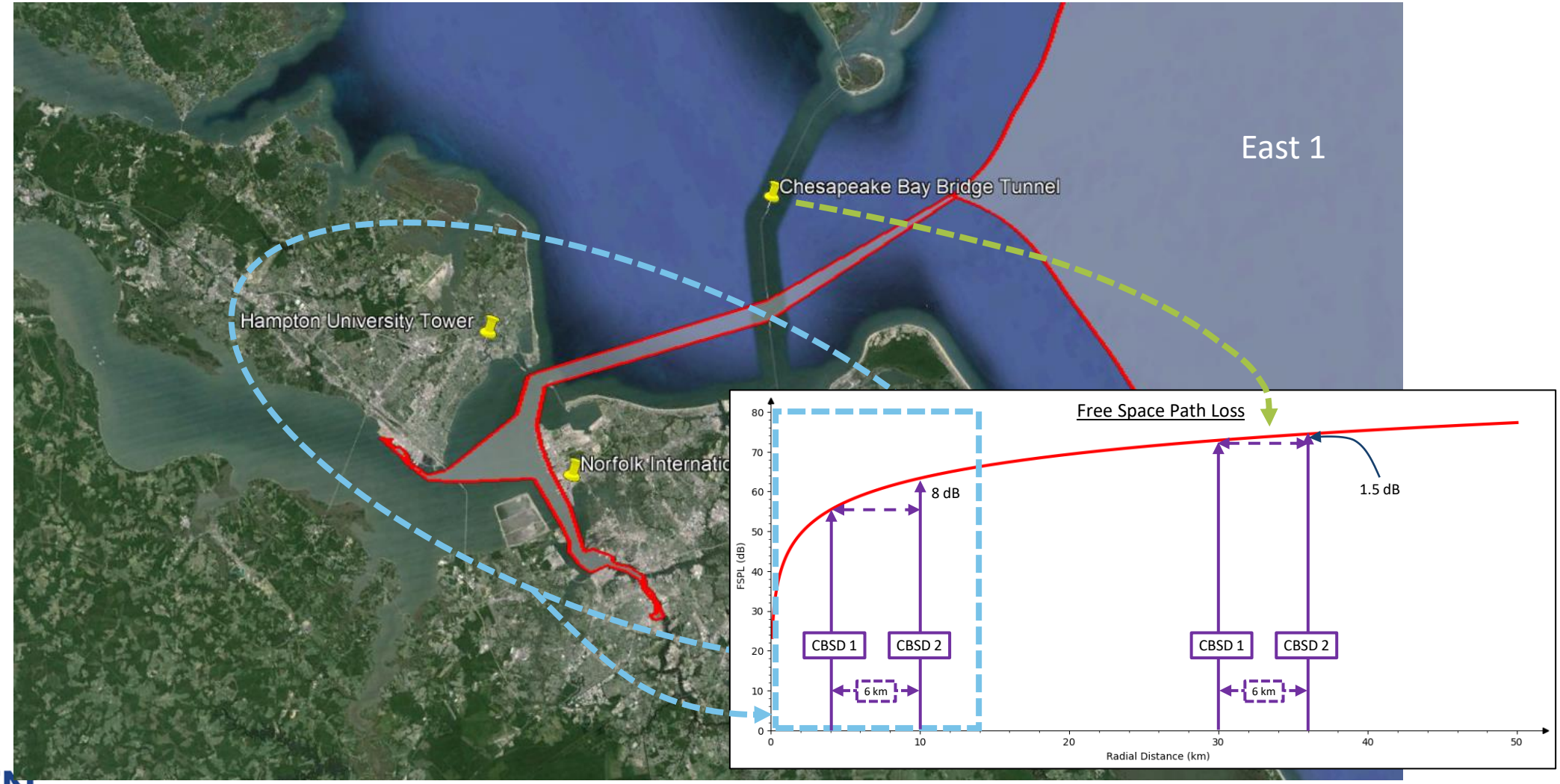
# Deployment Methodology

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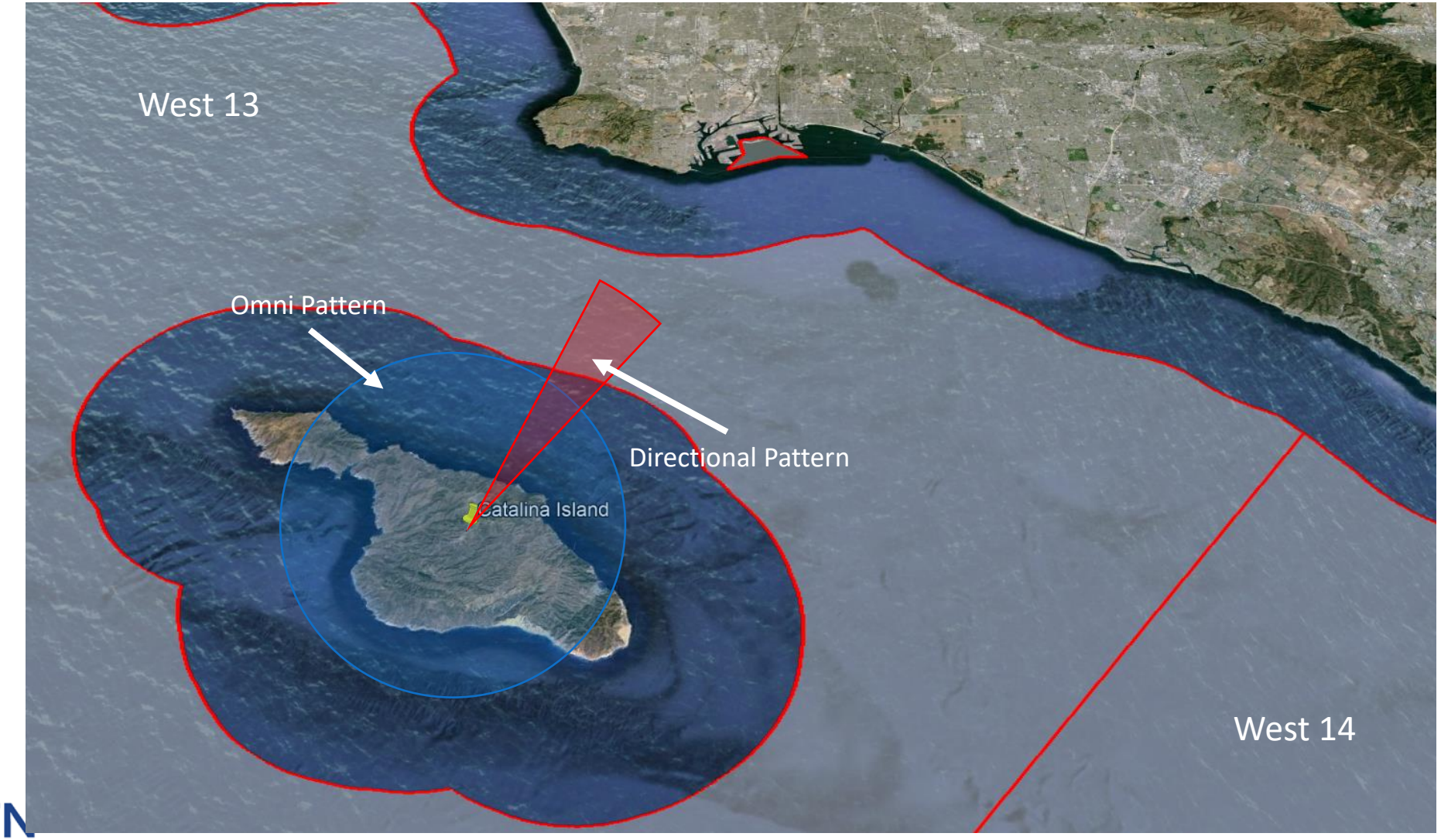
# Deployment Methodology (cont.)

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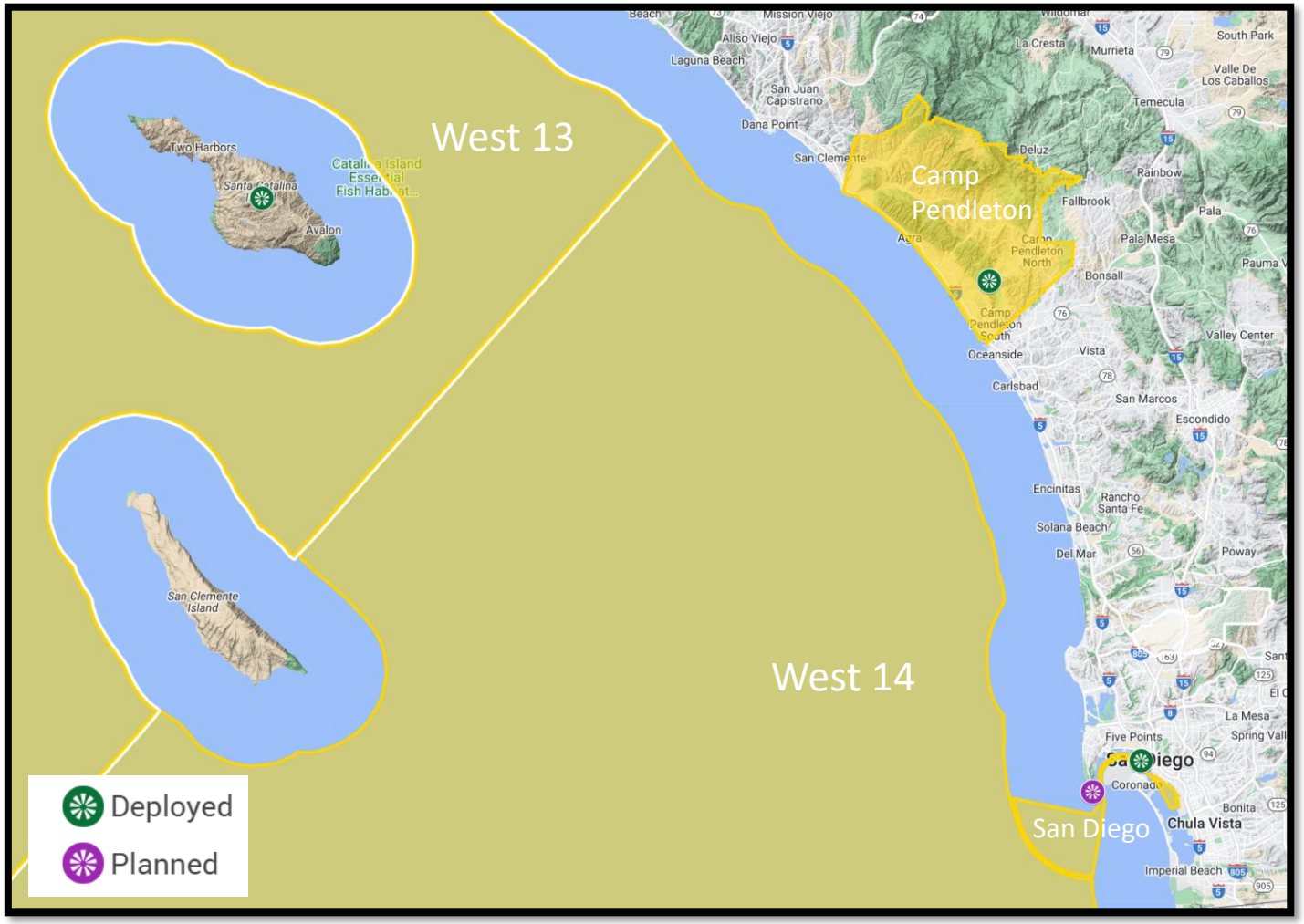
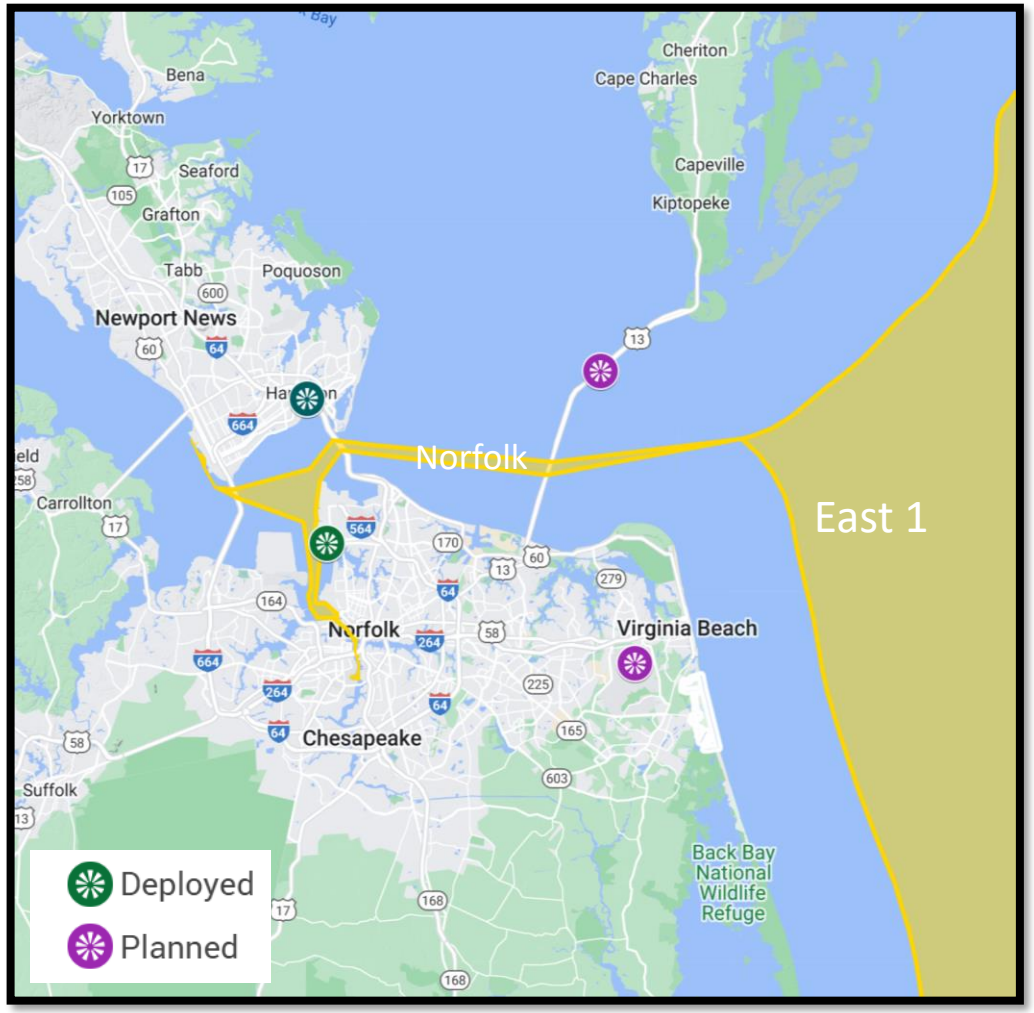
# Current and Planned Deployments




* One sensor will remain in Boulder, CO to both serve as a "non-DPA" baseline sensor as well as a local development sensor to test future software fixes before pushing to remote sensors.

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# Current and Planned Deployments

| Status | Sensor Name | Location | Lat | Lon | Height | Antenna 1 | Antenna 2 |
|---|---|---|---|---|---|---|---|
| Operational | Norfolk International Terminal (NIT) | Norfolk, VA | 36.91552 | -76.32245 | 48.5 m AMSL | Omni | N/A |
| Operational | Hampton University Tower (HU) | Hampton, VA | 37.02578 | -76.34120 | 65.5 m AMSL | Omni | N/A |
| Approved Install – Fall 24 | Island 4, Chesapeake Bay Bridge Tunnel (CBBT) | Chesapeake Bay, VA | 37.0460938 | -76.0628427 | Planned | Omni | 15 deg Panel Az: TBD |
| Approved Install – Fall 24 | Naval Air Station Oceana, (OCEANA) | Virginia Beach, VA | 36.825105 | -76.0295619 | Planned | Omni | N/A |
| Operational | US Coast Guard Tower Site (Mt Orizaba) | Catalina, CA | 33.3795615 | -118.4164147 | 4.5 m AGL | Omni | 15 deg Panel Az: 33.5 deg |
| Operational | USMC Camp Pendleton | USMC Camp Pendleton, CA | 33.2824683 | -117.3891615 | 6.4 m AGL | Omni | N/A |
| Operational | USS Midway Museum (Midway) | San Diego, CA | 32.7139892 | -117.175255 | 50 m AGL | Omni | TBD |
| Awaiting Approval | National Park Service, Cabrillo National Monument (Cabrillo) | San Diego, CA | 32.6777734 | -117.2440221 | Planned | Omni | 15 deg Panel Az: TBD |
| Operational | Green Mountain Mesa, (GMM) | Boulder, CO | 39.9918 | -105.2745 | 1783.4 m AMSL | 90 deg sector AZ: 12 deg | N/A |

1 sensor in reserve, up to 2 additional builds

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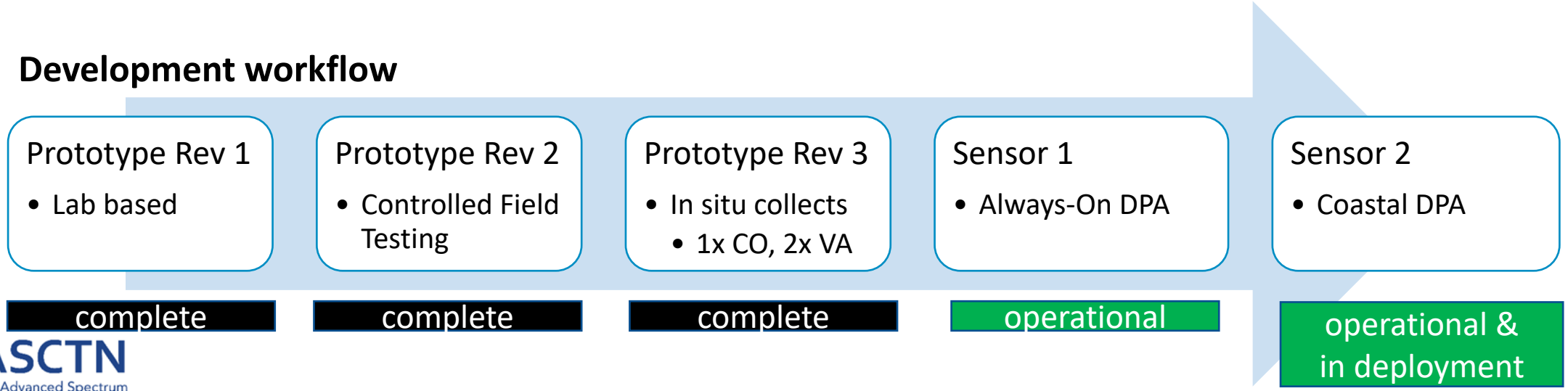
# Sensor Architecture

# Calibrated Sensor System – Iterative Design and Deployment

## Motivation:

- ✓ Insights into the CBRS ecosystem behavior at a representative location to inform Test Plans
- ✓ Demonstrate the operating of remote sensing nodes that perform autonomous, calibrated, measurements with quantified levels of uncertainty over time
- ✓ Trial edge compute data products on real world signals, and…
- ❖ Evolve CBRS ecosystem understanding with simulation and measured data. (ongoing)

**Development workflow**

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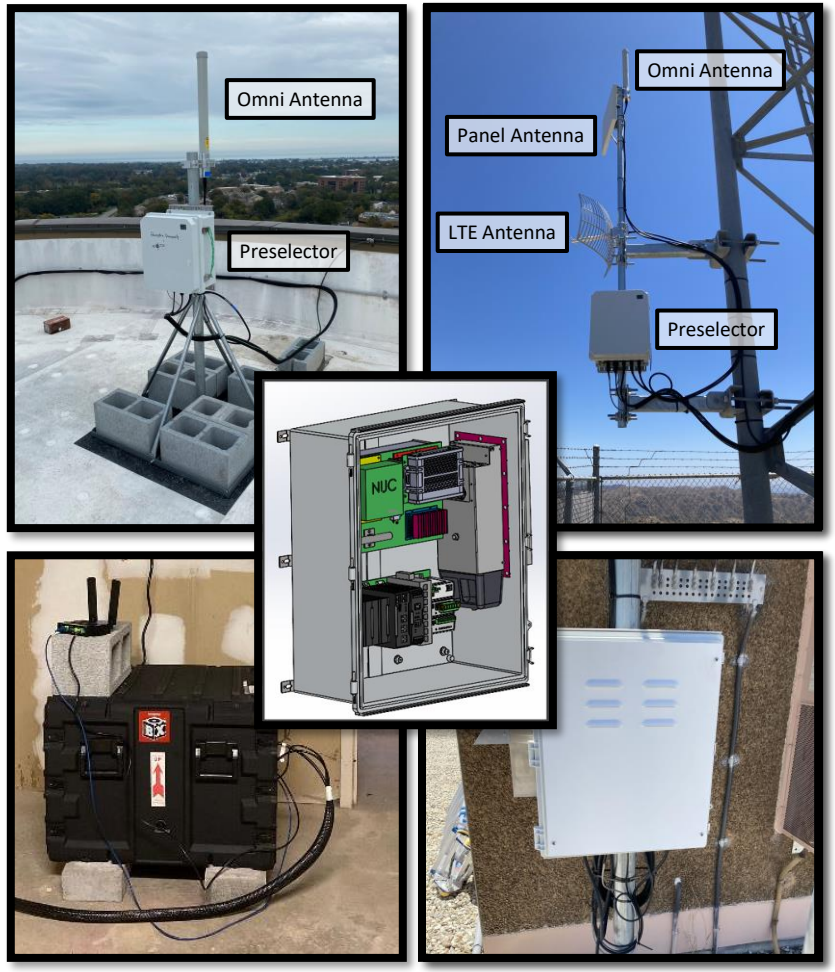
# Technical Highlights

- *Professional design and integration* through MITRE – Bedford Laboratories
- *Traceable to NIST* Calibrated and referenced to NIST's thermal noise radiometer (https://www.nist.gov/programs-projects/thermal-noise-metrology)
- *Authority To Operate network* through NTIA / ITS
- *Leverages NTIA's reference implementation* of the Spectrum Characterization and Occupancy Sensing (SCOS) sensor standard. (IEEE 802.15.22.3)
- *On-the-fly calibration* through NIST traceable on-board RF thermal noise reference
- *Portable lab to field uncertainty characterization methodology* demonstrated and in preparation for publication
- *Deployed sensor investigation and monitoring* through NASA Langley

# SEA Sensor Systems – at a Glance

Split System

All-Outdoor System




| | Parameter | Typical Value | | Conditions | Note |
|---|---|---|---|---|---|
| RF System | Frequency Range | 3530 – 3710 MHz | | | Additional channels on either edge of CBRS |
| | Gain | 31.5 dB | | **Channel 8** (3620 – 3630 MHz)<br><br>**RSA Settings:**<br>Preamp: Enabled<br>Reference level: -25 dBm<br>Input attenuator: 0 dB | |
| | Input-Referred Noise Power | -98 dBm/10 MHz | | | Additional dynamic range settings to adjust noise and overload levels |
| | Input 1 dB Compression Point (w/ CW Stimulus) | -48 dBm | | | |
| Antenna | Type | Omni (360°) | Panel (15°) | | *GMM sensor variation*<br>90° Sector<br>Gain: 17 dBi<br>Pol: +,- **45°** Slant Pol<br>Vert: 6° |
| | Gain | 9 dBi | 20 dBi | | |
| | Polarization | Vertical | Vertical | | |
| | Vertical 3 dB Beamwidth | 11° | 14° | | |

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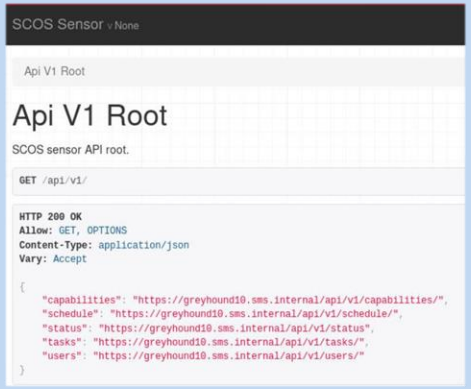
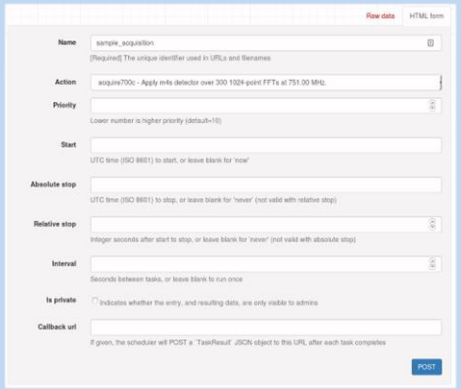
# SEA Sensor Software

## SCOS Sensor

- Universal API for a sensor that is hardware agnostic
- Decouple the hardware from the software
- Standardized to IEEE 802.15.22.3
- https://github.com/NTIA/scos-sensor




## SigMF Metadata

- Common metadata for data outputs from sensors
- Aggregate data across multiple projects and efforts
- Single “ingester” for all datasets
- https://github.com/sigmf/SigMF
- https://github.com/NTIA/sigmf-ns-ntia


- `ntia-algorithm` describes the measurement performed (detectors, algorithms, etc)
- `ntia-core` adds generally useful metadata fields
- `ntia-diagnostics` provides metadata to describe system diagnostic information.
- `ntia-emitter` gives information about the emitter being measured
- `ntia-environment` gives information about the environment around a sensor or emitter
- `ntia-nasctn-sea` provides metadata used within NASCTN Sharing Ecosystem Assessment project.
- `ntia-scos` provides metadata for the NTIA Spectrum Characterization and Occupancy Sensing (SCOS) implementation
- `ntia-sensor` defines hardware components and settings
- `ntia-waveform` provides metadata to describe measured or transmitted waveforms

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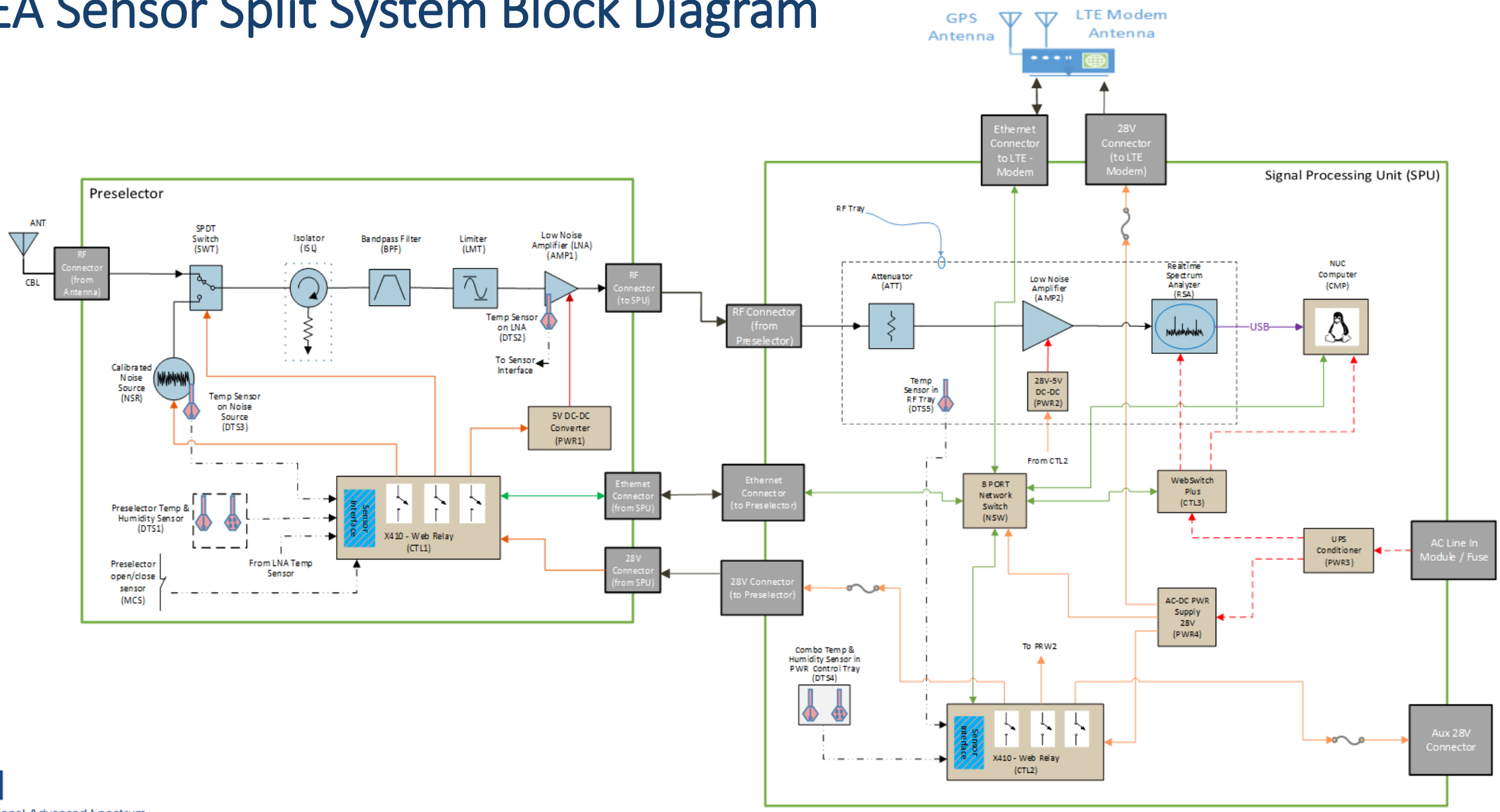
# SEA Sensor Split System Block Diagram

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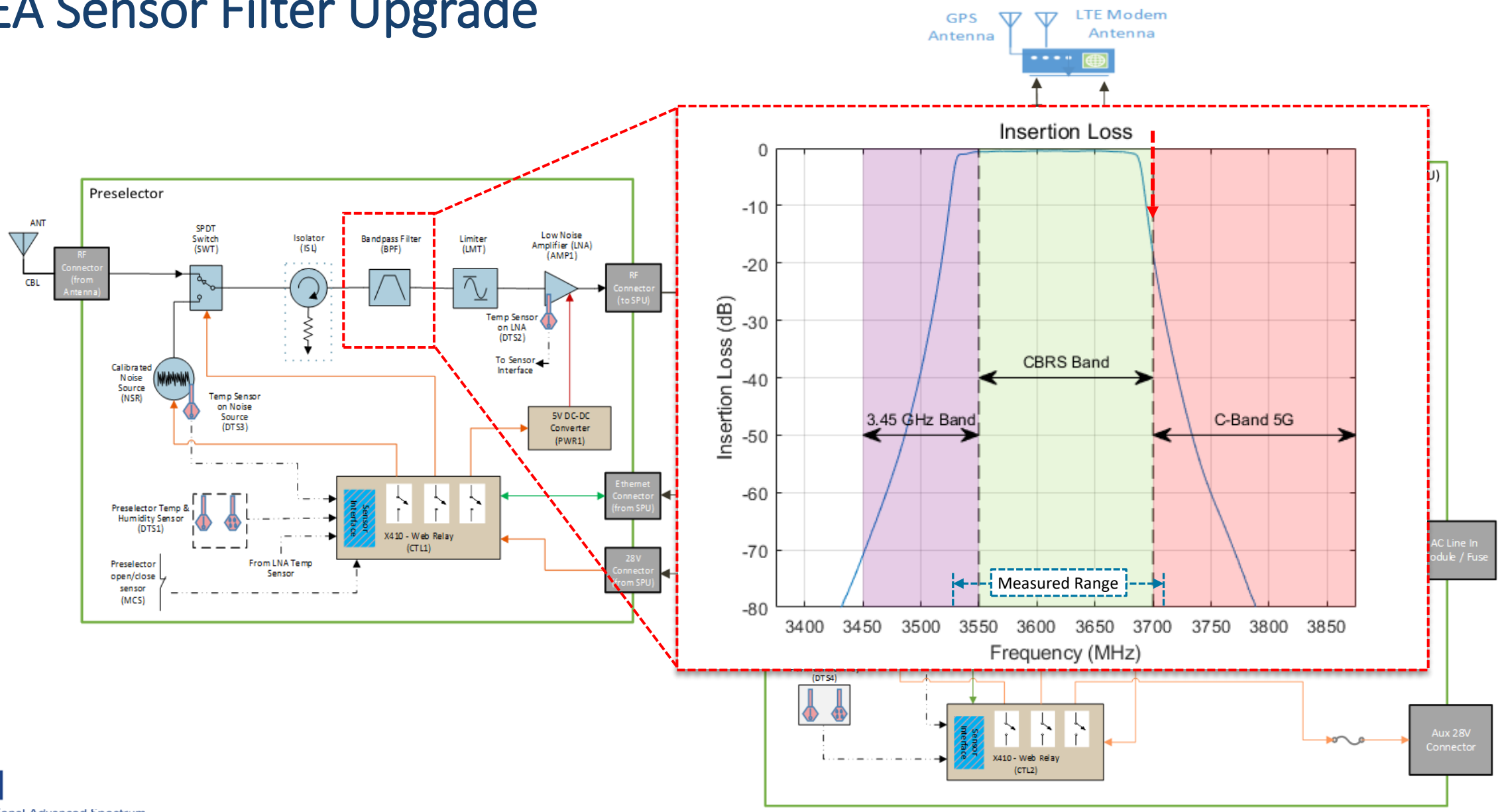
# SEA Sensor Filter Upgrade

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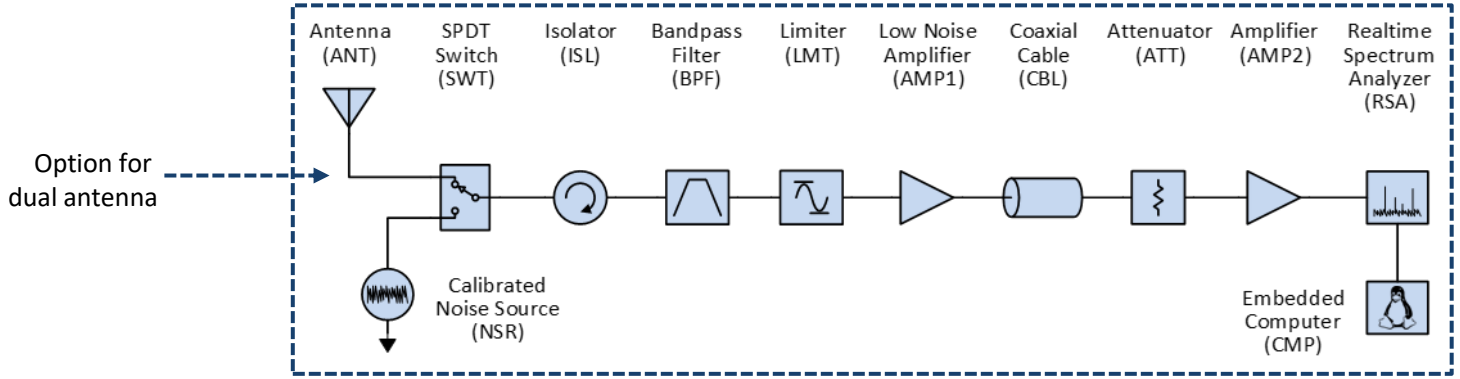
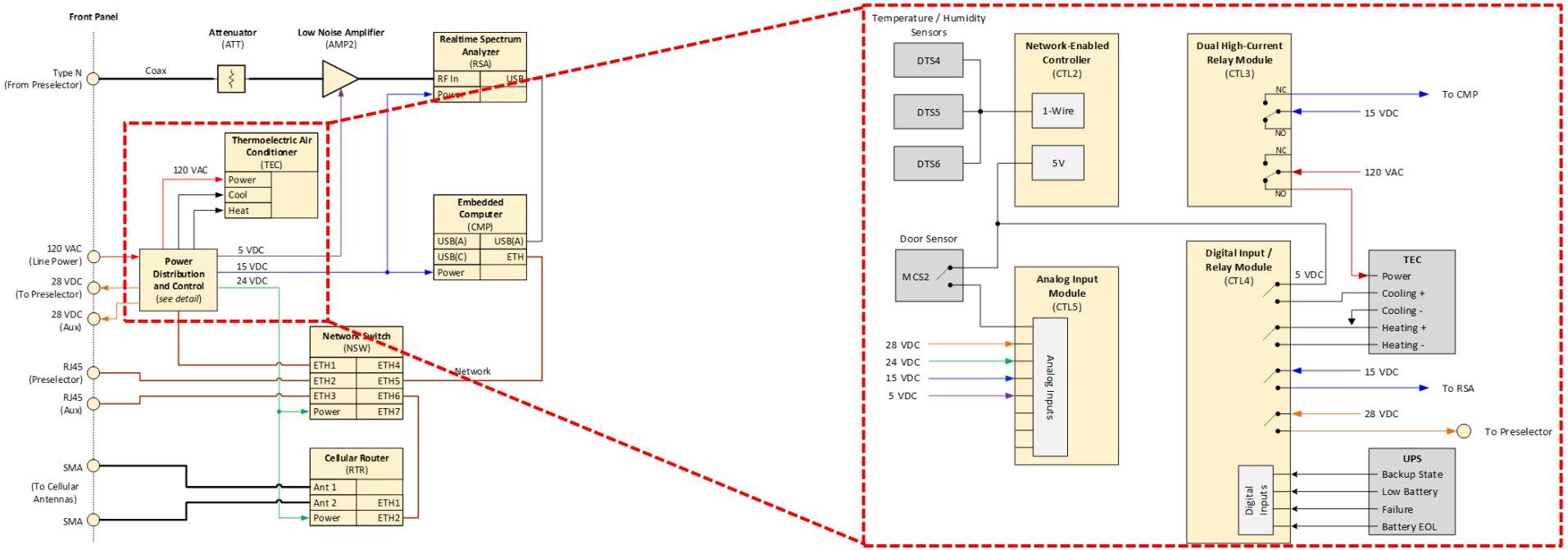
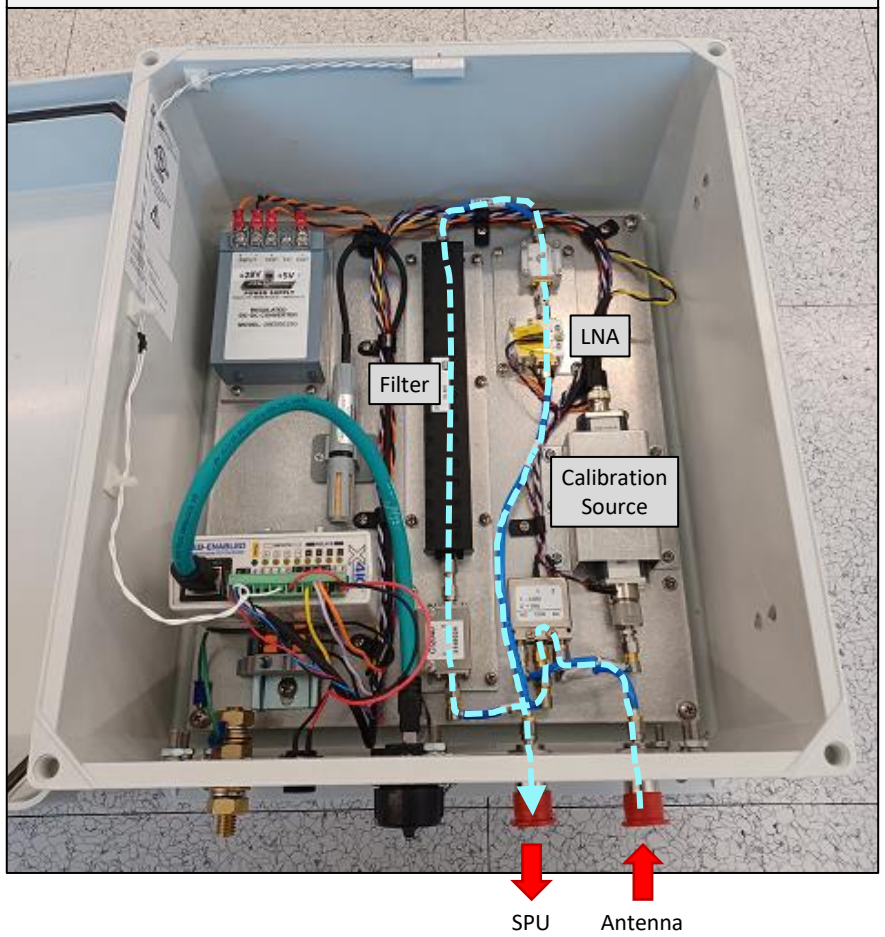
# SEA Sensor – Fully Outdoor Block Diagram



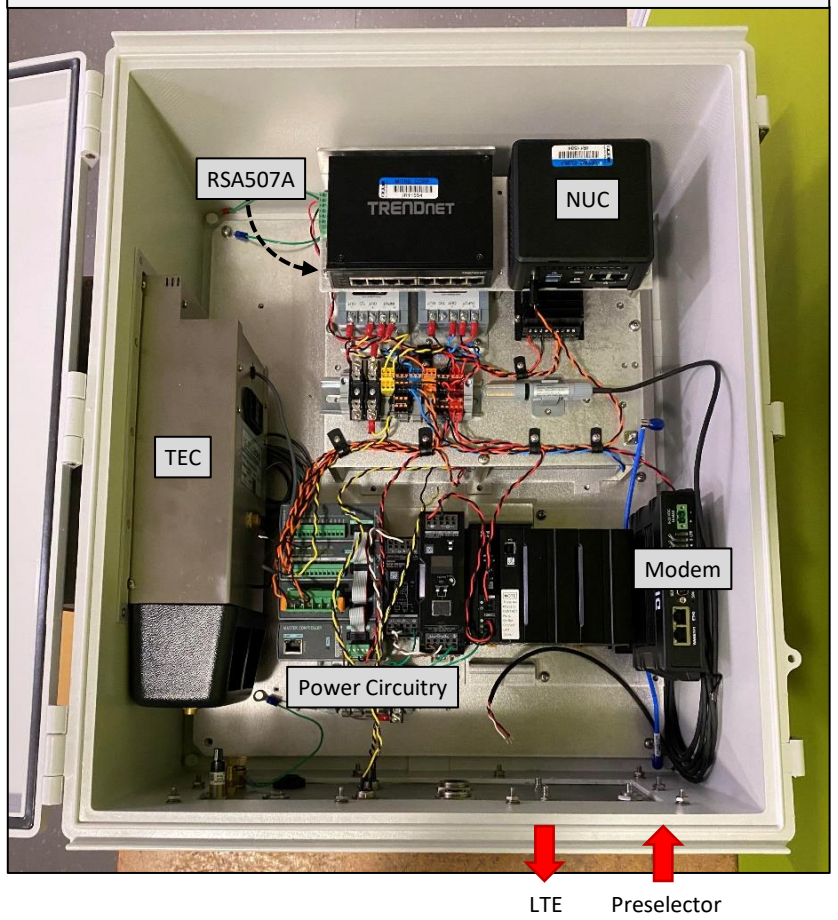



# SEA Sensor System

SEA Sensor Preselector




SEA Sensor Outdoor SPU

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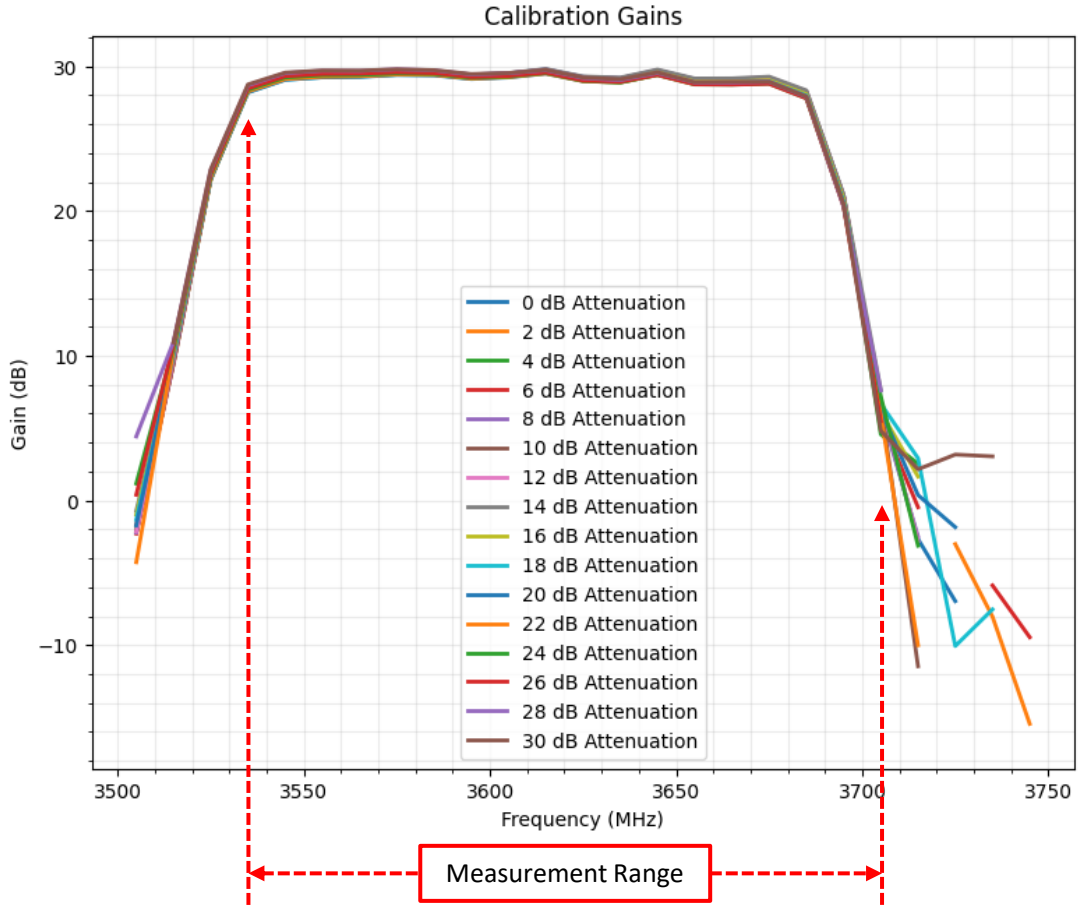
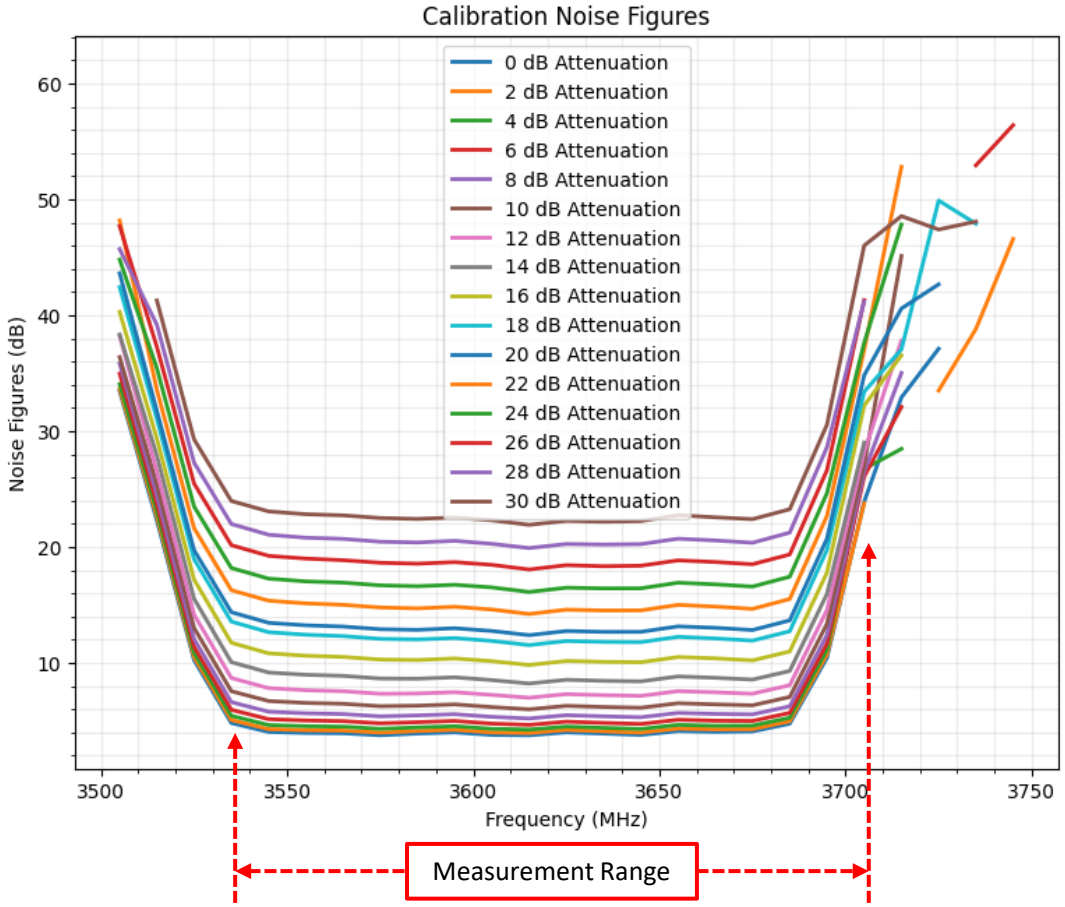
# SEA Sensor Calibration

## On-Board Calibration Ranges



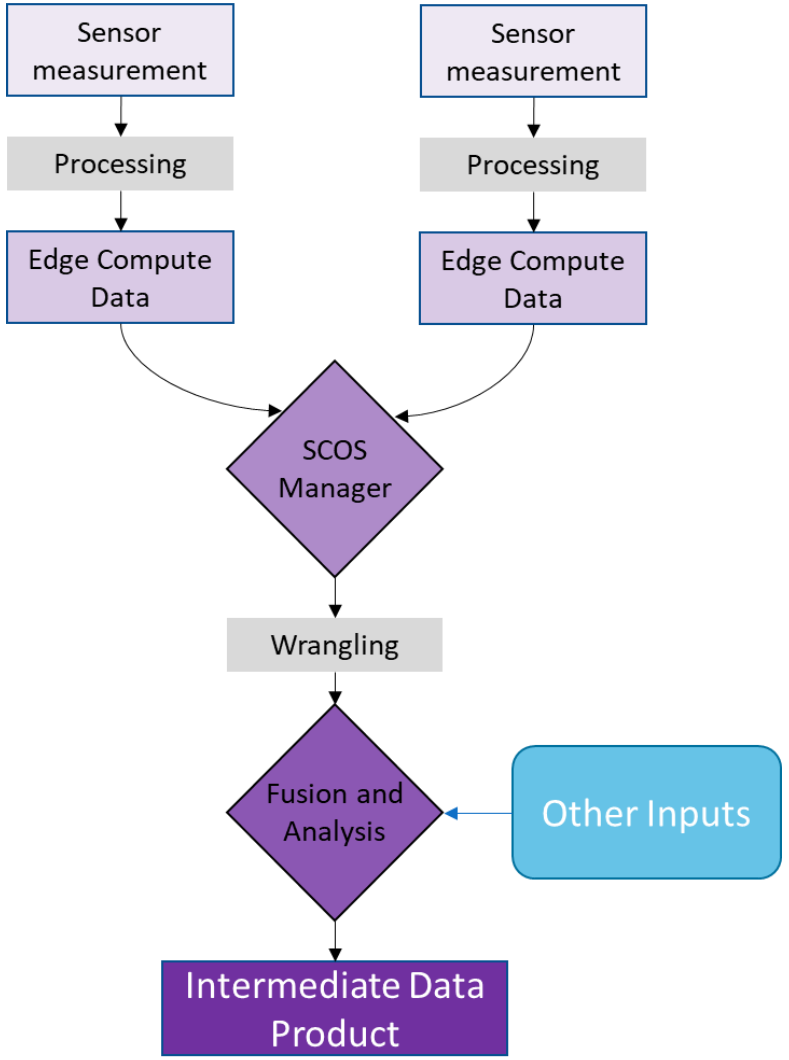
# Data Products

# Data Products: Data at the Edge

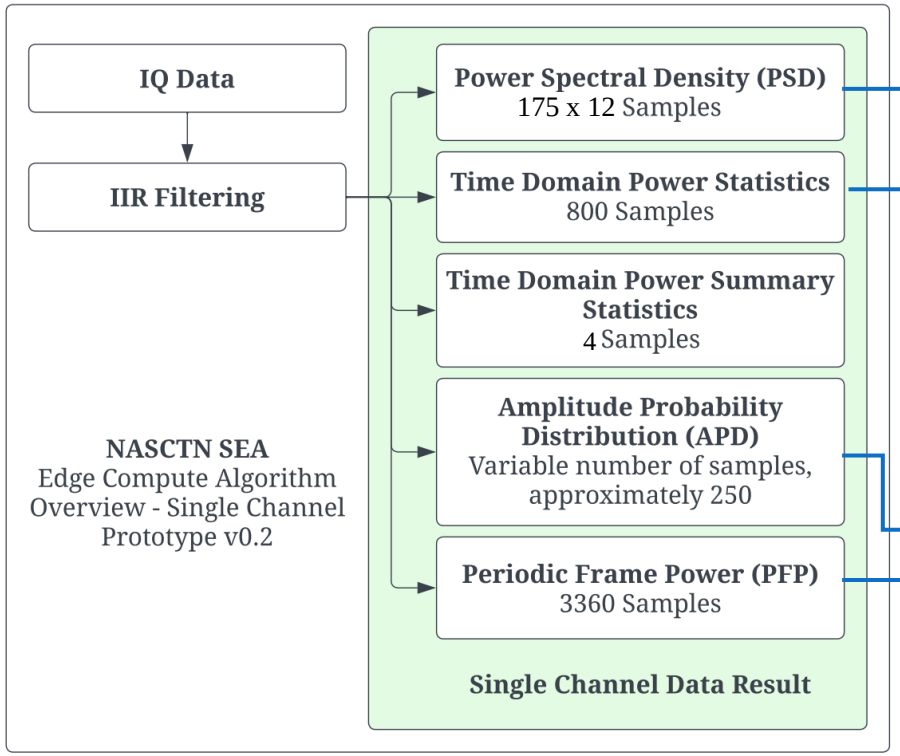
Goal: Compute a compressed stream of key measurements from field waveforms in real time

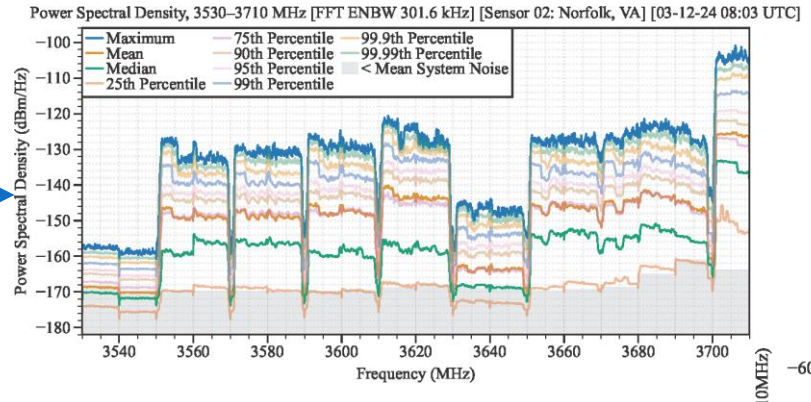
- Summary power statistics
- Structure/distributions in time/frequency

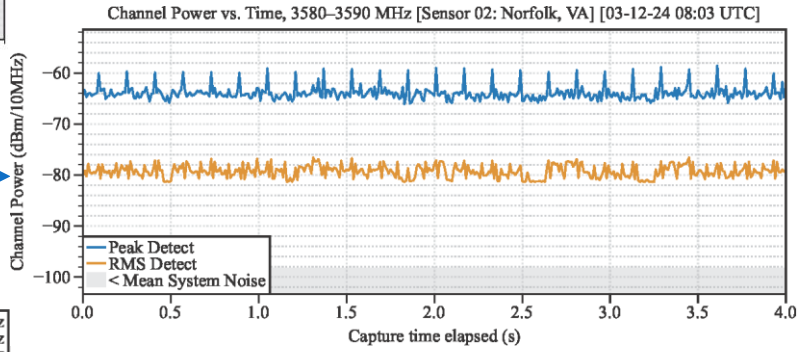
These are "building blocks" - downstream aggregation and analysis will digest into intermediate data products for each of the major tasks

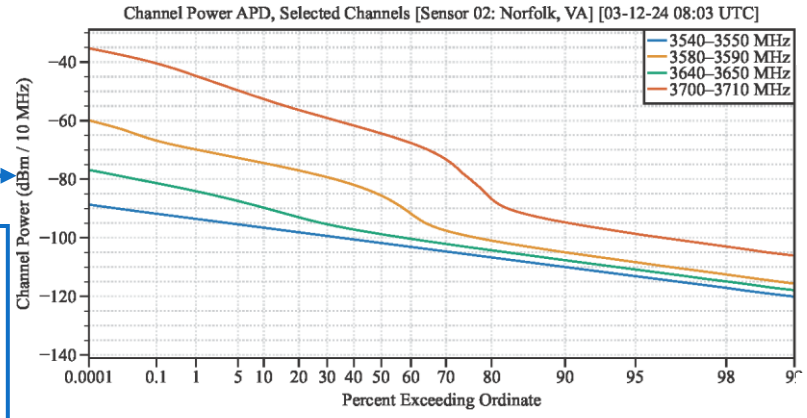


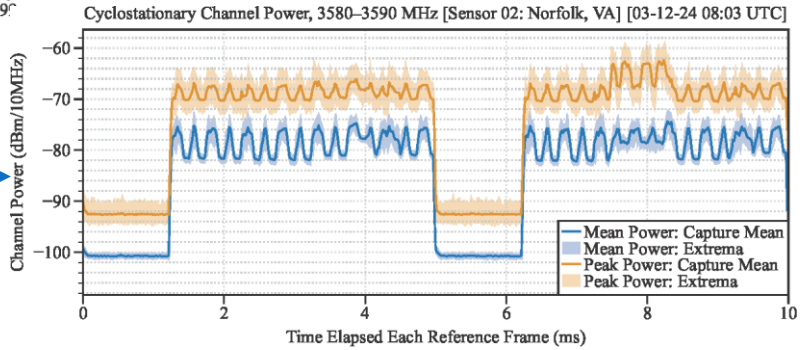
# Sensor Data Products



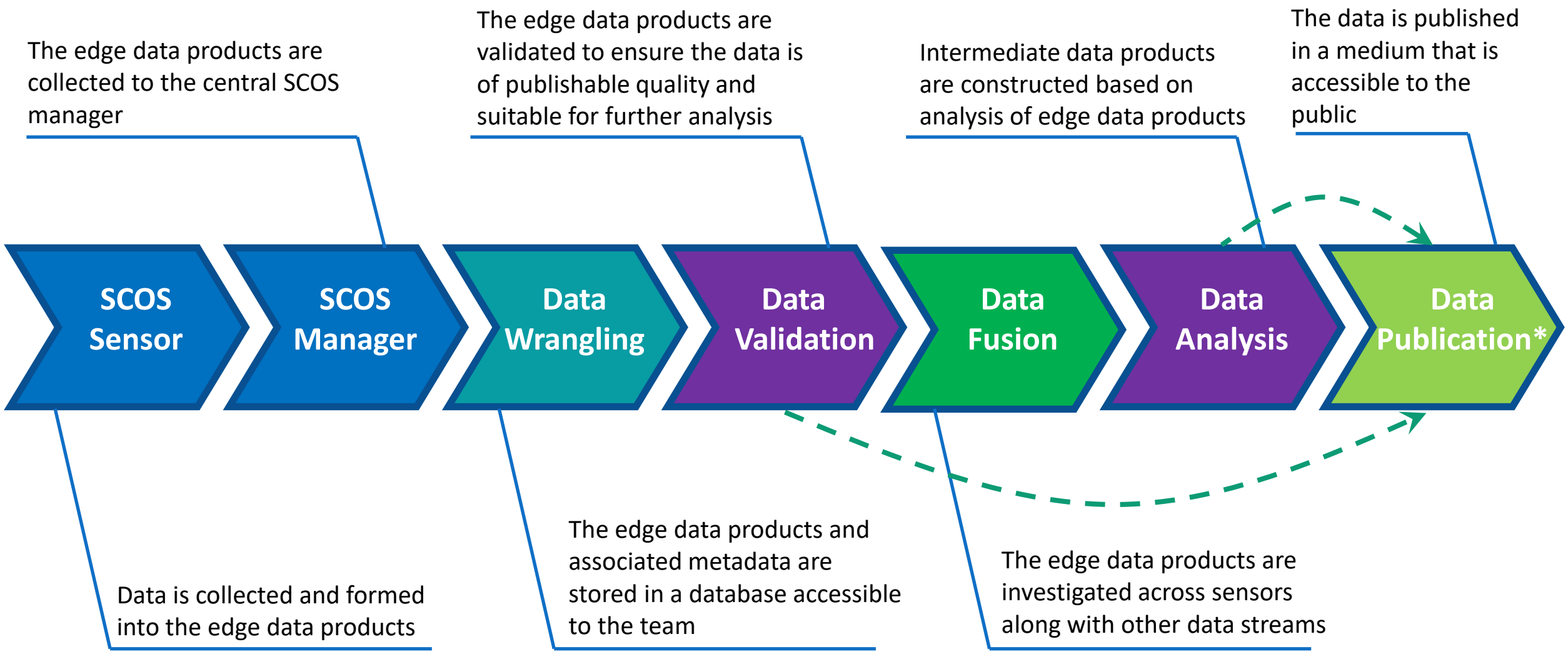




3530 MHz – 3710 MHz measured in 10 MHz channels with 4-second dwell times

# Sensor Data Publication Framework

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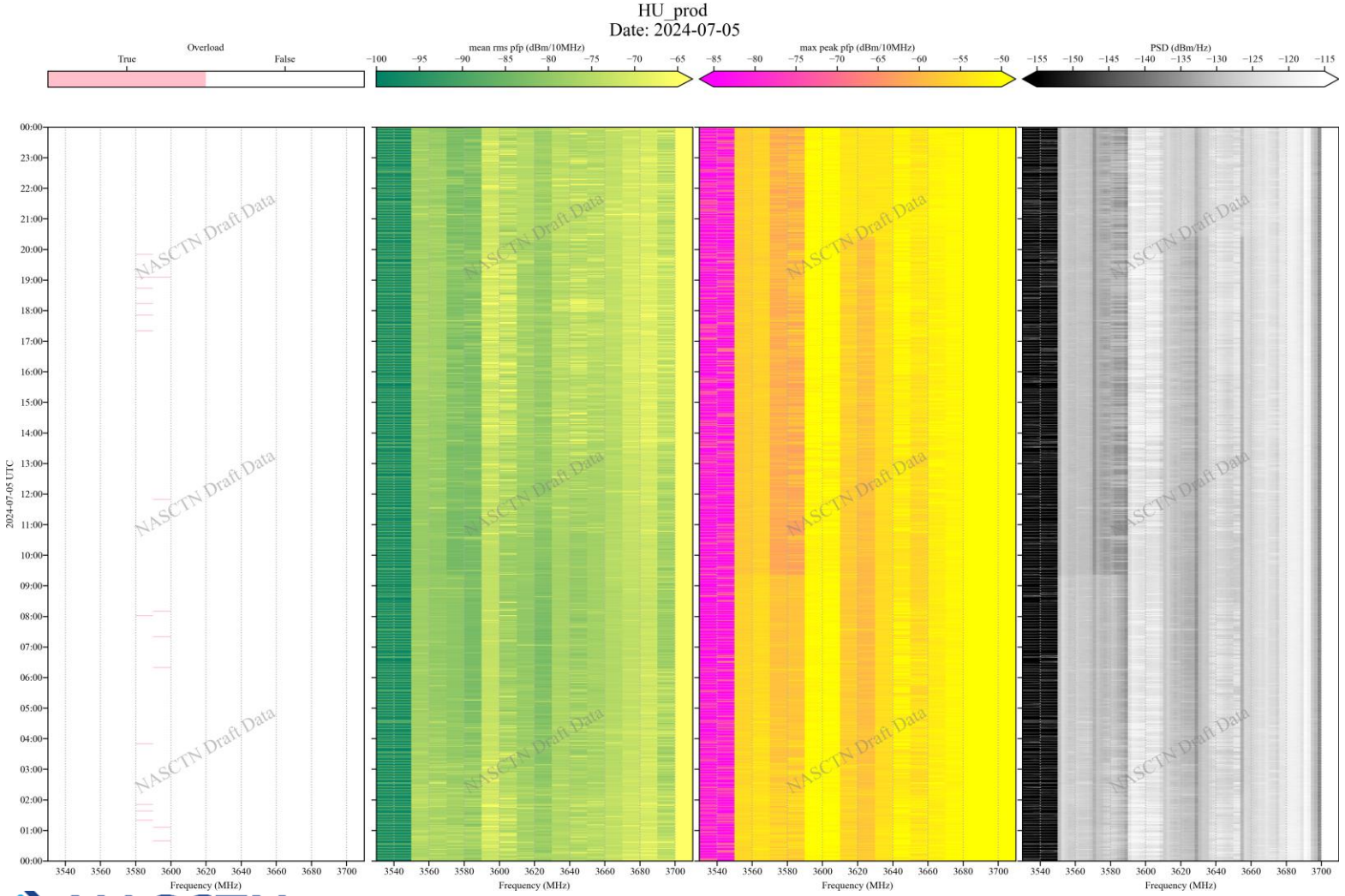
10 September 2024 – DRAFT – PRE-DECISIONAL

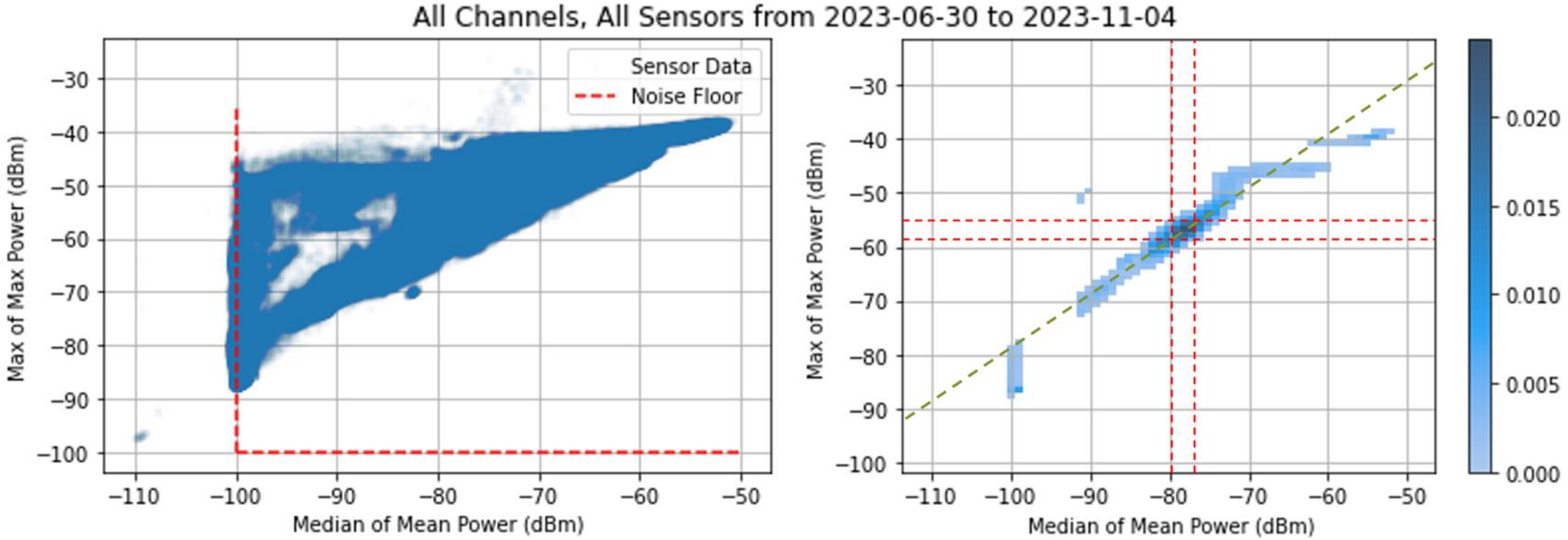
* Data publication follows the NASCTN review process, where every contributing agency of the project has the opportunity review the technical report, code, and associated data.

# Example Analyses – Day Plots




- Day-cycle trends from the ecosystem
  - Local dynamics
  - Shorter-time view
- Sensor-by-sensor and location-by-location

# Example Analyses – Longitudinal Trends




Longitudinal looks at the ecosystem across time, frequency, and location

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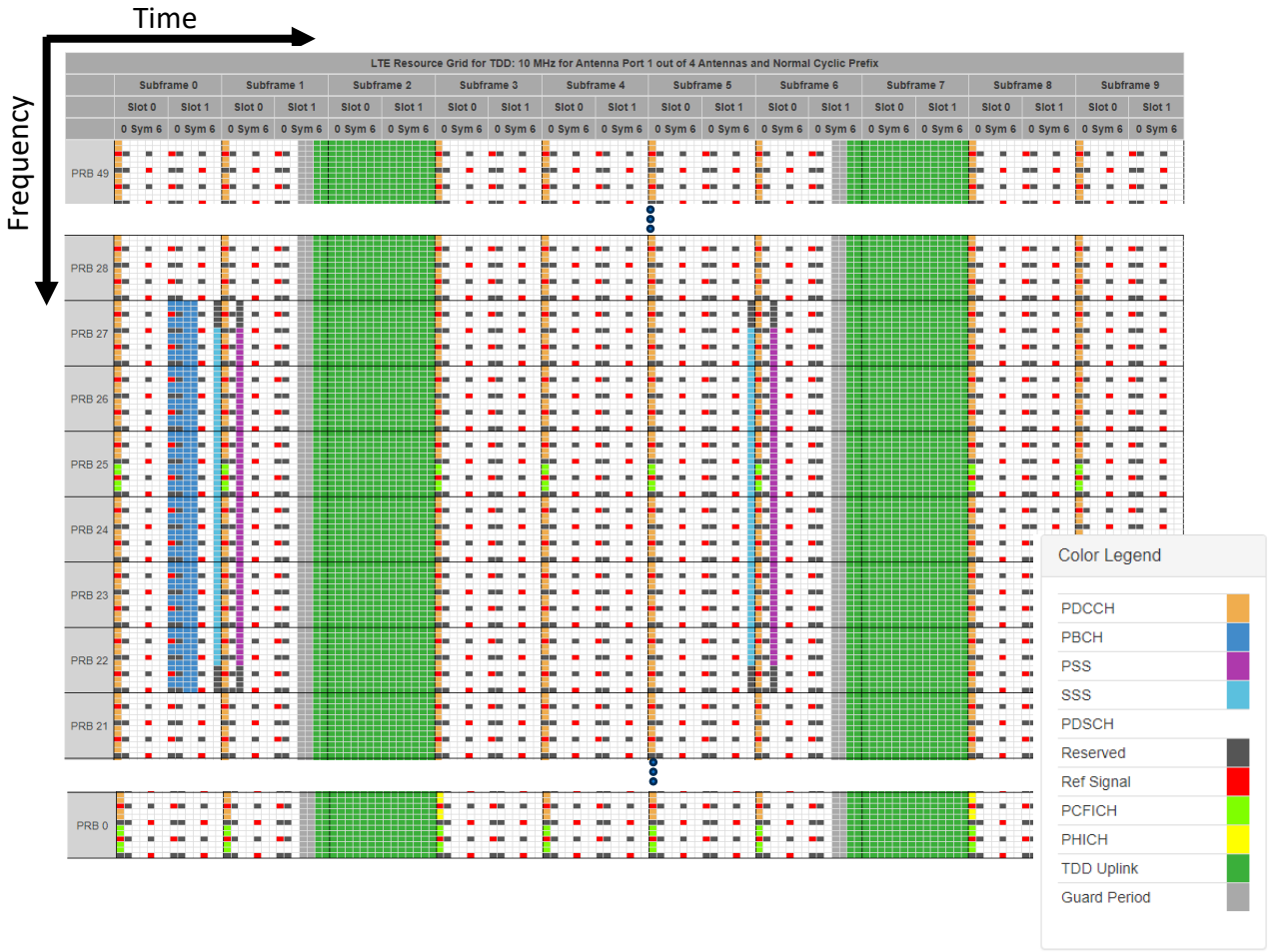
# Example Analyses – LTE/Cellular Resource Assignments

## Proof of concept

- Mapping TDD Resource Assignments to SEA Sensor Periodic Frame Power data
- Correlation to TDD Config 2, Special Subframe Config 7
- Investigate trends in PDSCH, TDD DL / UL activity

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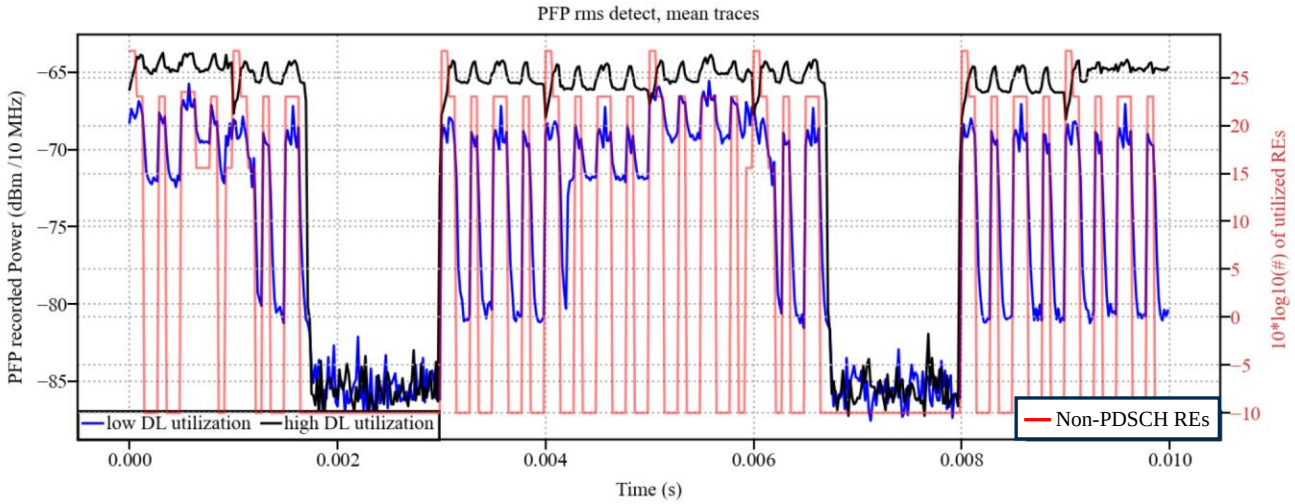
Resource Grid Tool Credit: dhagle.in/LTE

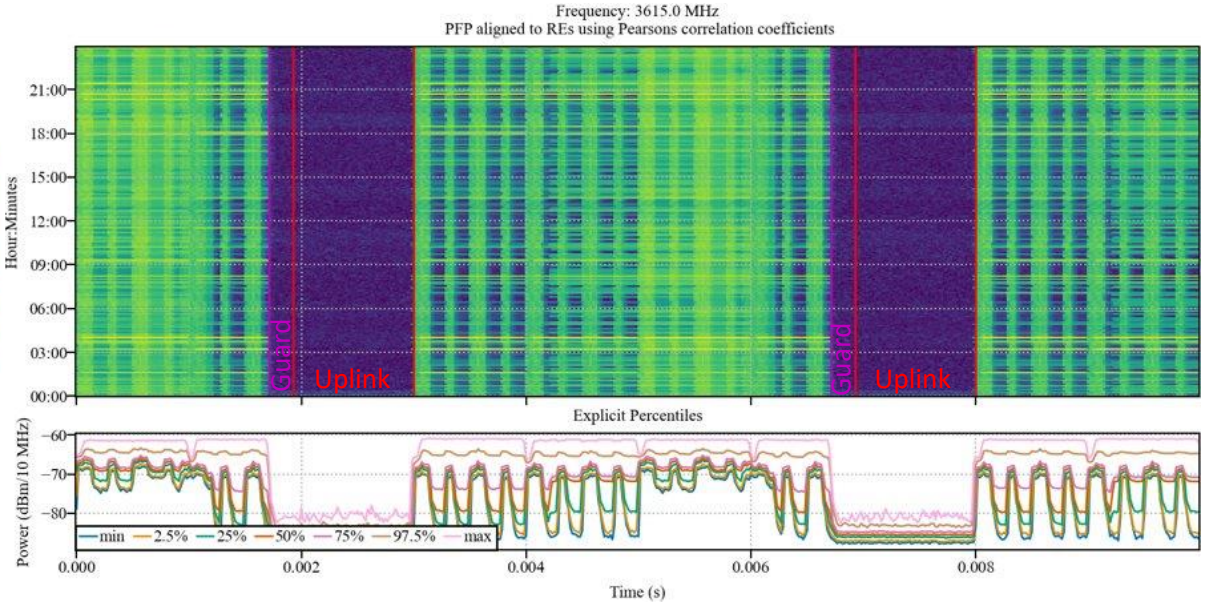
# Example Analyses – Mapping of Resource Element Mask to Measurements

## Correlation to LTE Control Channel Resource Element Utilization

### Individual Traces

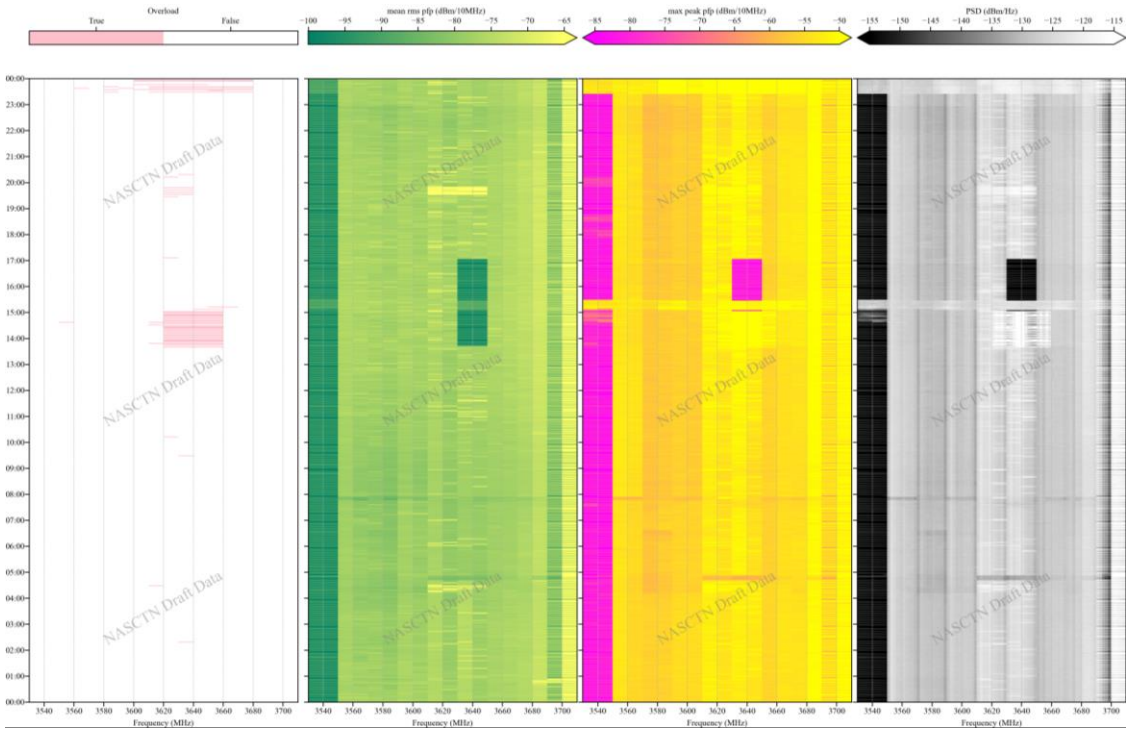



### Whole Day

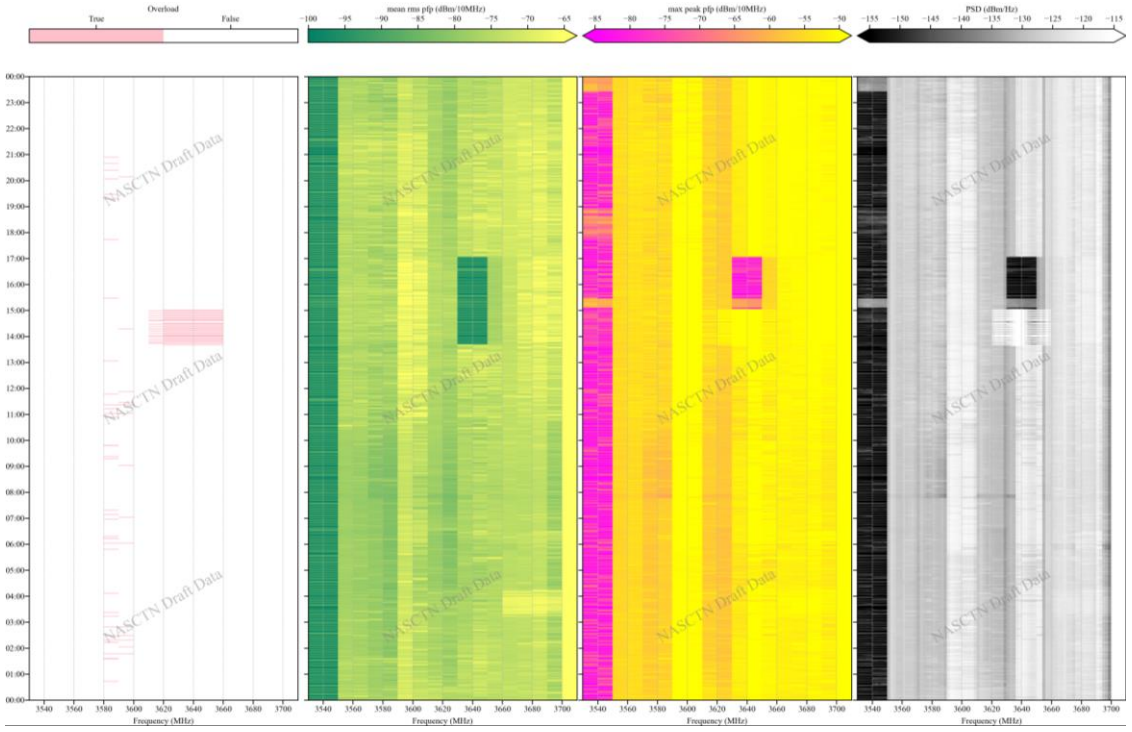


# Suspected Event Corroboration Across Sensors

## NIT Sensor

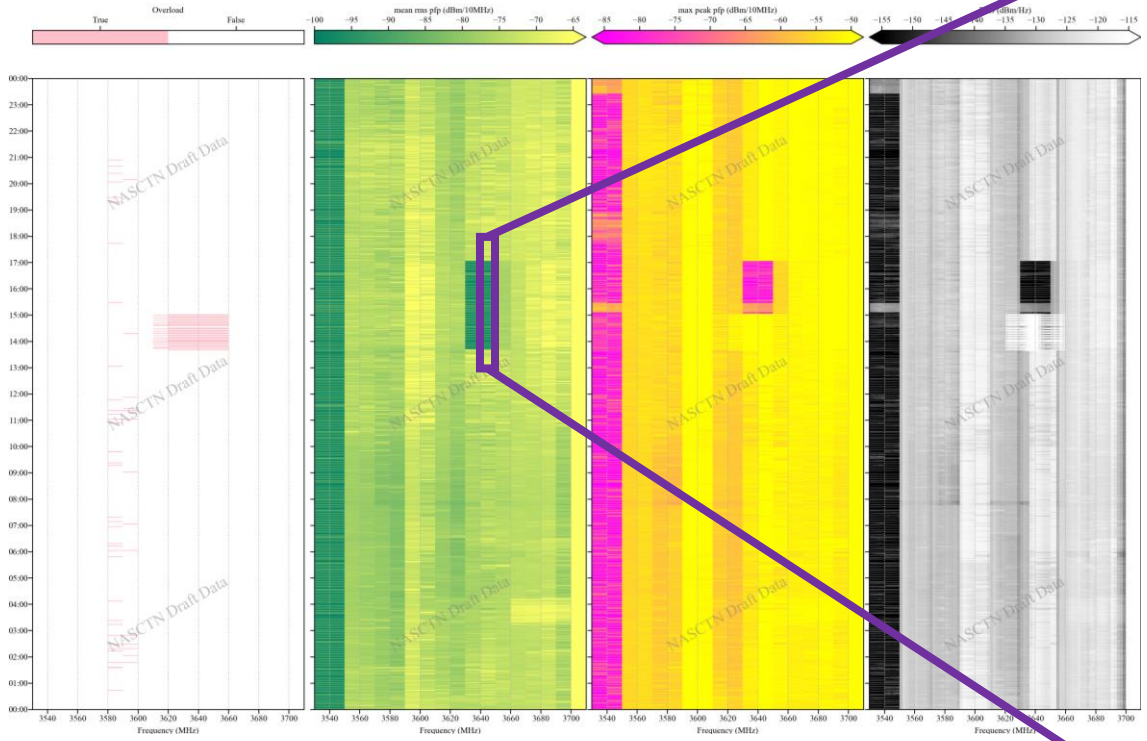



## HU Sensor

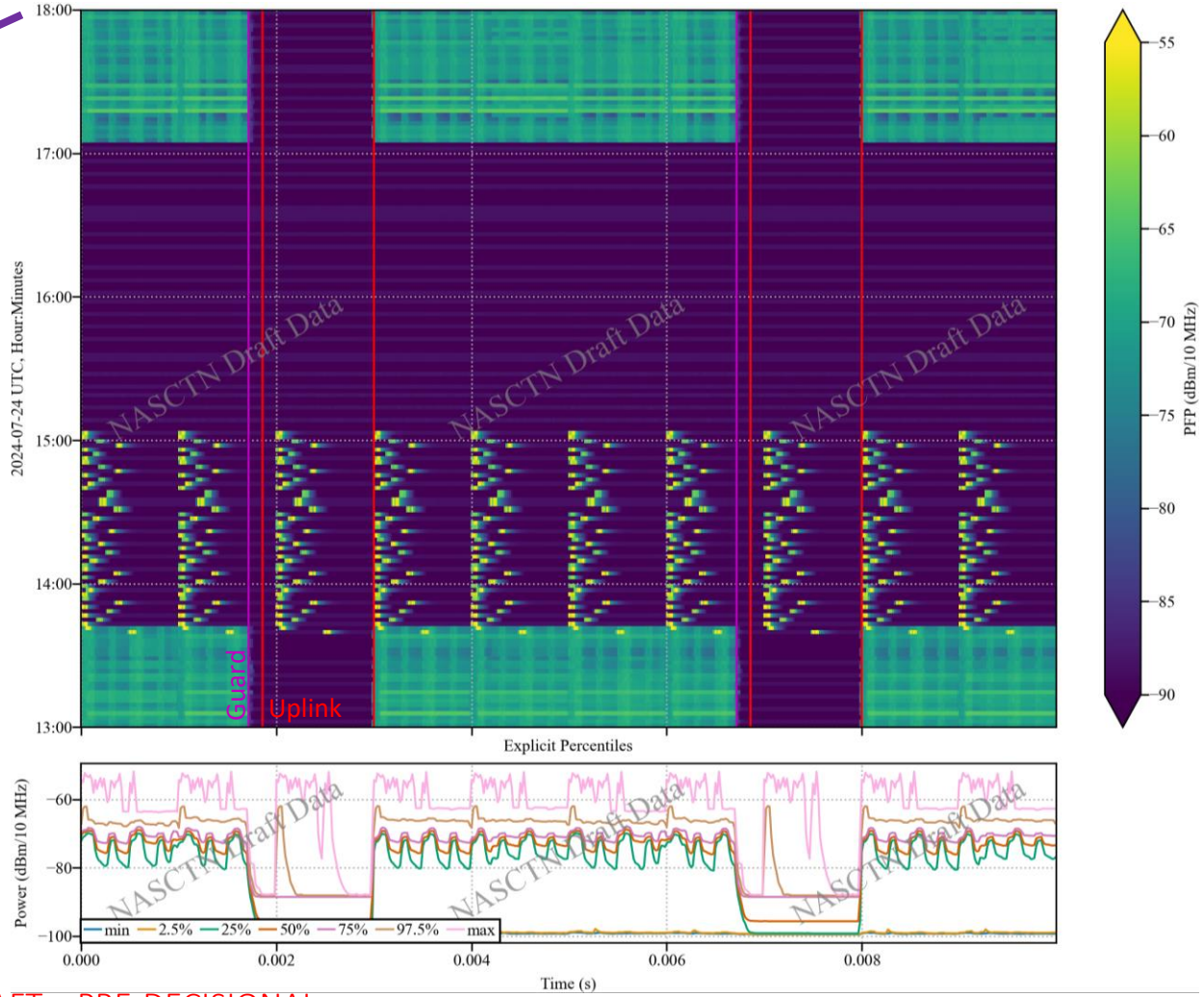


# Suspected Event Inspection

## HU Sensor




## Periodic Frame Power view



# State of Current Efforts

# State of Current Efforts

## A. Sensor Systems

- *Prototype systems upgraded to production units*
- *Sensor Data is informing Data Analysis & Data Methods Development*
- *Software – maintenance & minor revisions:*
  - To date improved sensor stability and reliability (latest round of updates points to >95%)
- *Hardware*
  - Weatherized outdoor system
  - Dual antenna provisions for select sites
  - Upgraded RF frontend selectivity and performance
    - *Possibility to revise further based on upcoming cellular deployments in lower adjacent band*
- *System verification checks*
  - Periodic tests identified and automation underway

| Green Mountain Mesa | Norfolk International Terminal | Hampton University Tower |
|---|---|---|
|  |  |  |
| 39.99180 N, 105.27452 W, 5851 ft +,- 5 ft ASL | 36.91552 N, 76.32245 W, 159 ft +,- 5 ft ASL | 37.02578 N, -76.34120 W, 231 ft +,- 5 ft ASL |

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# State of Current Efforts

## B. Sensor Deployments

- *6 fielded & operational / 3 to be deployed / 1 in reserve with 2 additional builds*
  - East 1: 2 sites deployed, 2 sites awaiting deployment
  - West 13/14: 3 sites deployed, 1 site remaining authorization
  - Green Mountain Mesa: 1 site deployed
  - Additional site opportunities under consideration

## C. Modeling

- Incorporating methods and industry provided data to inform site selections - *completed*
- Industry provided data under investigation for corroborating sensor measurements – *major focus*

## D. Data Ingestion

- Prototype database repository – *being trialed*
- Automated data validation and translation from SigMF to database repository – *major focus*

## E. Data Analysis

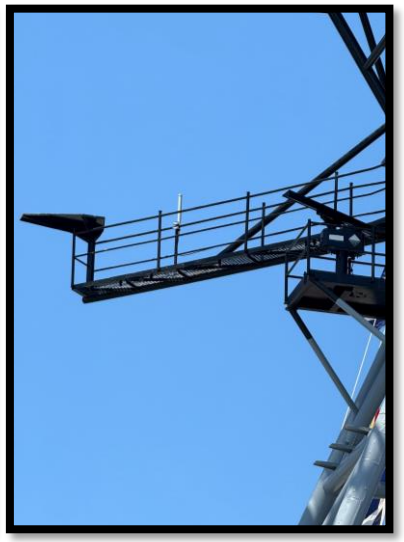
- Establish methods in formalized timeseries analysis – *major focus*
- Cross correlation across sensors – *being trialed*

## F. Data Publication Plan

- NASCTN has formalized process for publication

# Thank You

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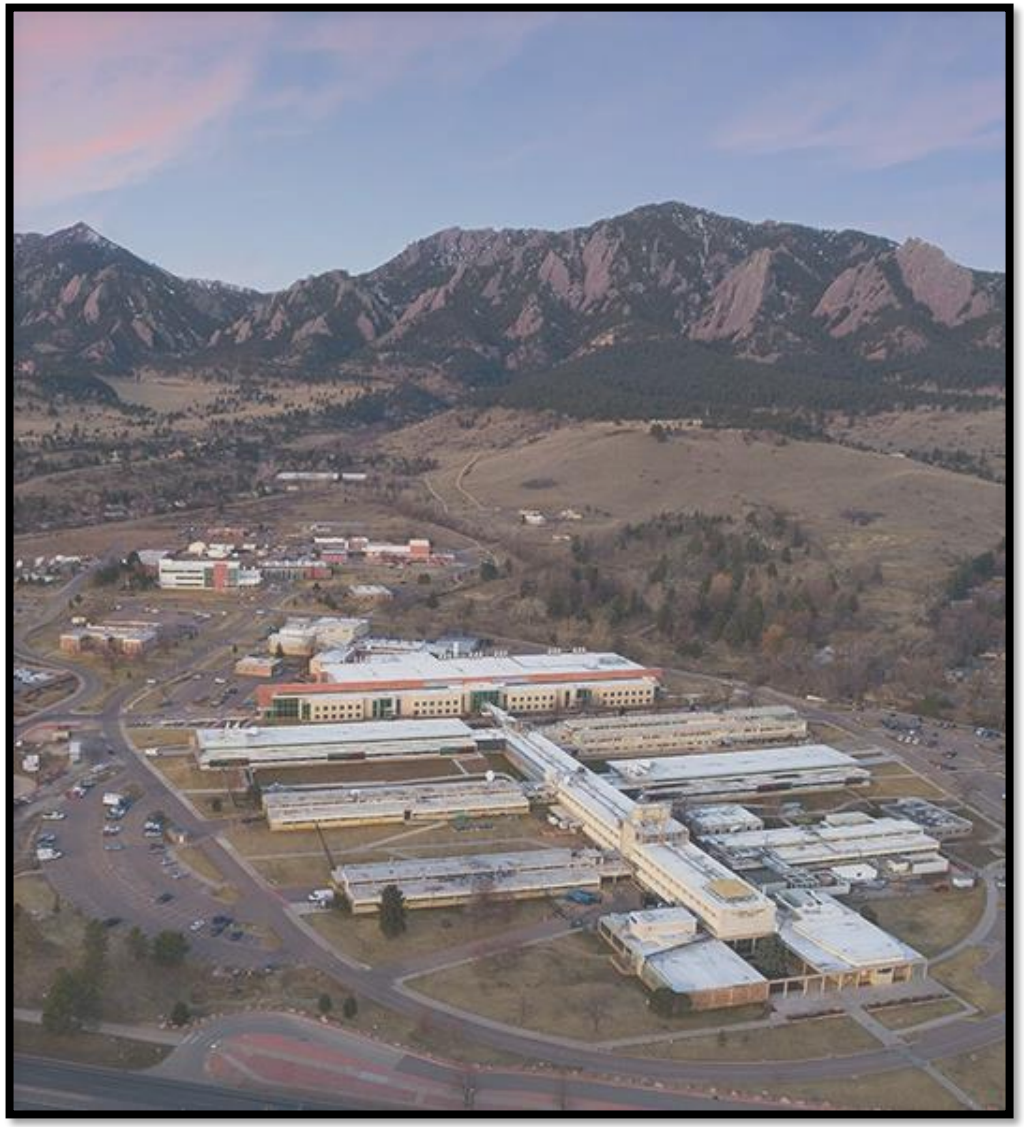

# Contact Us

nasctn@nist.gov

NASCTN Program:

- https://www.nist.gov/ctl/nasctn

Updates on the Project:

- https://www.nist.gov/programs-projects/cbrs-sharing-ecosystem-assessment

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