Coexistence between the 3.45 GHz Service and Environmental Sensing Capability Sensors in the 3.5 GHz Citizens Broadband Radio Service

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Preface

This document contains recommendations for ESC Operators and 3.45 GHz Service licensees (and potential licensees) to help facilitate co-existence between ESC sensors in the 3550-3650 MHz band and 3.45 GHz Service operations in the 3450-3550 MHz band.

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1 Introduction

Environmental Sensing Capability (ESC) is the primary method used in the Citizens Broadband Radio Service (CBRS) to protect federal government incumbent radars. ESC sensor networks, located in coastal areas, detect incumbent shipborne radar activity and alert a Spectrum Access System (SAS) so that the SAS can reconfigure devices in the band to avoid causing harmful interference to the federal radars. ESCs utilize receive-only sensors that listen for incumbent activity in the 3550-3650 MHz portion of the CBRS band. This band segment is directly adjacent to the 3450-3550 MHz band that has been designated for use by the 3.45 GHz Service. Because there is no guard band between the two, the ability of ESC sensors to adequately perform their sensing functions could be impacted by strong signals from systems operating in the 3.45 GHz Service. The dominant predicted impact is from blocking interference from 3.45 GHz Service fundamental emissions in the 3450-3550 MHz band, and not out-of-band emissions from 3.45 GHz Service signals present in the ESC sensor band.

3.45 GHz Service interference does not impact the calculation of CBRS Whisper Zones,[1] but rather 3.45 GHz Service interference can render an ESC sensor inoperable, causing a false activation of incumbent radar activity.

This document is an extension of a previous WInnForum report on the impact of in-band CBRS signals on ESC sensors (WINNF-TR-1015). The reader is strongly encouraged to refer to that document for necessary background information before reading this document.

2 Regulatory Basis

There are no CBRS or 3.45 GHz Service rules that require coordination between ESC and 3.45 GHz Service licensees[2]. However, the FCC notes in the text of the Report & Order:

> We expect 3.45 GHz Service licensees and Citizens Broadband Radio Service licensees, Spectrum Access Systems, and ESCs to work together to ensure coexistence among systems at the edge of the band. Because the reliable operation of ESCs is essential to enabling spectrum access for licensees of the Citizens Broadband Radio Service, ESCs are subject to protection from harmful interference from adjacent-channel operations as licensee operations. Harmful

[1] WInnForum, "ESC Sensor Impact Technical Report (WINNF-TR-1015-V1.0.0)", https://winnf.memberclicks.net/assets/work_products/Reports/WINNF-TR-1015-V1.0.0%20ESC%20Sensor%20Impact%20Technical%20Report.pdf

[2] Note: 3.45 GHz Service licensee includes potential licensees that have registered with the FCC to participate in the 3.45 GHz Service spectrum auction.

interference caused to ESC operations will be considered harmful interference to a primary service under our rules and dealt with accordingly. [3.45 GHz Order at para. 74]

3 Recommendations

The Wireless Innovation Forum recommends that:

1. A 3.45 GHz Service licensee contact ESC Operators prior to network design and deployment and request technical details of ESC sensors that require protection. The contact email for all ESC Operators is esc-operators@googlegroups.com.
2. Each ESC Operator that desires to suppress interference from the 3.45 GHz Service operations furnish to a 3.45 GHz Service licensee upon request all technical details of their ESC sensors that require protection, including antenna location, height, pointing direction, and effective pattern (as defined in WInnForum TS-0112, requirement R2-ESC-07(b))[3].
3. For any proposed 3.45 GHz Service base station within 150 km of any ESC sensor, the 3.45 GHz Service licensee predict the fundamental (3.45-3.55 GHz) signal strength from the base station as received by the ESC sensor, and if the predicted signal strength of any 3.45 GHz Service carrier exceeds -129 dBm/MHz RMS, the 3.45 GHz Service licensee contact the ESC Operator for coordination[4].
    a. The 3.45 GHz Service licensee use the NTIA ITS Irregular Terrain Model (ITM) propagation model as described in Wireless Innovation Forum Technical Specification TS-0112, requirements R2-SGN-05, -07, -09, -10, and -17.
    b. The 3.45 GHz Service base station antenna gain in the direction of the ESC sensor, and the ESC sensor antenna gain in the direction of the 3.45 GHz transmitter, be taken into account.
    c. When calculating the predicted signal strength, the 3.45 GHz licensee take into account an ESC receive filter that has 0.5 dB of attenuation at 3.55 GHz and reduces linearly at 1 dB per MHz below 3.55 GHz, down to -60.5 dB at and below 3.49 GHz.
4. If an ESC sensor receives suspected interference from 3.45 GHz Service operations, the ESC Operator contact 3.45 GHz Service licensees that operate in the area to help rectify the situation.
    a. The ESC Operator determine to the best of its ability the characteristics (frequency, location, etc.) of the signal(s) suspected of causing the interference before contacting a 3.45 GHz Service licensee.

[3] "CBRS Operational and Functional Requirements", https://winnf.memberclicks.net/assets/CBRS/WINNF-TS-0112.pdf

[4] -129 dBm/MHz corresponds to the -109 dBm/MHz protection criterion required for ESC sensors including 20 dB margin to account for aggregate interference and propagation prediction uncertainty

   b. In the case of suspected interference, the ESC Operator can request that 3.45 GHz Service licensees conduct the analysis of step (3) out to distances greater than 150 km.
5. ESC Operators and 3.45 GHz Service licensees negotiate in good faith when coordinating operations or when rectifying suspected cases of interference.
6. ESC Operators and 3.45 GHz Service licensees agree on methods to protect the confidentiality of each other's data.

The following recommendations are made to the National Telecommunications and Information Administration (NTIA) and the Department of Defense (DoD):

7. NTIA and DoD work with industry to rapidly develop and deploy an efficient Informing Incumbent Capability (IIC) system in CBRS and 3.45 GHz bands[5].
8. ESC not be used to detect radar systems that require protection from the 3.45 GHz Service.

Technical details that demonstrate the need for these recommendations are included in the Annexes.

[5] 3.45 GHz R&O, Paragraph 41

Annex A: Technical Characteristics of ESC Sensors Relevant to Coexistence with 3.45 GHz Service

- Band of operation: 3550 - 3650 MHz (receive only)
- Sensor locations: Proprietary. Site locations and coverage characteristics require prior approval by FCC, which typically takes a few weeks to months to obtain.
- Sensor antenna characteristics: Site-specific. Generally ocean-facing with as little gain toward populated areas as possible, but subject to coastal geometry, siting limitations, antenna performance, etc.
- Aggregate interference criterion: -109 dBm/MHz RMS (established by NTIA certification)
- Assumed receive filter characteristics
    - Filter 1
        - Based on application of WInnForum Standard for filtering above 3650 MHz. There is no WInnForum standard for filtering below 3550 MHz as there was no 3.45 GHz Service planned before ESC standardization, development, and certification.
        - 0.5 dB in-band attenuation
        - 3520-3550 MHz: Falloff at 1 dB per MHz below 3550 MHz, reaching 30.5 dB attenuation at 3520 MHz
        - Below 3520 MHz: Unspecified (WInnForum standard does not go beyond 30 MHz out-of-band)
    - Filter 2
        - Patterned after 4 GHz fixed-satellite service filter for coexistence with 3.7 GHz Service
        - 0 dB in-band attenuation
        - 3535 - 3550 MHz: 0 dB attenuation
        - 3530 - 3535 MHz: 30 dB attenuation
        - Below 3530 MHz: 60 dB attenuation

Annex B: Technical Characteristics of the 3.45 GHz Service Relevant to ESC Sensor Protections

- Band of operation: 3450-3550 MHz
- Maximum EIRP
  - Non-rural areas: 1640 W/MHz (62.15 dBm/MHz)
  - Rural areas: 3280 W/MHz (65.16 dBm/MHz)
- License Area
  - Partial Economic Areas
- Channel Plan
  - 10 MHz unpaired blocks

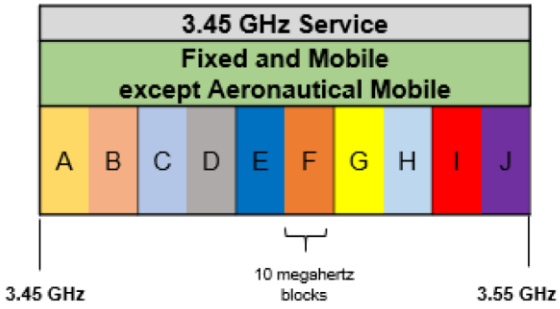

Figure 1: 3.45 GHz Service channel plan (source: FCC)

Annex C: Interference Impact Simulation

The treatment of potential interference from signals below 3550 MHz is treated identically to the standardized method used by SAS to calculate potential aggregate interference from CBRS transmitters operating outside the upper edge of the ESC passband. That method is detailed in TS-0112 (Requirement R2-SGN-25), quoted here:

A. SASs shall manage CBRS interference for all ESC sensors that require protection such that the aggregate mean interference at the reference ESC filter output of the protected sensor in 3550-3700 MHz does not exceed -109 dBm/MHz. The reference ESC filter has 0.5 dB insertion loss in the passband.
B. For initial certification, the SAS shall treat Category B CBSDs operating within the frequency range 3650-3680 MHz, and Category A CBSDs operating within the frequency range 3650-3660 MHz, as co-channel to ESCs and apply the same protection described above, after assuming a straight line 1 dB per MHz ESC reference filter roll-off from 3650-3680 MHz.

Effectively, strong adjacent band interference is treated as blocking interference, because there is no guard band between the edge of the ESC receiving band and emissions from potentially strong signals in the immediately adjacent band. The impact is from the fundamental emissions of the 3.45 GHz Service within the 3.45 GHz band, not from out-of-band emissions from the 3.45 GHz Service leaking into the CBRS band. Such computations of blocking interference into sensitive receivers are mandated by the FCC in other situations, such as CBRS into in-band and adjacent-band FSS receivers, and 3.7 GHz Service into in-band and adjacent-band FSS receivers.

Note that (B) assumes Filter 1 from section (2). In this Recommendation, analyses are performed using both filters. The following plot shows the filter curves overlaid on the 3.45 GHz Service channel plan.

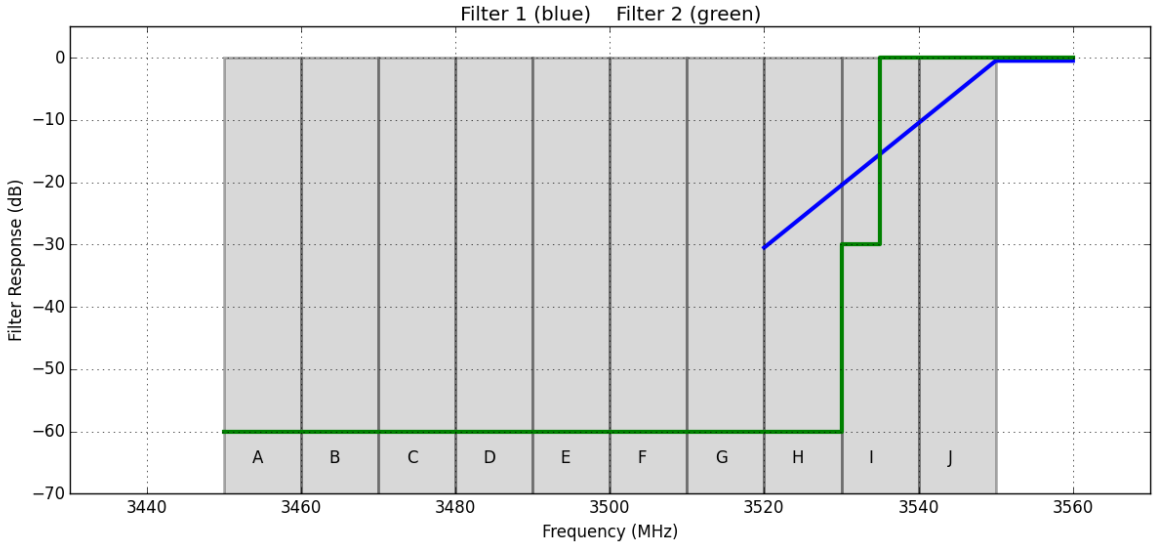

Figure 2: Filters 1 and 2 overlaid on the 3.45 GHz Service channel plan.

For demonstrating potential impact from 3.45 GHz Service transmitters, the methodology of (B) is applied. Because of the potential high-power operation, 3.45 GHz Service transmitters are treated the same as Category B CBSDs, so their impact up to 30 MHz below the ESC sensor band edge is considered. Because 3.45 GHz Service transmitters can have up to 28 dB greater EIRP than Category B CBSDs, it would be reasonable to consider their impact farther away than 30 MHz.

Table 1 shows the selectivity of the two filters to each of the defined 3.45 GHz Service channels. The values are computed by integrating the filter curves (in the linear domain) over the frequency range of the specific channel(s) and converting the result back into logarithmic units. Because a 3.45 GHz Service licensee can use channels wider than 10 MHz, selectivity to 20 MHz (I+J), 30 MHz (H+I+J), and 40 MHz (G+H+I+J) channels are included. As can be discerned from the table, assuming uniform received power spectral density, once channels I and J are both occupied, adding additional channels lower in frequency makes no appreciable difference to received interference power, for either filter profile. That is, if an ESC sensor is receiving a 20 MHz bandwidth signal from a particular base station that is using channels I and J, if that same base station expands its bandwidth wider than 20 MHz by adding channels H or below, using the same transmitted power spectral density, no appreciable additional interference occurs to the ESC sensor. However, this does not mean that a base station operating on a channel that is not I or J cannot interfere. For example, a base station that does not operate on channels that are not I or J, but is located very close to an ESC sensor, could cause interference.

Table 1: Selectivity of the two filters to each of the defined 3.45 GHz Service channels

Channel(s)	Bandwidth (MHz)	Filter 1 Selectivity (dB)	Filter 1 Relative Power Throughput* (dB)	Filter 2 Selectivity (dB)	Filter 2 Relative Power Throughput* (dB)
A - G	10	Better than -30.5	Less than -30.5	-60	-60
H	10	-24.6	-24.6	-60	-60
I	10	-14.6	-14.6	-3	-3
J	10	-4.6	-4.6	0	0
I+J	20	-7.2	-4.2	-1.2	+1.8
H+I+J	30	-8.9	-4.2	-3	1.8
G+H+I+J	40	-10.2	-4.2	-4.3	1.8

* Relative to a 10 MHz channel with no filtering. Includes the effect of both the filter and the total transmitted power (i.e., 20 MHz bandwidth would have twice the total transmitted power of a 10 MHz channel). Effectively equals filter selectivity + $10*\log_{10}$(number of channels).

Annex D: Example Whisper Zone Maps

The filter 1 characteristics provided in Annex A are applied to 3.45 GHz Service transmissions, and whisper zones maps are created by the methodology in Annex A of WINNF-TR-1015. The reader is referred to Annex A of WINNF-TR-1015 for further details on the analysis methodology employed.

For example, if a 3.45 GHz Service transmitter is using a 20 MHz bandwidth employing channels I and J, at a transmit EIRP of 2000 W in the direction of an ESC sensor, then application of the filter selectivities in the table equates to filtered EIRP in the direction of the ESC sensor of 2000 W - 7.2 dB (= 381 W) for Filter 1, and 2000 W - 1.2 dB (= 1517 W) for Filter 2. Otherwise, these powers are treated as in-band interference and the Annex A methodology is applied.

The following sample maps show whisper zones using the following assumptions:

- Filter 1
- 30 MHz bandwidth 3.45 GHz transmission, channels H + I + J
- Tx EIRP max allowed (i.e., 1640 W/MHz non-rural and 3280 W/MHz rural), as well as 10 dB below.
- 25 m transmitter antenna height
- Actual characteristics of ESC sensors (locations, heights, antenna patterns, etc.)
- ESC sensor characteristics as of June 1, 2021

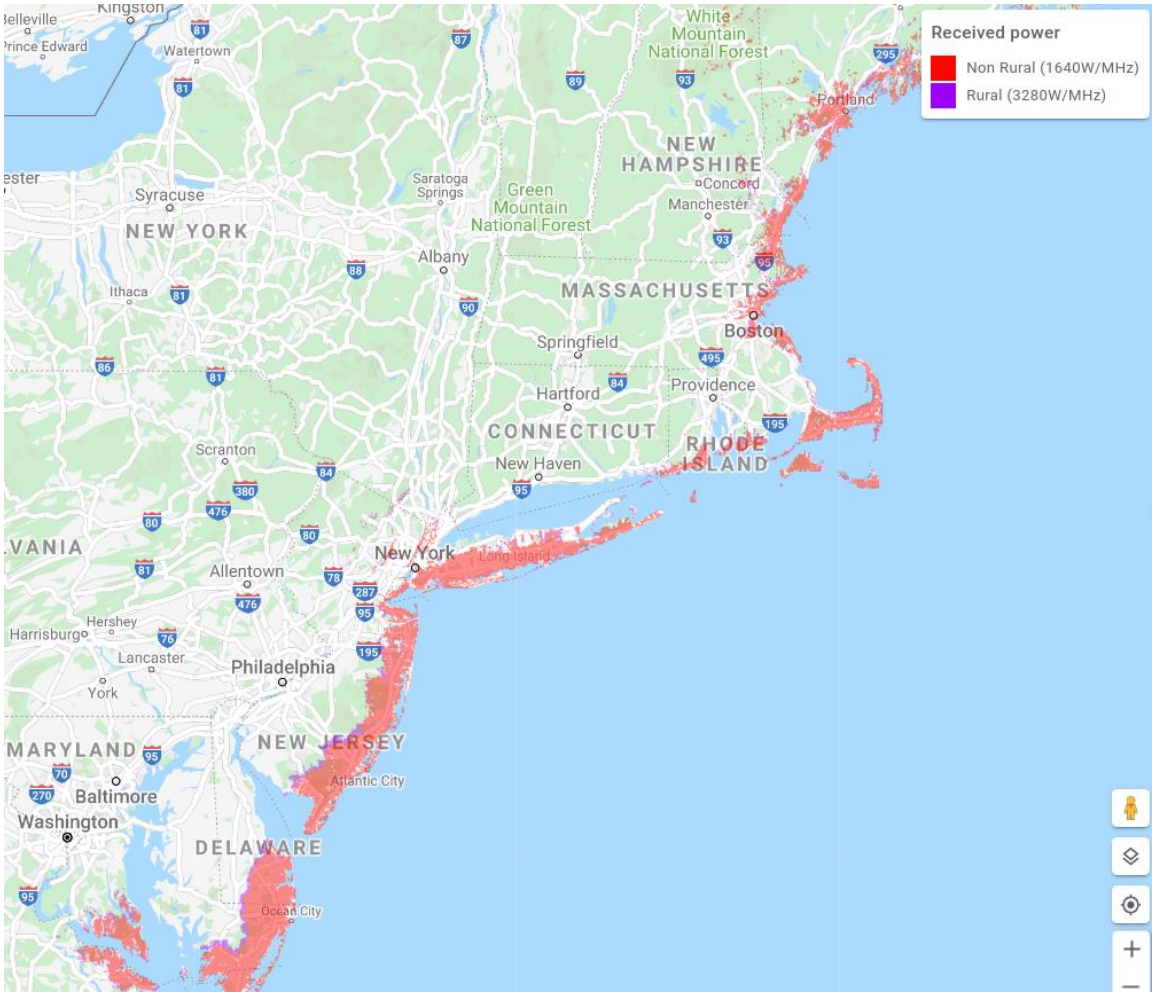

Figure 3: 3.45 GHz Service whisper zones for 30 MHz (3420-3450 MHz) 3.45 GHz Service carrier in the Northeast region, at max allowed EIRP.

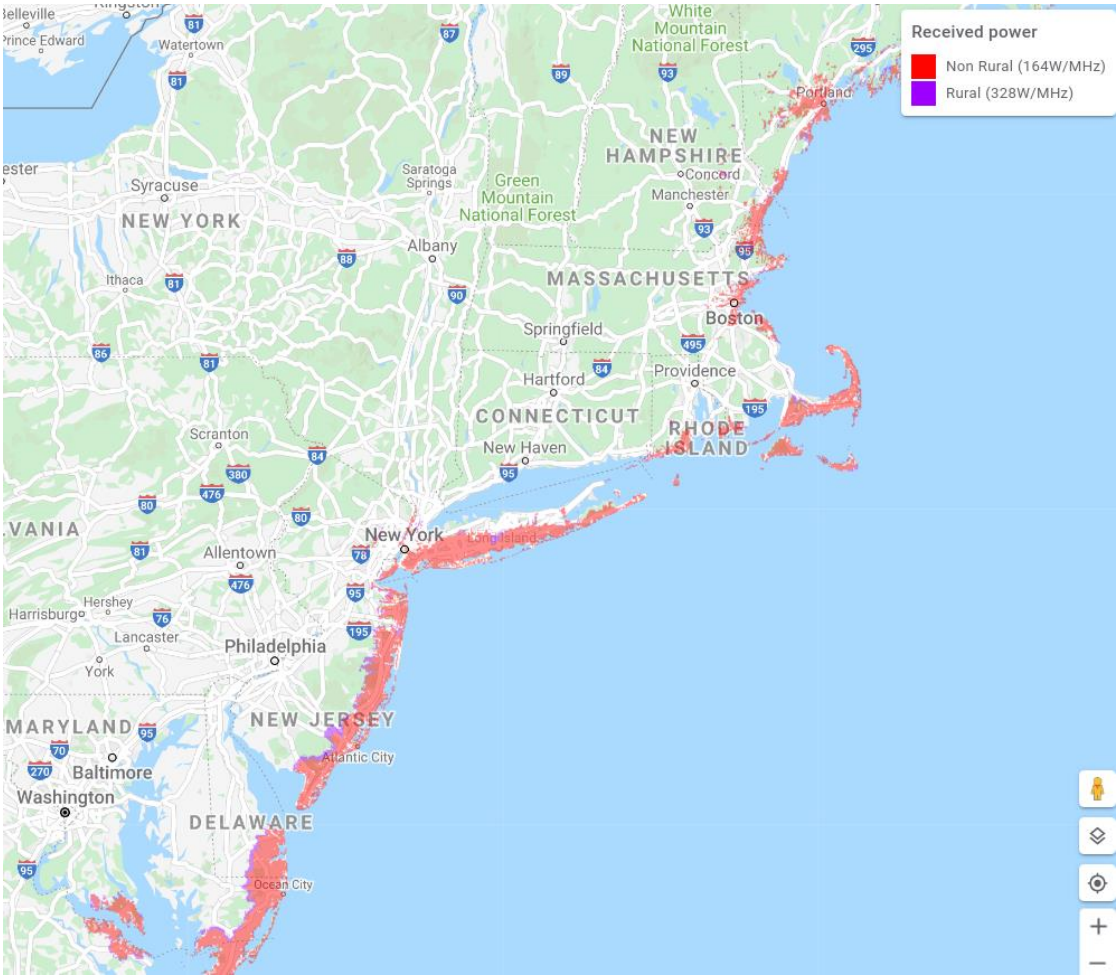

Figure 4: Same as Figure 3, using 10 dB lower transmit EIRP.