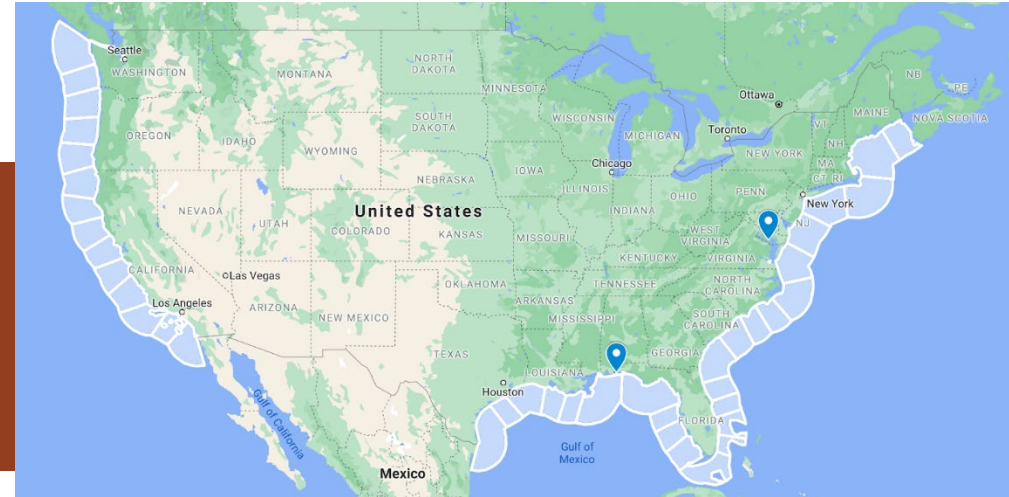


Methods of Sharing

WINNF-TR-1015
WINNF-RC-1016
IIC



Agenda

Types of Spectrum Sharing

- Reservation Time Sharing (Drones, UASs)
- Dynamic Sharing
 - Spectrum Access Systems (CBRS)
 - Incumbent Informing Capability (CBRS, Others)
 - Automated Frequency Coordination (6 GHz)

Environmental Sensing Capability (ESC) System

- Dynamic Protection Areas (DPA)
- SAS Requirements
- Impact Measurements
 - Single Exposure Population
 - Deployment Power
- Coexistence

Reservation Time Sharing

Drones and UASs may require spectrum for the duration of a flight

Similar to an authorization for flight (e.g. LAANC)

- May include an authorization for licensed (5G, mmWave) Spectrum Usage
- Example: From 2 minutes prior to flight until 5 minutes after completion of flight

Attend Day 3: The Wireless World of Drones and Beyond

What is an Environmental Sensing Capability (ESC) System

Terms

Dynamic Protection Areas (DPA)

- Protect incumbent users from harmful interference
 - e.g. Department of Defense (DOD) Radar Systems
- NOT exclusion zones

Environmental Sensing Capability (ESC) System

- Monitors a DPA for DOD Radar Activity
- Operate in 3550 to 3650 MHz band

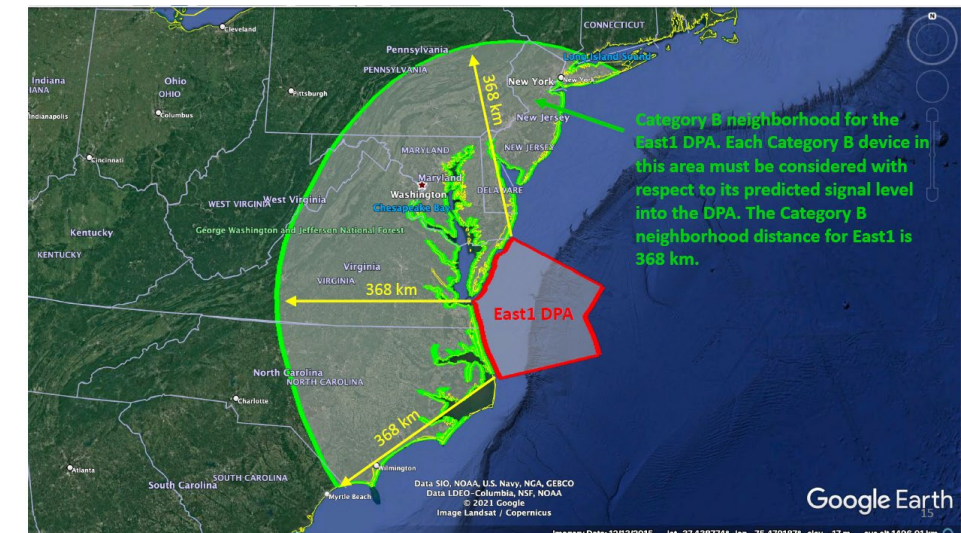
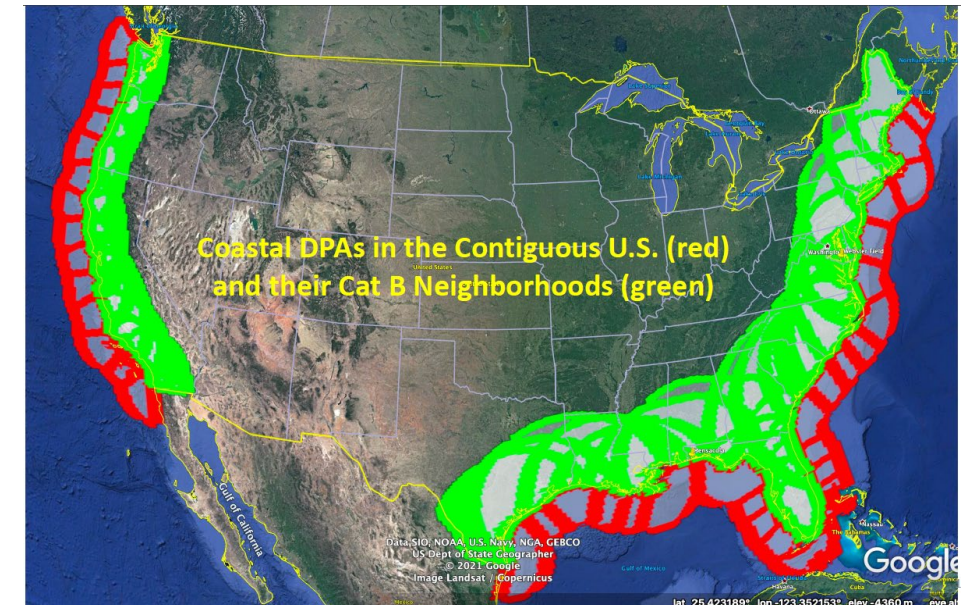
Spectrum Access System (SAS)

- Required to incorporate ESC sensor data
- Protect incumbent DOD radar systems
- Uses ESC locations and antenna characteristics when assigning spectrum

Citizens Broadband Radio Service (CBRS)

- 150 MHz of spectrum from 3550-3700MHz
- Citizens Broadband Radio Service Device (CBSD)

CBSDs must not interfere with ESC sensors



NTIA Matlab Model

National Telecommunications and Information Administration (NTIA)

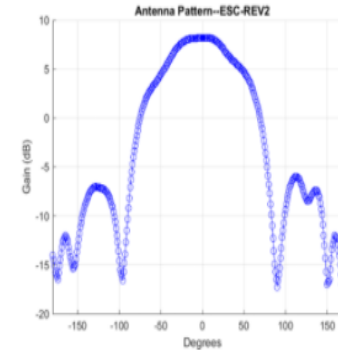
- Developed Matlab software
- Determining if a DPA is adequately covered by an ESC

Inputs

- Antenna pattern
- ESC site information

Output

- If DPA is adequately covered
- Within an expected statistical reliability
 - 70 km coastal zone 95% reliability
 - Further out 50% reliability

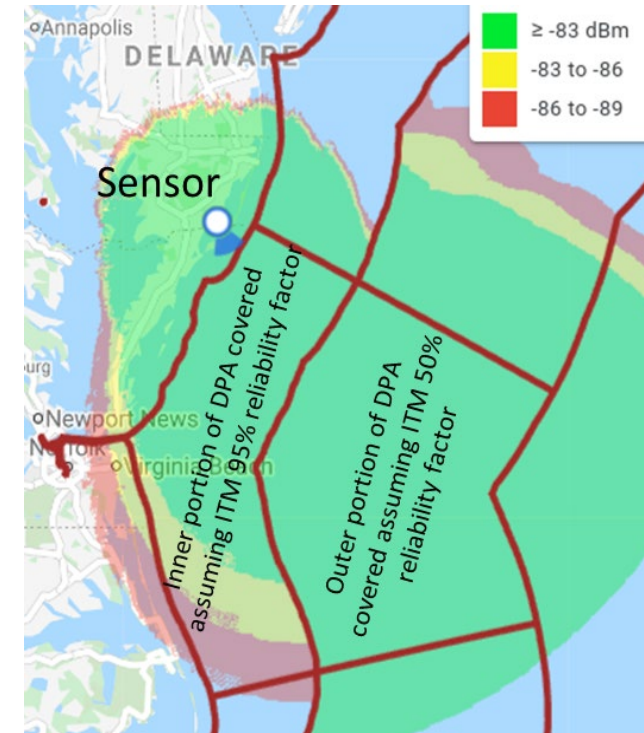


ESC Site Information

ESC Name	Latitude (DD)	Longitude (DD)	ESC Height (m)	Azimuth (deg)	Antenna Beam width (deg)	Antenna Gain (dBi)	Cable Loss (dB)	Antenna Name
ExampleESC1	36.92	-76	40	300	90	8	0	ESC-REV2

DPA Combo Logic

DPA Covered	Site Name 001	Site Name 002	Site Name 003
Norfolk	ExampleESC1		
East1	ExampleESC2	ExampleESC3	



A Bad ESC Network Design

Norfolk DPA with hypothetical ESC atop Cape Henry Lighthouse

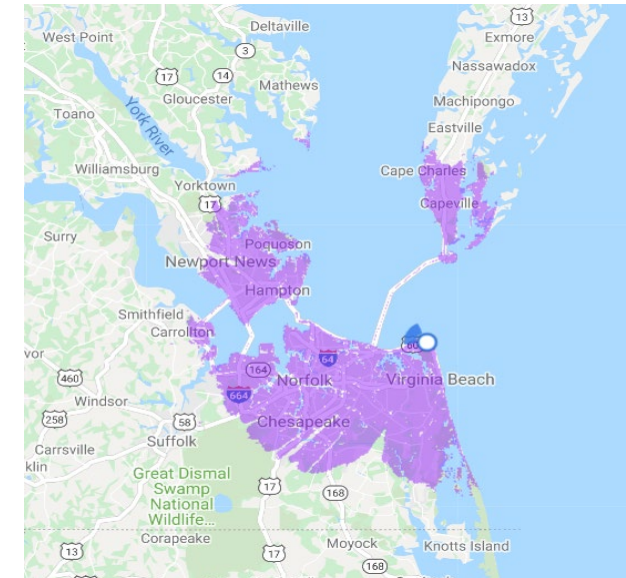
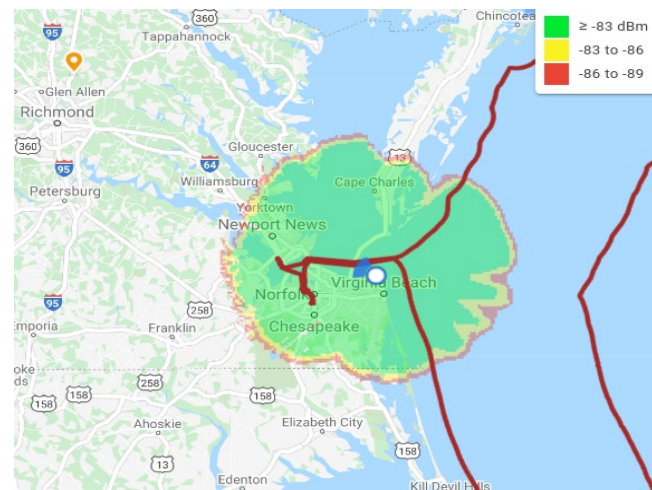
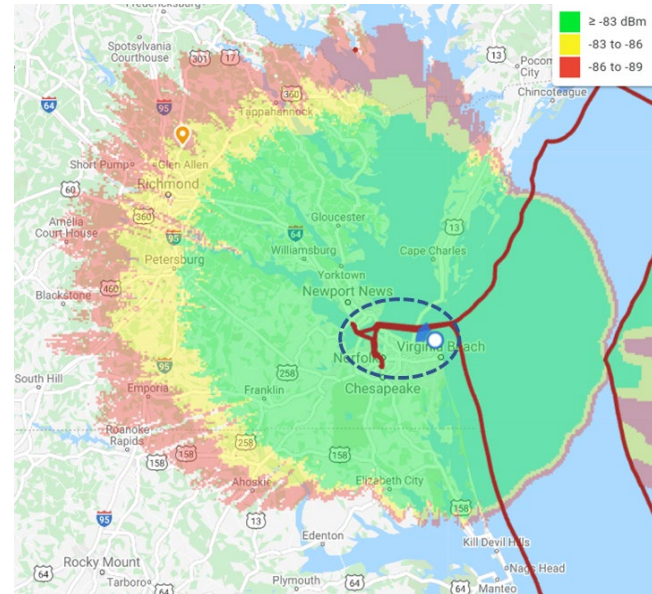
- 1.25M people impacted

Huge whisper zone

- Extends well beyond DPA
 - All the way to Richmond
- DPA is over-protected

50 dB of Attenuation

- DPA still protected
- Much smaller whisper zone



ESC Network Design



Problem

How to locate an ESC with minimal impact to CBRN CBSDs



Considerations

How to measure “impact”

How to validate impact

- Antenna pattern transmitted to SASs doesn't have to be the NTIA modeled pattern

ESC Impact Measurement

Methodology

Software

- Open source provided by Google
- Available on WinnForum's github

148 ESC Sensor Locations

- Covers all 48 coastal US DPAs
- Provided by multiple ESC sensor network providers
- Aggregated and anonymized

Two metrics considered

- Single Exposure Population Impact
- Deployment Power Impact

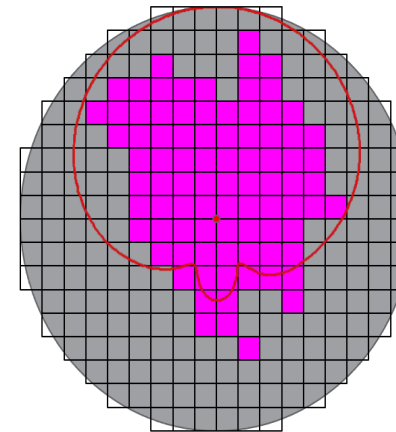
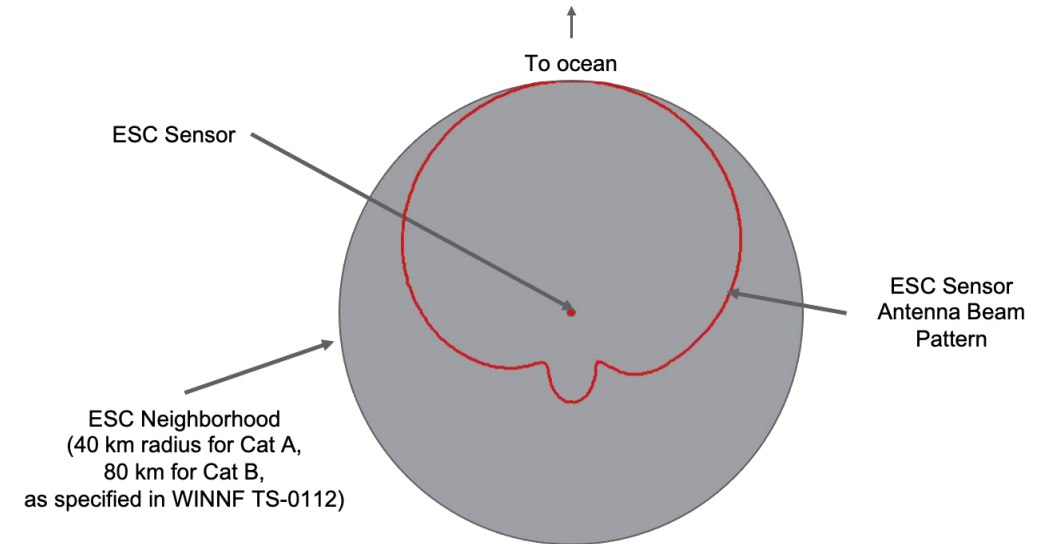
Single Exposure Population Impact

Methodology

- Point single CBSD directly at ESC sensor
 - At maximum power (EIRP)
- Find population that resides within area where ESC sensor is interfered with
- Sum all the impacted populations for all CBSD (pixel) locations without double counting overlapping populations

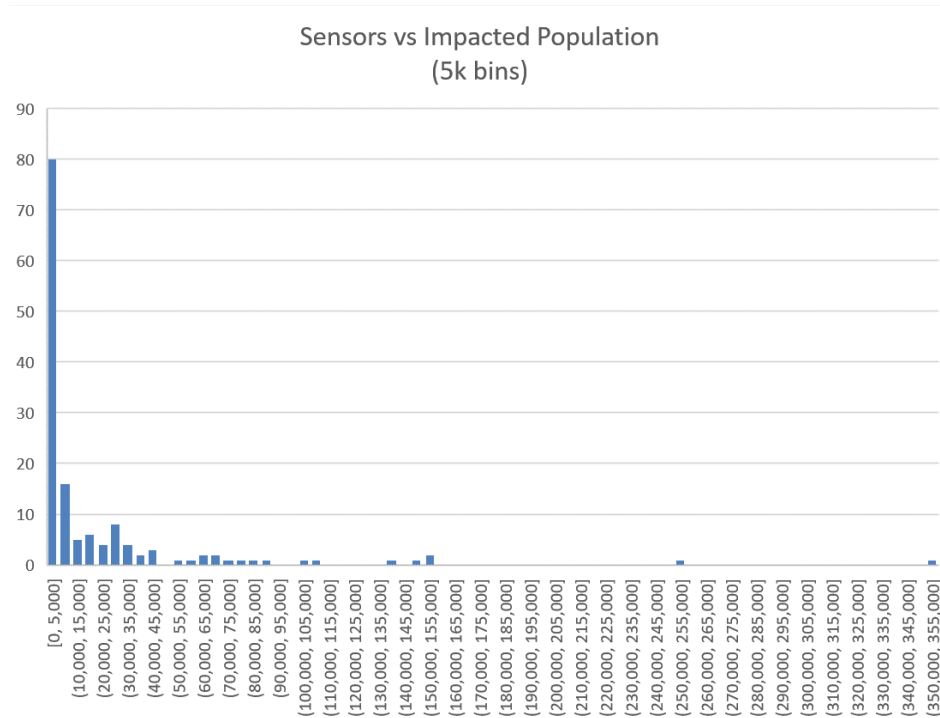
Caveats

- Considers a single CBSD at a time
 - Conservative
- A CBSD coverage area might extend into adjacent (unimpacted) populations

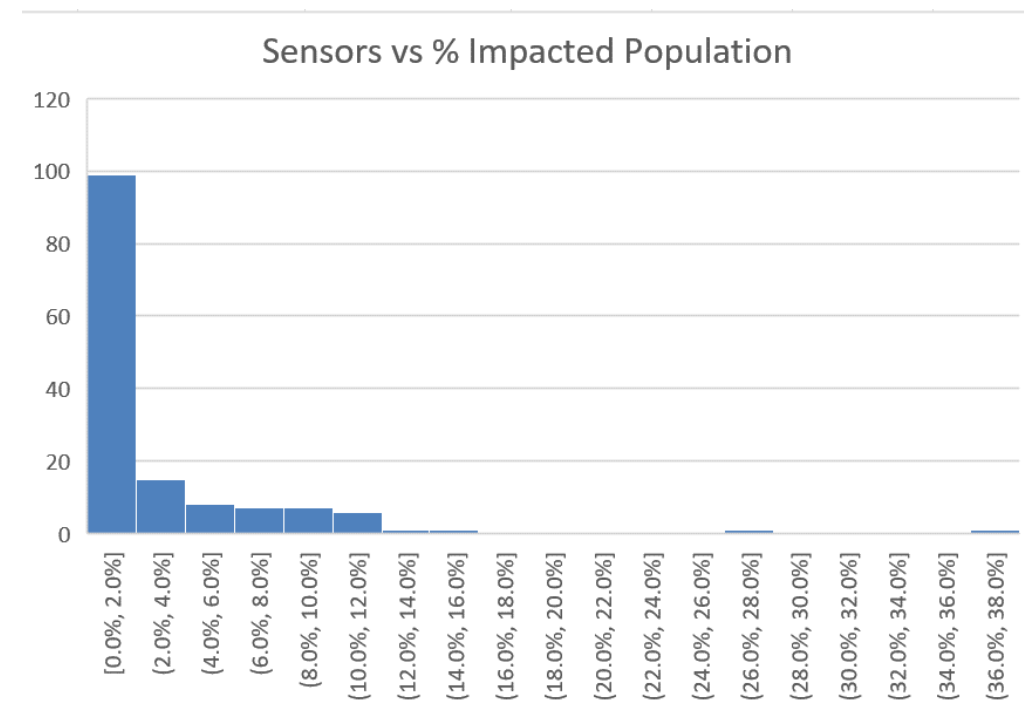


- Divide the ESC sensor neighborhood into pixels
- For each pixel in turn, place a CBSD at the center of the pixel, pointed directly at the ESC sensor
 - Assume a particular EIRP and antenna height for the CBSD
- Compute total path loss from the CBSD to the sensor, including propagation loss and the impact of the sensor's antenna pattern
- If the EIRP of the CBSD minus the total path loss exceeds the interference threshold of the ESC sensor, shade the pixel. Otherwise the pixel remains clear
- Repeat for all of the pixels in the ESC neighborhood, using only a single CBSD at a time (i.e., there is always only one CBSD within the ESC neighborhood)
- The totality of the shaded pixels is the single-exposure whisper zone for that sensor
 - The shape and extent of the whisper zone will depend on the ESC antenna pattern, the ESC antenna height, the local terrain, the CBSD height, and the CBSD EIRP
- Compute the sum of the population in the shaded pixels

Population Impact by Sensor



Sensors vs Population within 80km Impacted



Sensors vs % Population within 80km Impacted

146 sensors	Impacted Population	Total Population	Impact / Total Population
Network	2,645,709	74,751,160	3.5%
Min	0	12,444	0%
Max	353,271	13,846,585	37.6%
Average	21,223	2,277,758	2.7%
Std Dev	45,809	3,231,552	4.8%

Deployment Power Impact

Using CBSD deployment location info

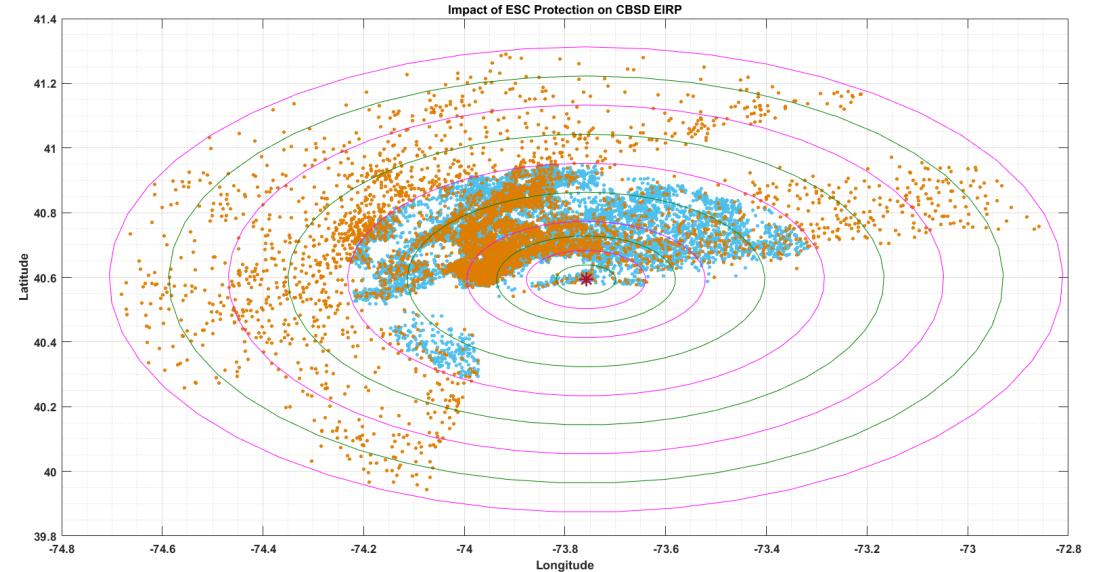
- Find number of CBSDs that must reduce transmit power

Uses NTIA deployment model

- Random population-weighted distribution
- per DPA basis and global US
 - We used per DPA basis

Caveats

- Maximum EIRP is conservative
- Some CBSDs may lower transmit power without affecting users
- Impact varies significantly with distance. Calculating over entire region might not be accurate
 - Adding per distance “rings” may mitigate



CBSD Power Reduction for 6 DPAs

6 DPAs

176 CBSDs

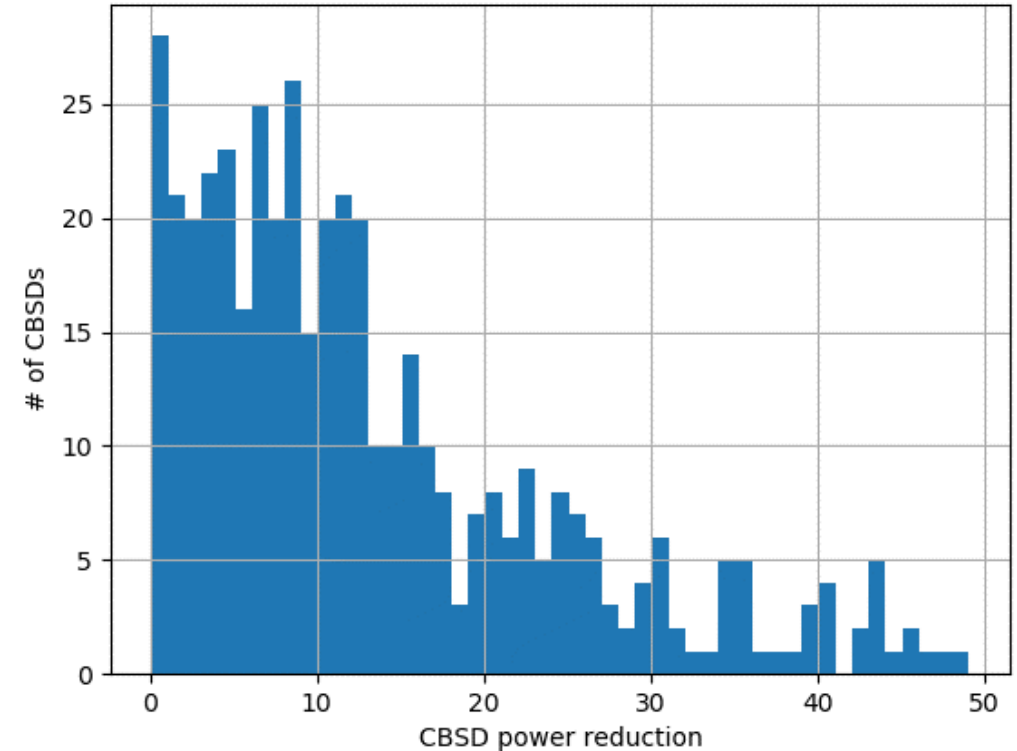
- NTIA Deployment Model

ESC Network Provider supplied sensor locations

- 23 sensors

Average 75 CBSDs affected per DPA

- 29 minimum
- 176 maximum



Impact of 3.45 GHz Service on ESCs

WINNF-RC-1016

Interference at Edge of Service Band

3.45 GHz Service May Render an ESC Sensor Inoperable

- Causes a false alarm
- SAS must treat this incumbent use

Spectrum

- 3.45 GHz: 3450 – 3550 MHz
- CBRS: 3550 – 3700 MHz
- ESC: 3550 - 3650 MHz
- NO guard band at 3550

Blocking Interference from 3.45 GHz

- Not out-of-band emissions

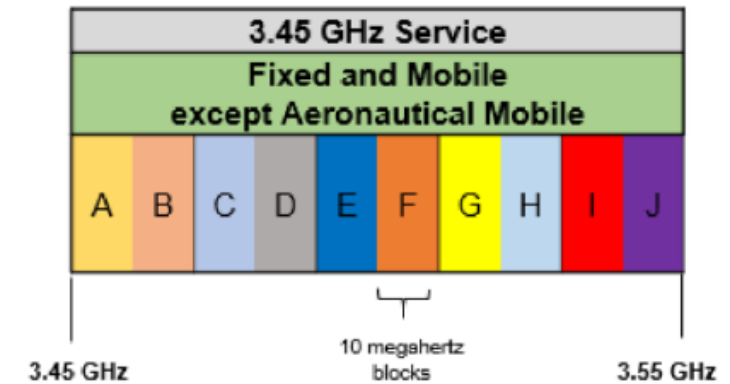


Figure 1: 3.45 GHz Service channel plan (source: FCC)

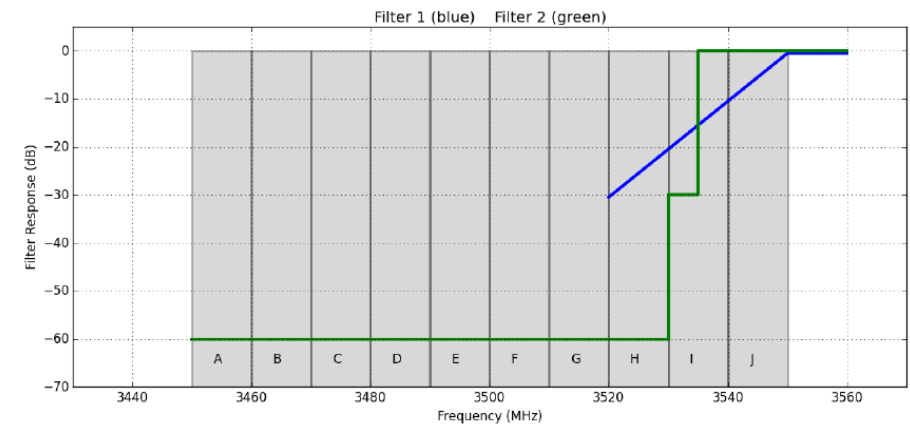


Figure 2: Filters 1 and 2 overlaid on the 3.45 GHz Service channel plan.

Incumbent Informing Capability (IIC)



Proposed by NTIA Dec 2020

- [NTIA report 2/2021](#)

Time- and Location-based

Implemented in ESC sensor networks located in American Samoa