CBRS Sharing Ecosystem Assessment: Test Framework and Approach

Public Briefing and Community Input

July 12, 2022

NASCTN
National Advanced Spectrum and Communications Test Network

Briefing Goals

- Communicate Test Framework and Scope of Project
- Communicate recommended approach and context
  - Roadmap of how each task supports the Objectives (Noise Floor, Always-On, Data)
  - Review modeling that led to recommendations
  - Identify analysis outcomes
- Identify appropriate venues for coordination with stakeholders

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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

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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

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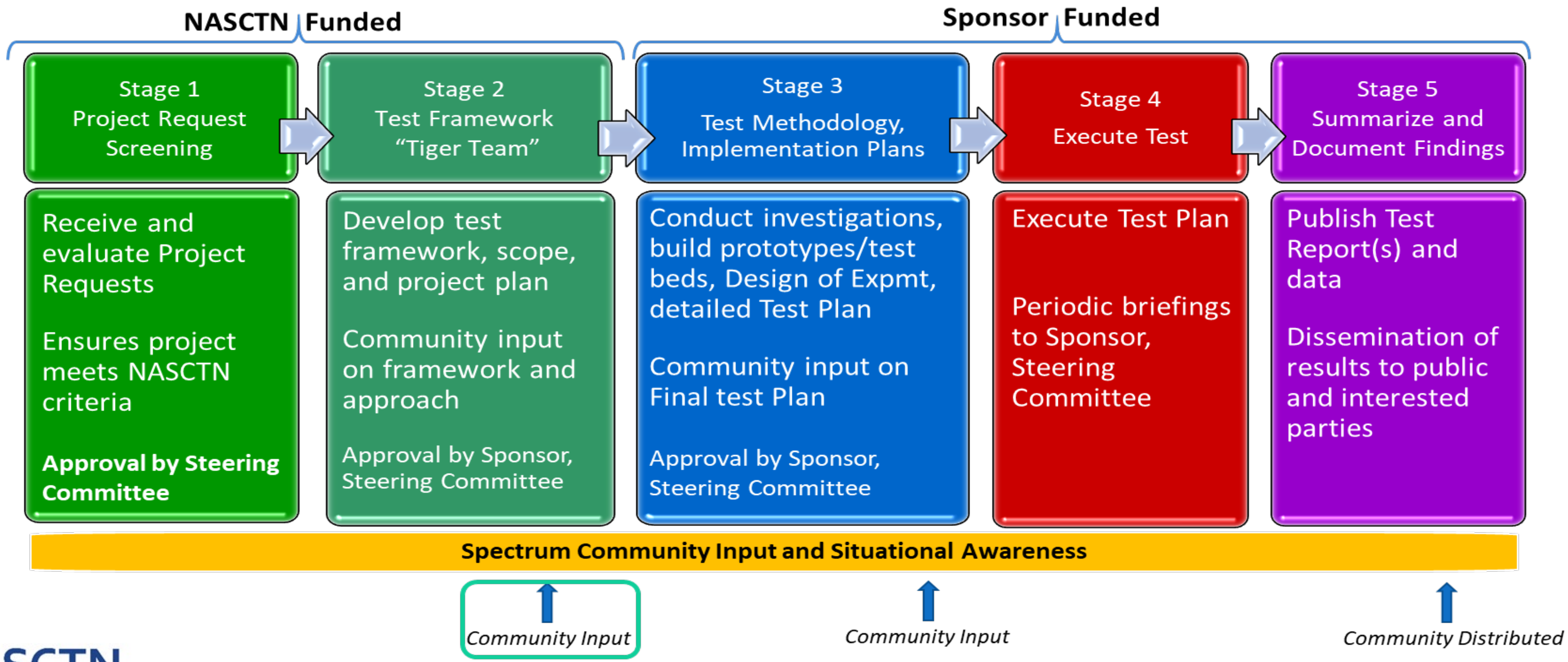
NASCTN 5-Stage Framework

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.



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

Test Request: CBRS Sharing Ecosystem Assessment (SEA)

Collect 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). Provide insight into the sharing ecosystem's effectiveness, and track changes in the spectrum environment over time.

4 Key Objectives:

Provide data driven insights into:

1. Efficacy of permanent sharing between CBRS systems as managed by SASs and DoD systems
2. Noise floor measurements through continuous automated observations
3. CBRS emissions within the Always-On Dynamic Protection Areas at Army and Marine sites

Support:

4. The development & management of a measurement data repository

2 Phases:

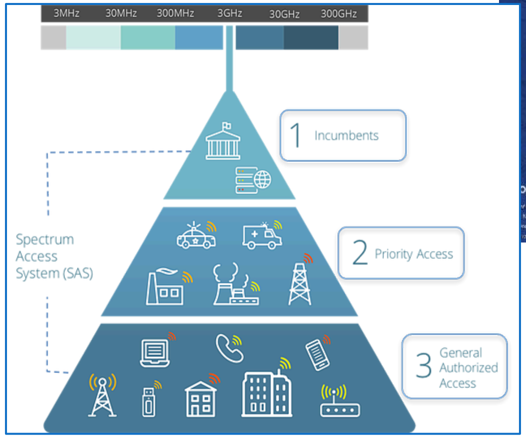
- Phase 1: Establish the measurement system requirements; develop, build, deploy a metrology system to measure the CBRS ecosystem performance at DoD sites.
- Phase 2: Long-term analysis phase, with continuous noise floor measurements and annual deep dive measurements and analysis.

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 <u>independent trusted agent</u>*

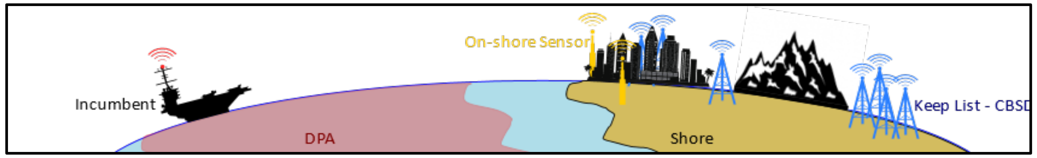
Citizens Broadband Radio Service (CBRS)

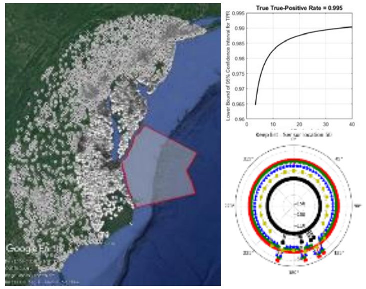
The Citizens Broadband Radio Service (CBRS) is the "first of a kind" shared spectrum ecosystem, implemented nationwide.

- **Shared band, 3 tier approach** - Incumbent, Priority Access License, General Authorized Access
- **Sharing stipulations**
- **Environmental Sensing Capability (ESC)** detects incumbents and **Spectrum Access Systems (SAS)** coordinates spectrum access



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





Modeling & Data Analytics

Laboratory Capabilities

Monitoring Expertise

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.

NIST NTIA NASA MITRE

NASCTN SEA Project Approach

To achieve the 4 objectives, 5 major technical tasks were identified:

Passive Observation:

- **Task 1 – Measure Aggregate CBRS Emissions in Coastal DPAs**
  - Characterize aggregate CBRS emissions with and without DPA activations.
    - Obj 1: Assess ecosystem performance to timely respond
    - Obj 2: Measure increase in noise floor due to deployment of CBRS systems over time
- **Task 2 – Measure Aggregate CBRS Emissions in Always-On DPAs**
  - Characterize aggregate CBRS emission levels over time in always-on DPAs.
    - Obj 1: Collect data to provide insights into the Always-On Dynamic Protection Areas
    - Obj 2: Measure increase in noise floor due to deployment of CBRS systems over time

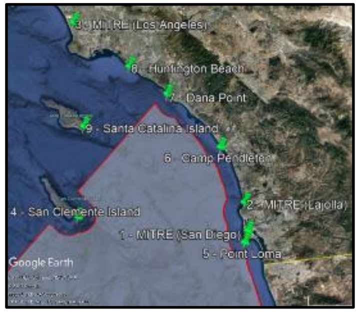
Active Experimentation:

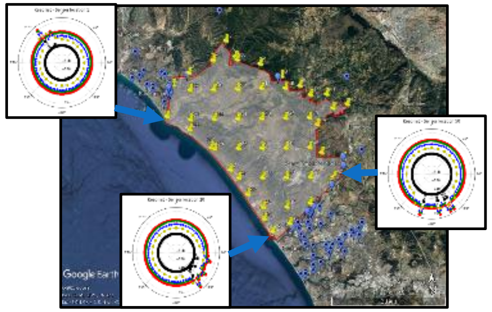
- **Task 3 – Evaluate ESC Performance in the Field (with Navy Ship)**
  - Assess ESC detection performance for a representative set of ESCs in the field.
    - Obj 1: Collect data on ESC site alerting due to Navy transmission. Assess true-positive and false-positive rates and independently verify incident power levels at ESC sensor locations
  - Coordinated investigation with Federal and commercial stakeholders

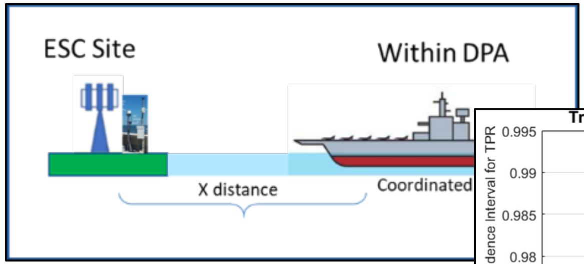
Long Term Support:

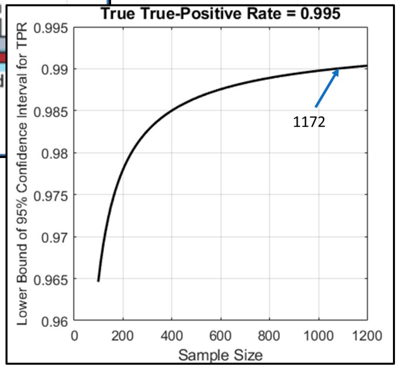
- **Task 4 – Long Term Data Analysis** of the measurements from Task 1 and 2
- **Task 5 – Support DoD Measurement Data repository**
  - Support the development & management of a measurement data repository

DPA = Dynamic Protection Area









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Underlying Assumptions of the Approach

- Data driven insights into how the CBRS ecosystem shapes the spectrum environment for Federal incumbents are desirable
- Independent measurements and data that inform on the deployed CBRS ‘sense and vacate’ spectrum sharing strategy are valuable
- Characterizing the real-world detection performance of ESCs against actual in-situ radar emissions is of value to CBRS stakeholders and the spectrum sharing community

- The following slides highlight the technical and logistical challenges associated with observation and experimentation of systems in the real-world.
- The presented approach does not imply an endorsement by CBRS stakeholders

Task 1 – CBRS Emissions in Coastal DPAs

- **Characterize aggregate CBRS emissions with and without DPA activations.**
  - Obj 1: Assess ecosystem performance to timely respond
  - Obj 2: Measure increase in noise floor due to deployment of CBRS systems over time (multiple years)

- **Not Doing:**
  - Obj 1: Adjudication or attribution of timeliness to respond
  - Obj 2: On-land measurements will not be translated to in-DPA

- **Assumptions:**
  - DPAs East 1 and West 14 are desirable
  - Knowledge of DPA activations can be obtained
  - DPA activation & geographic impact can be modeled and is informative:
    - NTIA OSM deployment models
    - WInnForum's reference move list algorithm
    - ITM P2P propagation model

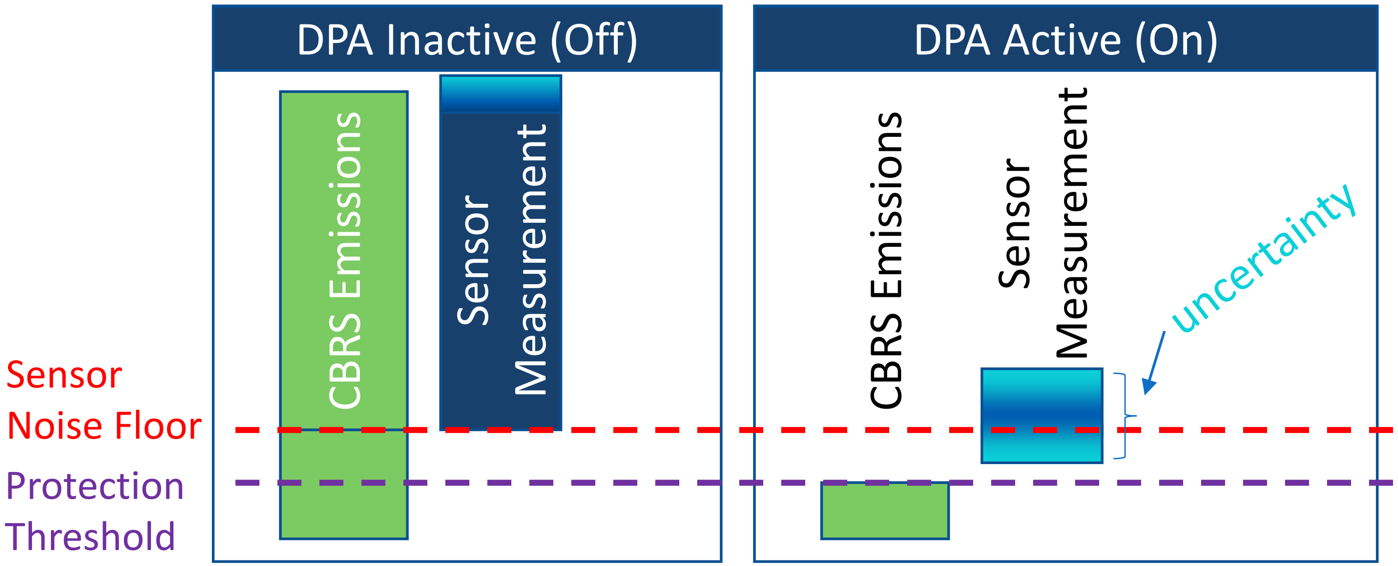
- **Description:**
  - Shore based sensors provide for longitudinal study of CBRS on a per 10 MHz channel basis
  - Information from CBRS stakeholders combined with standard models allow for optimized sensor locations

Task 1 - Key Technical Challenge of the Measurement Campaigns within DPA

Challenges for the Dynamic range of a COTS based sensor system

- Ability to distinguish between DPA On and Off → Simulation shows great difficulty even for highly specialized sensors
- DPA based sensor nodes would provide limited insight into protection thresholds
- Requires sensor resiliency to strong incumbent signals
- High sensitivity and wide dynamic range are anticipated requirements

Measurement of aggregate CBSD emissions in an ideal case

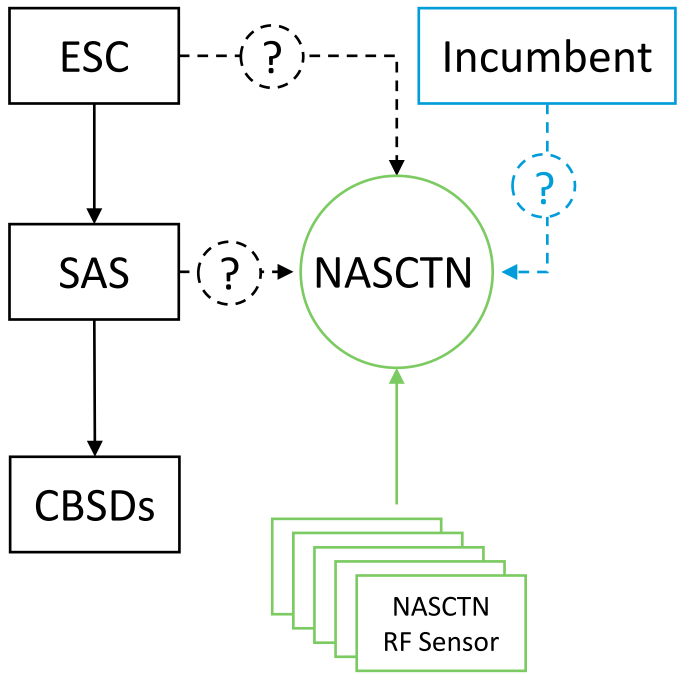


Initial simulation results highlight the technical challenge

Task 1 – Sensors Deployed near Coastal DPAs

Anticipated Analysis Outcomes

- Passive observations of CBRS emissions
- Longitudinal (over time) study of CBRS emissions and power at select locations within neighborhood distances of DPAs East 1 and West 14
  - Coordination sought to incorporate DPA state notifications to:
    - ❑ Analyze CBRS emissions based on DPA state
    - ❑ Quantify CBRS timeliness to respond to DPA activation and deactivation



Simulations for Task 1

Objective:

- Estimate the max 95th percentile aggregate emissions from CBSDs at protection points (inside DPA) and sensor locations (outside DPA)
  - Without DPA activation, i.e., emissions from neighbor list CBSDs
  - With DPA activation, i.e., emissions from keep list CBSDs

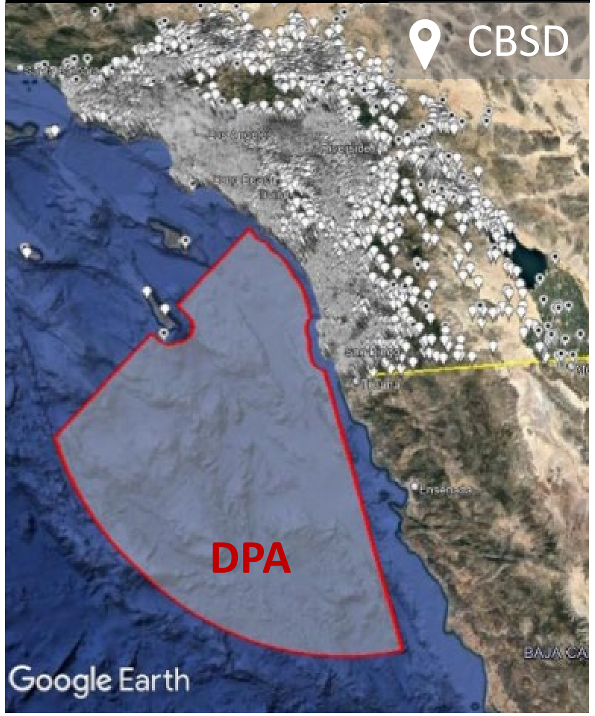
Assumptions:

- Simulated CBSD deployment using the NTIA OSM full deployment assumptions[2]
- ITM P2P propagation model
- WInnForum's reference DPA move list algorithm
- Reference receive antenna (*)
- Set of receive 2D antenna patterns/gains
- Projected noise floor of sensor system (290K, 5 dB NF)

2D Antenna	Peak Gain (dBi)	Elevation Beamwidth (degree)	Azimuth Beamwidth (degree)
Vertical polarized omnidirectional	9.03	11.02	360
Slant polarized omnidirectional	11.13	Slant +45: 11.92 Slant -45: 11.13	360
Panel antenna	17.18	6.02	90.80

2D Antenna Boresight	
Azimuth (degree)	Downtilt (degree)
0	0
20	0
0	10
120	6

San Diego (DPA West14)



CBSD Deployment	
Neighbor list size	19,501
Keep list size	10,529

Protection Criteria	
freqRangeMHz	3550-3650
protectionCritDbmPer10MHz	-144
refHeightMeters	50
antennaBeamwidthDeg	3
minAzimuthDeg	0
maxAzimuthDeg	360
catBNeighborhoodDistanceKm	192
catBOOBNeighborhoodDistanceKm	0
catANeighborhoodDistanceKm	150
catAOOBNeighborhoodDistanceKm	0

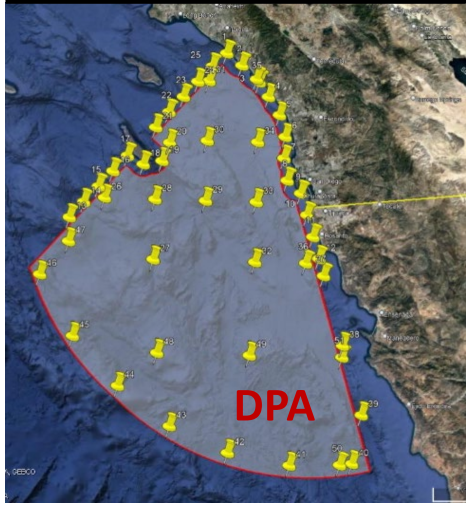
CBSD	Max EIRP (dBm/10MHz)	Height AGL (m)	Location
Cat A	26	[3, 60]	Indoor
Cat B	[40, 47]	[6, 100]	Outdoor

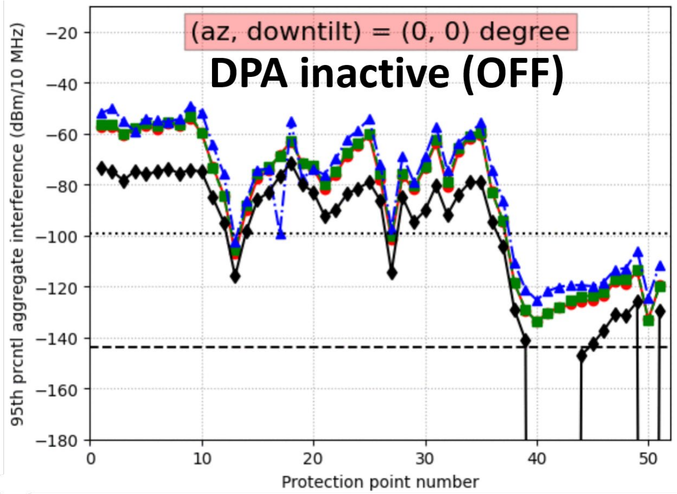
(*) reference receive antenna used in WINNF-TS-0112 V1.9.0 Antenna height set to 50m ASL for task 1B, and 2m AGL for 1C

[2] Deployment assumptions found in NTIA TR 15-517 & reflect the FCC authorized max power of CBSDs

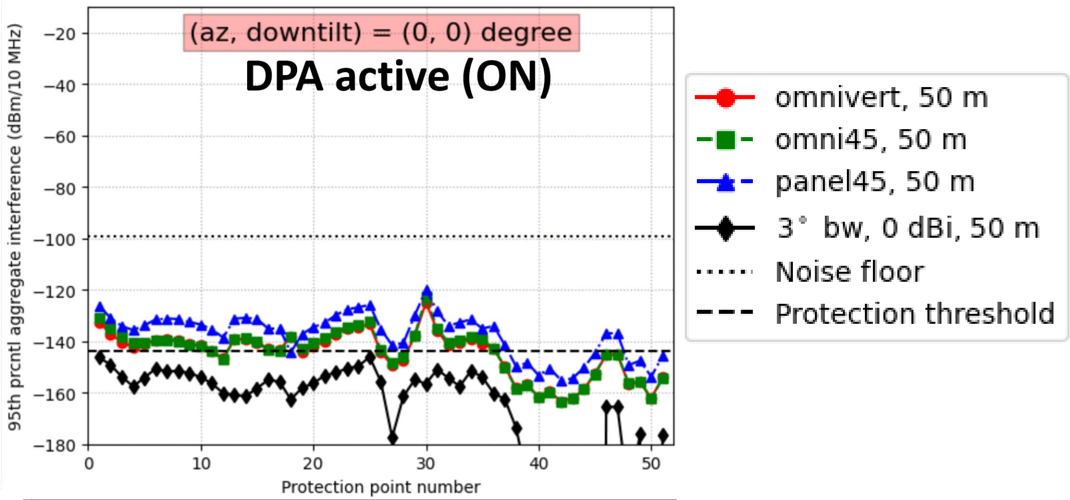
Simulation Results – West 14 / San Diego CA

DPA Protection points



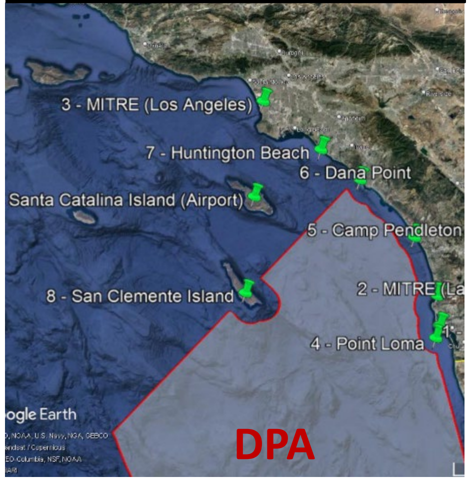


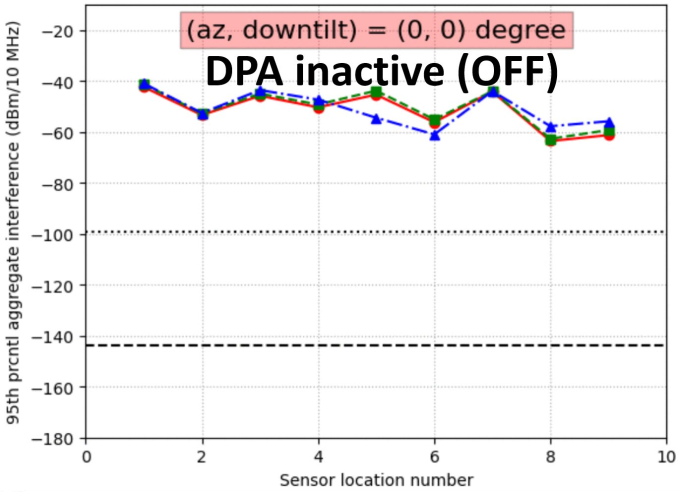
CBSD emissions are above the noise floor, except at a few points further out to sea



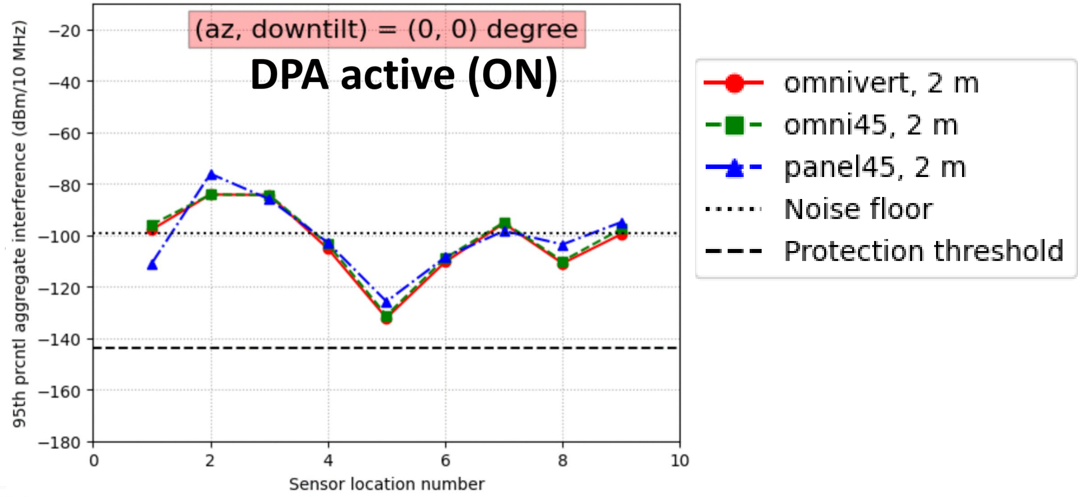
CBSD emissions stay below the noise floor for all protection points

Examples outside DPA





CBSD emissions at all example locations are above the sensor noise floor



CBSD emissions are above the sensor noise floor at some example sensor locations

Task 2

Task 2 – CBRS Emissions in the Always-on DPAs

- **Characterize aggregate CBRS emission levels over time in always-on DPAs.**
  - Obj 1: Collect data to provide insights into the Always-On Dynamic Protection Areas
  - Obj 2: Measure increase in noise floor due to deployment of CBRS systems over time

- **Not Doing:**
  - Obj 1: Adjudicate or attribute the protection threshold

- **Assumptions:**
  - Camp Pendleton is a representative always-on DPA
  - Sensors can be situated in locations informative to DoD stakeholders

- **Description:**
  - Longitudinal study measuring aggregate RF emissions in the CBRS band over several years.
  - Select one or multiple location(s) within the always-on DPA, informed by simulation and stakeholder interaction.

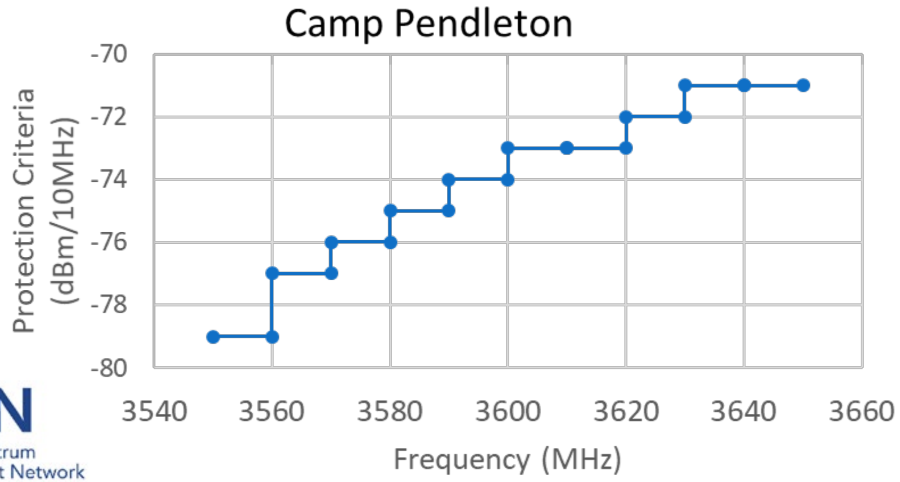
Task 2

Anticipated Analysis Outcomes:

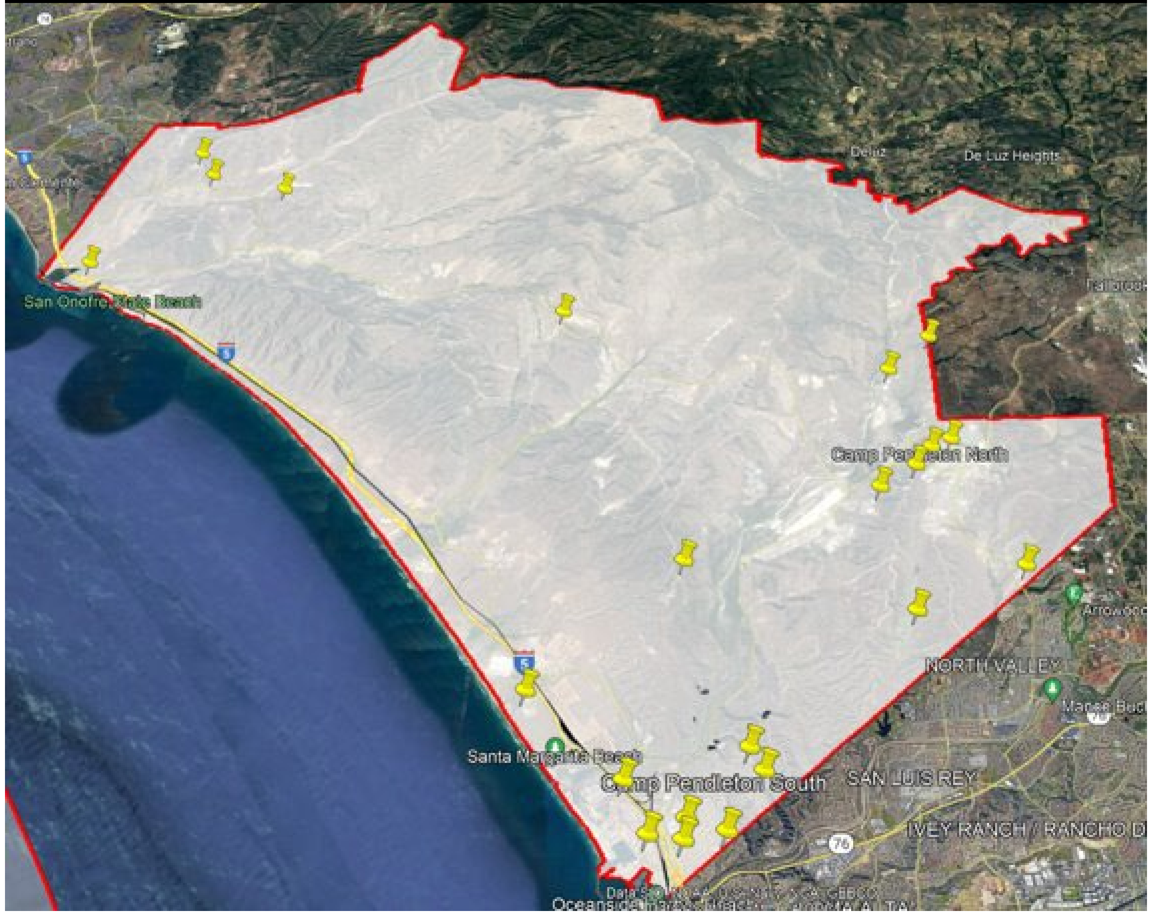
- Noise floor change over time
- Quantify CBRS aggregate emissions levels at a set of locations within the always-on DPA
- Collect data to provide insights into R2-IPM-05: SAS's shall manage CBSD aggregate interference levels for inland DPAs

DPA limits:

- Frequency: 3550 MHz – 3650 MHz
  - Licenses channelized to 10 MHz blocks
- Protection criteria varies by frequency:



Camp Pendleton: sites surveyed on recent field visit



Task 3

Task 3 – Evaluate ESC Performance in the Field

Objective: **Assess ESC detection (True/False-Positive and True/False-Negative rates) for a representative set of ESCs in the field.**

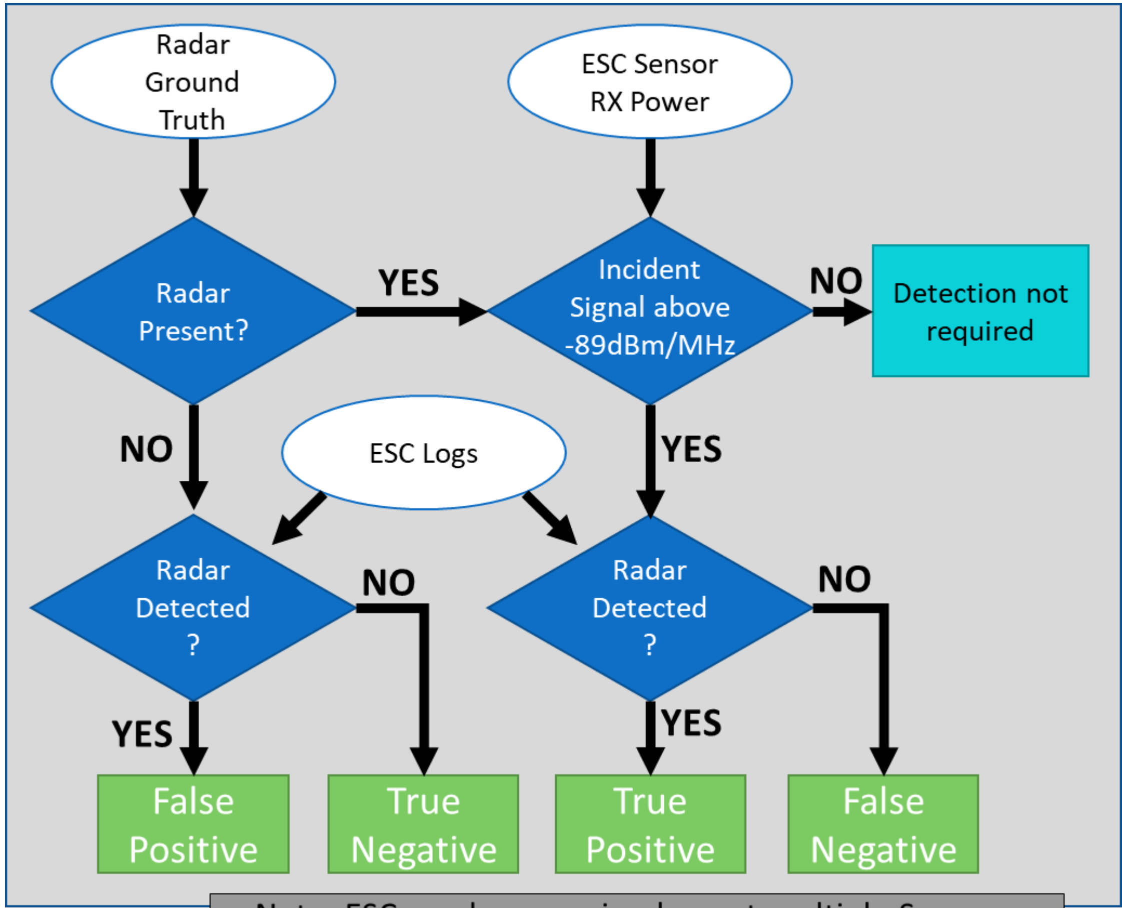
Not Doing: Adjudication or Attribution of results

Description:

- Independently verify CBRS band incident power levels at ESC sensor locations.
- Compare ground truth radar presence to CBRS stakeholder system key performance indicators (KPIs).

Anticipated Analysis Outcomes:

- True-Positive, False-Positive, True-Negative, False-Negative rates
- Potential bonus insights into:
  - Path loss models
  - ESC whisper zones



Note: ESC vendors may implement multiple Sensors. This assessment can be done holistically as well.

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Task 3 - Recommended Approach: Active Experiment

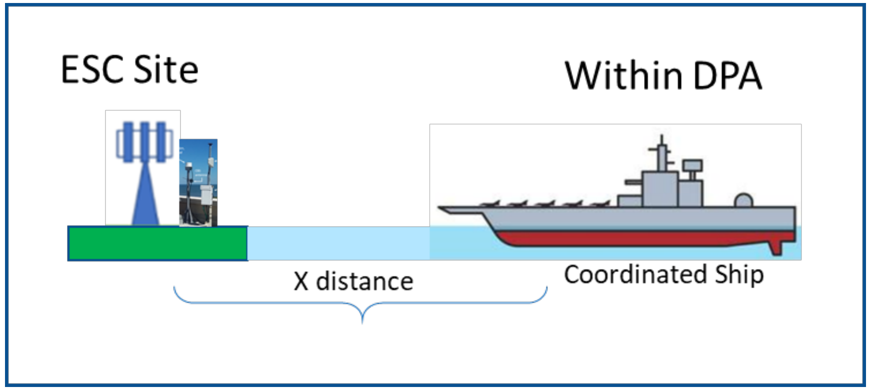
Concept: Coordinated in DPA "ground truth" incumbent with designed periods of radar activity and "quiet" times. Evaluate ESC performance using system key performance indicators. Independently verify incident power levels at ESC sensor locations.

Advantages:

- Known ground truth for radar presence – necessary to verify specified performance level
- Focused measurement campaign in a DPA
- Better control and more efficient data collection than passive observation
- Does not require developing and testing radar detection algorithms.
- Need to measure incident power levels.

Disadvantages:

- Mistakes have high opportunity cost
- High level of coordination with incumbent operators
- Potential for being highly disruptive to CBRS end users
- Shorter measurement campaign means less representative range of weather & propagation conditions — Could mitigate by repeating at different time of year



Sites: Investigate and select DPA for suitability of active experimentation

Summary

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

- NASCTN Test Framework has proposed a test approach under a set of assumptions that need to be verified to enable tractable measurements
- The team is working through the Test Plan Development Phase
- Two test plans will be generated, one for Tasks 1&2, another for Task 3

Test Plan

- The team will develop the Test Plans for this project, then hold another public briefing where they will be presented
- The draft Test Plans will be posted to the NASCTN website for review
  - Formal written comments may be submitted by anyone
- All comments and their adjudications will be posted to the NASCTN website along with the updated draft Test Plan

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