+-Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	
Facilitating Shared Use in the 3100-3550 MHz Band	WT Docket No. 19-348
3.5 GHz SAS and ESC Applications	GN Docket No. 15-319

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INTRODUCTION AND SUMMARY

With the Commission's freeing of substantial mid-band spectrum for commercial services over the last several years, industry is now occupied with putting that spectrum to use. Making additional mid-band spectrum available remains extremely important for long-term success in 5G, but there is no immediate crisis. Setting the right rules for the 3.45-3.55 GHz band (3.45 GHz Service) is of utmost importance.[1]

To that end, Commission decisions should leverage learnings from the Citizens Broadband Radio Service (CBRS) and from practical implementation of the 3.7-3.98 GHz Band (3.7 GHz Service). Notably, similar to CBRS, the Department of Defense (DoD) will continue to use and share 3.45-3.55 GHz frequencies with other services. While the *Further Notice* shows a preference for extending rules for the 3.7 GHz Service to the 3.45 GHz band,[2] this and other similarities suggest the Commission should

[1] *See In the Matter of Facilitating Shared Use in the 3100-3550 MHz Band*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 11078 (2020) (*Further Notice*).
[2] *Id.* ¶ 38.

consider applying parts of the CBRS rules to the 3.45 GHz Service. In particular, the Commission should examine the functional, operational, and interface standards of the Wireless Innovation Forum (WInnForum) multistakeholder group, leverage dynamic spectrum availability technologies, provide robust information about actual frequency availability prior to any spectrum auction, and maximize efficiency by incorporating use-or-share principles. The Commission also should adopt the incumbent-informing capability (IIC) framework for the 3.45 GHz Service and extend it to the CBRS band to remedy spectrum waste caused by the current Environmental Sensing Capability (ESC) regime.

It also is vital to protect, not endanger, the substantial progress already made toward freeing mid-band spectrum for 5G. The Commission should have a holistic view of mid-band spectrum that accounts for coexistence issues that can crop up at the edges of the CBRS band. Higher permitted power levels in the 3.45 GHz Service could harm operations in the adjacent CBRS band, an especially troubling outcome after more than $4.5 billion was spent on licenses in the recent CBRS auction and millions more have been invested in General Authorized Access (GAA) deployments.[3] Furthermore, under certain conditions, harmful interference from CBRS into the 3.45 GHz Service could occur. Proper rules will recognize these technical challenges at the shared band edges.

[3] *See Auction of Priority Access Licenses in the 3550-3650 MHz Band Closes*, Public Notice, 35 FCC Rcd 9287 (2020) (noting that the CBRS auction "raised a total of $4,543,232,339 in net bids ($4,585,663,345 in gross bids)").

Unlike the CBRS/3.7 GHz Service boundaries, no guard band exists between 3.45 GHz Service operations and CBRS ESC sensors that at present are required to operate in the 3.55-3.65 GHz band. Advance coordination with ESC Operators is critical to avoid situations in which 3.45 GHz transmitters block the ability of ESC networks to detect DoD radars, which in turn would require widespread activations of Dynamic Protection Area (DPA) neighborhoods that shut down CBRS services. Similarly, the Commission should ensure that relocation plans for federal radars in the 3.45-3.55 GHz band do not negatively impact CBRS.

I. ADDITIONAL INFORMATION IS NEEDED BEFORE OPTIMAL REGULATORY PARAMETERS FOR THE 3.45 GHz SERVICE CAN BE SET

Over the past several years, the Commission has rightly prioritized freeing spectrum to fuel the nation's 5G transition. As a result, large quantities of spectrum critical for next-generation deployments are in the process of being deployed or are in the pipeline. For instance, winners of Priority Area Licenses (PALs) in the recent CBRS spectrum auction await Commission notices regarding the status of their applications.[4] Meanwhile, Spectrum Access System (SAS) administrators are already enabling use of 150 megahertz of GAA tier spectrum in the CBRS band that became available early this year.[5] The Commission just announced the 57 bidders qualified to participate in the

[4] *See id.* ¶¶ 39-40.
[5] *See*, *e.g., Further Notice* ¶ 1 (noting that commercial deployments for General Authorized Access spectrum across the full 150 megahertz began in early 2020).

auction of 3.7-3.98 GHz band spectrum.[6] Together, this represents 430 MHz of prime mid-band spectrum. Wireless stakeholders are focusing significant economic and technical resources on these new mid-band spectrum opportunities, which are ample to meet early demand for dedicated mid-band 5G frequencies. This gives the Commission enough breathing room so that it can carefully and deliberately craft the 3.45 GHz Service rules.

A. Alignment with 3.7 GHz Rules

The *Further Notice* proposes adopting "service, technical, and competitive bidding rules for flexible use licensees" in the 3.45 GHz Service that would "largely align with the 3.7 GHz band rules."[7] This determination is premature. The 3.7 GHz auction is looming, and the relocation of band incumbents pending. Because the 3.7 GHz rules' performance has not been proved in a real-world environment, no experience points to those rules being the right model for the 3.45 GHz band. As discussed below, recent experience in the CBRS band shows that issues with the design of technical rules may not come to light until spectrum becomes operational. As the technical complexity surrounding the mid-band spectrum environment increases, it would be prudent for the Commission to leverage actual experience with CBRS and the 3.7 GHz Service in its 3.45 GHz Service rules.

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[6] *See* Public Notice, *Auction of Flexible-Use Service Licenses in the 3.7-3.98 GHz Band; 57 Applicants Qualified to Bid in Auction 107*, AU Docket No. 20-25, DA 20-1333 (rel. Nov. 12, 2020).
[7] *Further Notice* ¶ 38.

Reliance on the 3.7 GHz Service rules also presupposes similar uses for the 3.45 GHz band. This could prejudice industry and consumers by excluding some potential providers. For instance, the *Further Notice* proposes to issue "licenses on a Partial Economic Area (PEA) basis" as in the 3.7 GHz service.[8] But license areas that are too large reduce interest by smaller entities and price them out of the band. This would be very unfortunate in light of the record number of bidders in the recent county-based CBRS auction.[9] Smaller license sizes for 3.45 GHz Service spectrum also could attract qualified, non-traditional auction participants like "[u]tilities, rural service providers, universities and others."[10]

B. Uncertainties Surrounding the Spectrum Environment

Beyond the danger of overreliance on the 3.7 GHz band rules, other uncertainties surrounding the 3.45 GHz band make it too early to create effective rules. For instance, more information is needed on the band-clearing process and where current federal operations will relocate, which as discussed below could affect how the 3.45 GHz Service interacts with services in adjacent spectrum bands. As Commissioner Rosenworcel observes, "Coordination matters . . . so we don't end up increasing

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[8] *Further Notice* ¶ 96.
[9] *See* Mike Dano, *With a Record Number of Bidders, CBRS Auction Estimates Rise to $10B*, LIGHT READING, July 7, 2020, https://www.lightreading.com/5g/with-a-record-number-of-bidders-cbrs-auction-estimates-rise-to-$10b/d/d-id/762223.
[10] *See* Monica Alleven, *CBRS 3.5 GHz Auction Concludes, Raising $4.58B*, FIERCE WIRELESS, Aug. 26, 2020, http://www.fiercewireless.com/regulatory/cbrs-3-5-ghz-auction-concludes-raising-4-58b.

interference and decreasing utility of our limited mid-band resources."[11] In particular, details about the nature of DoD's planned activities in Cooperative Planning Areas (CPAs) and Periodic Use Areas (PUAs), including the geographic extent of impacts, the fraction of time activity is expected, and issues such as out-of-band coordination requirements, appear to be necessary prerequisites to both Commission action[12] and maximal commercial interest in the 3.45 GHz Service.

C. Integration of 3.35-3.45 GHz Spectrum

The Commission seeks "input on the feasibility of reallocating the 100 megahertz of spectrum between 3.35 GHz and 3.45 GHz for commercial wireless service at the same power levels [proposed] for the 3.45-3.55 GHz band."[13] Usage of the 3.35 GHz band is far more likely to occur efficiently, and be far more appealing to commercial interests, if it is combined with 3.45 GHz band frequencies. The Commission should take action on the full 200 MHz of spectrum collectively when there is more certainty about the timing and logistics of the 3.35 GHz band becoming available, rather than setting rules for the 3.45 GHz Service alone. In particular, there should be a unified clearing and/or dynamic sharing process across all 200 MHz.

NTIA reports that there is more incumbent activity in 3.10-3.45 GHz than in 3.45-3.55 GHz: "the lower portion of the band is more congested and includes additional

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[11] *See* Statement of Commissioner Jessica Rosenworcel, *In the Matter of Facilitating Shared Use in the 3100-3550 MHz Band*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 11078, 11169 (2020).
[12] *Further Notice* ¶¶ 45-47.
[13] *Id.* ¶ 44.

systems that have not been analyzed."[14] Therefore, the Commission ultimately may find that the 3.35-3.45 GHz band lends itself more readily to a CBRS-type of lower-power, multi-tiered, dynamic shared use. There is a risk, however, that by then the 3.45-3.55 GHz band may have already been established as a high-power band. In that case, the 3 GHz band in the United States would be a checkerboard of alternating spectrum use models, with low power/high power boundary conflicts at 3.45, 3.55, and 3.7 GHz.

Figure 1: Inconsistent spectrum uses in the U.S. 3 GHz band that could result from failing to consider 3.35-3.45 GHz incumbent operations when adopting rules for 3.45-3.55 GHz

By contrast, if the Commission's rules are based on a full understanding of the incumbent situation in 3.35-3.45 GHz, a CBRS-like framework in 3.45-3.55 GHz may be the best choice to allow access to a unified band of 350 MHz with a consistent sharing and deployment framework throughout, and only one internal boundary conflict at 3.7 GHz.

[14] U.S. Department of Commerce, *Feasibility of Commercial Wireless Services Sharing with Federal Operations in the 3100-3550 MHz Band*, at 11 (July 2020), https://www.ntia.doc.gov/files/ntia/publications/ntia_3100-3550_mhz_mobile_now_report_to_congress.pdf.

II. THE COMMISSION SHOULD CONSIDER INCORPORATING ASPECTS OF ITS CBRS RULES INTO RULES FOR THE 3.45 GHz SERVICE

The proposed 3.45 GHz band and the adjacent CBRS band share important characteristics. The bands have similar propagation characteristics and both contain static and dynamic incumbent activity in pre-defined geographic areas, with the principal incumbent being the DoD. Some DoD systems, for example the SPN-43 radar discussed below, operate across the bands. Given the similarities between the 3.45 GHz Service and CBRS bands, the Commission should examine which aspects of the CBRS rules merit application in 3.45-3.55 GHz.

A. Dynamic Incumbent Activity

Primary similarities between the 3.45 GHz Service and CBRS bands relate to dynamic incumbent activity. In CBRS, dynamic activity occurs mainly from shipborne radar off the coasts and limited amounts of ground-based radar activity. In the proposed 3.45 GHz framework, dynamic activity will be in the form of PUAs, which are pre-defined geographic areas requiring enhanced protection during certain periods when the band is in use by DoD.[15] In CBRS, ESC sensors are used to sense and avoid shipborne radar activity, while SASs are alerted to land-based radar activity primarily via communication from an incumbent (i.e., informing incumbent capability).

The Commission's rules for the 3.45 GHz Service can leverage CBRS tools and procedures to avoid harmful interference to occasional incumbent use. Various standards developed by the WInnForum inform operational and functional requirements

[15] *Further Notice* ¶ 46.

for such protections, as well as protocols and tests to ensure proper functioning of dynamic avoidance capability.[16] CBRS SAS Administrators, working with DoD, have also implemented a basic version of an incumbent informing capability, which Google believes is a necessary replacement for sensing networks, as explained in Section II(D) below. The Commission should consider how the 3.45 GHz Service would benefit from adopting and likely expanding upon aspects of these standards and systems.

B. Use-or-Share

The *Further Notice* discusses clearing and auctioning the 3.45 GHz band for exclusive commercial use.[17] Here again, the Commission should consider components of the CBRS framework to enhance efficient spectrum usage. In 3.45 Service license areas that are not completely built out (i.e., rural, underserved areas), and in PUA neighborhoods during periodic incumbent activity (i.e., when licensees' full-power flexible use operations may be temporarily suspended in whole or in part), there will likely be opportunities for lower-powered operations. For example, devices similar to CBRS Category A devices (particularly indoor devices, with maximum EIRP of 15 dBm per 10 MHz, including building loss) may be able to operate in PUA neighborhoods during times of incumbent activity when full-power 3.45 GHz Service systems cannot. Or, in rural areas, the 3.45 GHz band could be used opportunistically to offer additional

[16] *See* WInnForum CBRS Knowledge Base, *at* https://cbrs.wirelessinnovation.org/cbrs-baseline-specifications (last visited Nov. 19, 2020) (listing baseline specifications for commercial operations in the CBRS band).
[17] *See, e.g., Further Notice* ¶ 60.

broadband capacity. A “use-or-share” framework like that for CBRS GAA services would be able to accommodate both uses.

Expanding SAS capabilities below the 3.55 GHz boundary to support such “extended GAA” operation would be straightforward. Given the closeness in frequency to CBRS, the same propagation models could be applied. Moreover, CBRS equipment manufacturers can likely extend device frequency ranges below 3.55 GHz, while maintaining SAS management of the devices. Methods that protect DoD incumbents in CBRS translate almost directly into the protection framework of CPAs and PUAs and their related neighborhoods. Protecting licensees’ systems when and where they are operating also is analogous to the implementation of PAL Protection Areas (PPAs). There is effectively no challenge to using SASs to implement a use-or-share framework in the 3.45 GHz Service that has not already been solved, certified, and successfully deployed in CBRS. Such a framework should be adopted for the 3.45 GHz Service.

C. Upfront Knowledge of Spectrum Availability

The Commission should work with the National Telecommunications and Information Administration (NTIA) and DoD to bring greater certainty to participation in the 3.45 GHz Service. *All* in-band and out-of-band protections should be known up front, before auction, to a level of detail sufficient to allow potential licensees to fully understand deployment opportunities and limitations. This will allow for 3.45 GHz band spectrum to be more efficiently and effectively placed into service with appropriate auction pricing.

D. The IIC Framework Should Be Adopted, As Well As Extended to the CBRS Band with Deployment As Quickly As Possible

The *Further Notice* indicates that NTIA is considering developing an automated, real-time, incumbent-informing spectrum sharing system (i.e., IIC) to be operated "in conjunction with DoD to notify commercial entities when the latter would need to cease operations."[18] Because the IIC would help to overcome major shortcomings in the CBRS ESC sensing framework, Google enthusiastically supports the proposal.

The primary deficiency of sensing networks is that the need to protect the sensors from interference prevents nearby utilization of the very band that the networks are designed to support. This is especially problematic if an ESC network operator is not rigorous in its choice of sensor deployment locations, and puts them in areas with strong commercial demand. The existence of an ESC sensor in CBRS can block spectrum use in the 3550-3650 MHz segment for up to 40 km for Category A devices, and up to 80 km for Category B devices. Today, millions of potential users are blocked from using CBRS spectrum due to the proximity of ESC sensors.

Even adjacent band systems can be highly disruptive to ESC sensors. Contemplated 3.45 GHz Service systems threaten to disrupt CBRS ESC sensors over very large distances. In CBRS, where the maximum allowed EIRP is 50 W per 10 MHz, the impact distance can be up to 80 km. In the 3.45 GHz Service, with no guard band serving as a buffer to the ESC sensor band and with a potential EIRP of up to 32,800 W per 10 MHz (28 dB higher than CBRS), the impact distance would be even greater. To

[18] *Id.* ¶ 53.

avoid potentially massive disruption to the CBRS service, 3.45 GHz Service base stations placed within 400 km of the coast line should be required to be coordinated with ESC operators.[19]

For the same reasons, the Commission, with the DoD and NTIA, should develop an IIC system for the 3.45 GHz Service instead of using sensing networks to detect incumbent activity. Because CBRS ESC sensors and 3.45 GHz Service deployment plans can disrupt each other, deploying an IIC simultaneously for both services would be advantageous. This improvement would remove the need to coordinate 3.45 GHz transmitters around ESC sensors, while eliminating the impact that ESC sensors have on CBRS operations. With regard to national security concerns, DPAs activated via an IIC by DoD operations are geographically large enough to conceal the DoD systems' precise locations. DoD also could activate DPAs via an IIC without active operations in a DPA to mask the location and timing of actual operations.

III. THE COMMISSION SHOULD TAKE A HOLISTIC APPROACH THAT MAXIMIZES OPPORTUNITIES TO UTILIZE MID-BAND FREQUENCIES

In addition to setting rules that best fit the 3.45 GHz Service on its own terms, the Commission should coordinate its regulation of mid-band spectrum bands to minimize interference across bands and allow continued success of already-deployed services. Among other benefits, a holistic approach will protect CBRS deployments and guard

[19] The 400 km figure is derived by scaling the 80 km protection distance for a 50 W/10 MHz EIRP CBRS device to the equivalent distance for a 32,800 W/10 MHz EIRP 3.45 GHz Service device using an r^4 propagation loss factor. This distance is actually smaller than the maximum distance over which NTIA computes that aggregate interference from much lower power (50 W) CBRS operations could interfere with DoD radars.

against uncertainty that would diminish the opportunity for the commercial success of the 3.45 GHz Service.

Operations in the 3.45 GHz Service will occur adjacent to those in the CBRS band, in particular to the 3550-3650 MHz segment of the CBRS band where PAL operations must occur and GAA operations may occur. The recently-concluded CBRS PAL auction grossed more than $4.5 billion in bids from a large variety of parties,[20] with deployments expected soon. Failure to consider the impact of future 3.45 GHz Service deployments could jeopardize the success of these substantial commercial investments. Specifically, in formulating the 3.45 GHz Service rules, it is imperative to avoid the following potential harms to PAL and GAA operations: (i) increased incumbent radar activations in the CBRS band; (ii) adjacent band interference between the 3.45 GHz Service and CBRS services; and (iii) interference from the 3.45 GHz Service into CBRS ESC networks.

A. Increased Incumbent Radar Activations in the CBRS Band Related to Clearing of the 3.45 GHz Service Band

The principal radar that impacts the CBRS band is the SPN-43 radar that operates as an air traffic control and weather radar on aircraft carriers and large-deck amphibious assault ships.[21] The SPN-43 has an operational frequency range of 3500-3700 MHz,[22] but is restricted from operating in the 3650-3700 MHz range within

[20] *See* Allewen*, supra* n.10.
[21] *See* Reply Comments of Google Inc. in GN Docket No. 12-354, Attachment A, ¶¶ 4, 6 (filed Aug. 15, 2014).
[22] *Id.* ¶ 4.

44 nautical miles of the coast.[23] Thus, its primary band of operation close to the coast is 3500-3650 MHz, one-third of which (3500-3550 MHz) falls outside the CBRS band, but within the 3.45 GHz Service range.

Among the methods that the DoD has identified to clear much of the 3.45 GHz band are modifying its concept of operation and/or retuning systems operating in the band.[24] If SPN-43 operations are restricted to frequencies outside the 3.45 GHz Service band, then the radar would only operate above 3550 MHz. And if current SPN-43 use is evenly distributed across 3500-3650 MHz, then operating only above 3550 MHz could increase SPN-43 activity in the CBRS band by up to 50%, directly impacting the part of the CBRS band primarily used for PAL operations.

The Commission should work with DoD and NTIA to understand how clearing the band for the 3.45 GHz Service would increase radar activity within the CBRS band and how to mitigate resulting negative impacts on commercial use of recently-auctioned PALs. One solution would be to relocate radar activity from 3500-3550 MHz to 3650-3700 MHz. Because this range of frequencies is generally not monitored by coastal ESCs, increased operation there would not cause additional sensor activations and would minimize effects on CBRS. Moreover, monitoring data indicate that the DoD is currently using this range for some shipborne radar activity, so apparently interference from CBRS and legacy Part 90 operations is not a significant interference

[23] NTIA, *Manual of Regulations and Procedures for Federal Radio Frequency Management*, Chapter 4c, n.US349 (May 2013), *available at* https://www.ntia.doc.gov/files/ntia/publications/redbook/2017-09/4c_17_9.pdf.
[24] *Further Notice* ¶ 12.

issue for the military. Finally, CBRS systems would be operable in the presence of even strong SPN-43 signals in 3650-3700 MHz. Studies of LTE/SPN-43 compatibility[25] show that LTE systems can operate co-channel to a SPN-43 radar at a distance of as close as 4 km, and adjacent channel when as close as 1.2 km, line-of-sight.

B. Adjacent Band Interference Between the 3.45 GHz Service and CBRS

Just as the proposed 3.45 GHz Service is immediately adjacent to the bottom of the CBRS band, the 3.7 GHz Service is immediately adjacent to the top of the CBRS band, with no guard band in between. When the Commission formulated the 3.7 GHz Service rules, it considered, but decided against, specific rules to deal with co-existence between the 3.7 GHz Service and CBRS.[26] Instead, it determined that to the extent harmful interference occurs, a SAS could move CBRS users to other channels farther from the band edge, or operators could coordinate to adopt Time Division Duplex (TDD) synchronization between systems in close proximity. The former solution effectively carves a guard band out of limited CBRS spectrum to mitigate the effect of interference from the adjacent 3.7 GHz Service. The latter incorrectly assumes that 3.7 GHz Service operators have an incentive to coordinate with CBRS operators in the immediately adjacent band. In reality, there is a significant power imbalance between the two groups, both literally and figuratively. The 3.7 GHz Service is allowed a maximum EIRP of 32,800 watts per 10 MHz, while the highest-power (Category B) CBRS devices are

[25] *See, e.g.,* Jeffrey H. Reed, et al., *On the Co-existence of TD-LTE and Radar over 3.5 GHz Band: An Experimental Study* (May 3, 2016), https://arxiv.org/abs/1605.01081.
[26] *See In the Matter of Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, Report And Order and Order of Proposed Modification, 35 FCC Rcd 2343, ¶¶ 396-397 (2020).

limited to only 50 watts per 10 MHz, which is lower by a factor of 656 (28 dB). At the same time, with large license areas of cleared spectrum available for greenfield exclusive use in the 3.7 GHz Service and copious contiguous spectrum available, only the best-funded entities with large geographic service areas will be the likely winners in the upcoming 3.7 GHz auction. In comparison, the top of the CBRS band is limited to GAA operations, many of which will be run by small rural broadband providers or similar entities. It is thus predictable that imbalances of technical resources and personnel will permeate co-existence discussions.

If the Commission applies 3.7 GHz-like rules to the 3.45 GHz band, the situation at the 3.7 GHz boundary could be repeated at the 3550 MHz boundary between CBRS and the proposed 3.45 GHz Service. The proposed EIRP limits for the 3.45 GHz Service are identical to those for the 3.7 GHz Service,[27] and there is no guard band between the services. The lower part of the band will be predominantly used by PAL operations limited to 70 MHz of spectrum within the 3550-3650 MHz segment, instead of GAA. These PAL operators—who have already committed to their purchase prices at auction—would face potential harmful interference from 3.45 GHz Service transmissions in the immediately adjacent band at power levels as much as 28 dB higher than their own. Figure 2 shows the disparate levels of power between the CBRS band, the proposed 3.45 GHz Service, and the 3.7 GHz Service.

[27] *Compare Further Notice,* Appendix D*,* Proposed 47 C.F.R. § 27.50(k)(1), *with* 47 C.F.R. § 27.50(j)(1).

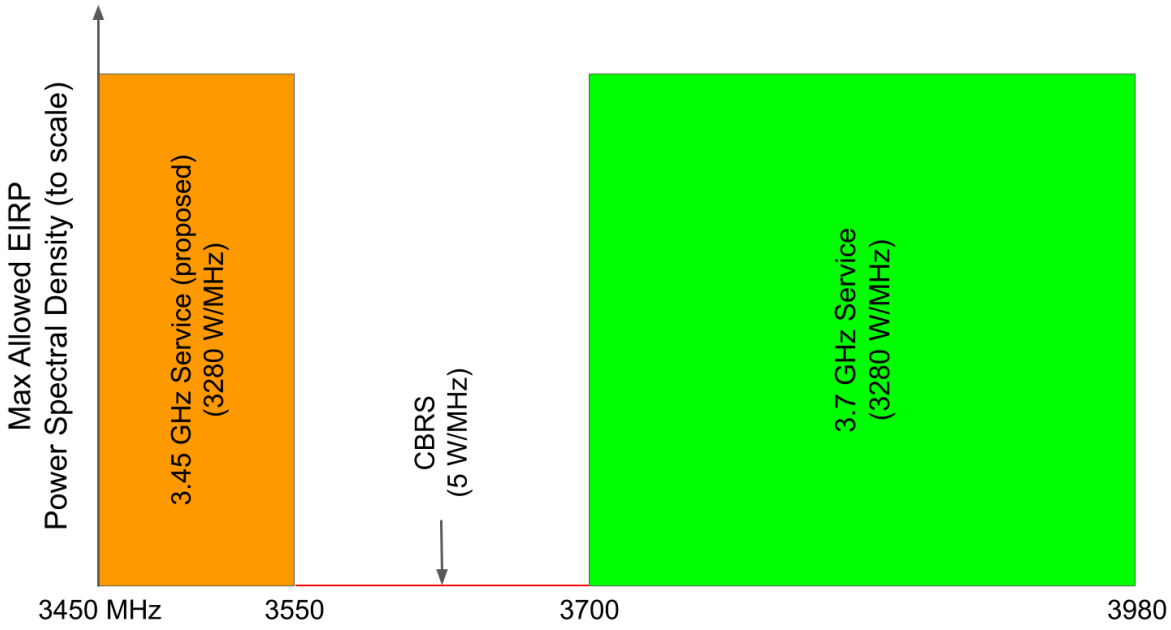

Figure 2: Graphical comparison of allowed (or proposed) maximum radiated power spectral density for the 3.45 GHz Service, CBRS, and the 3.7 GHz Service, presented to scale. The height of the bar representing CBRS is 656 times smaller than the other two and is nearly invisible at this resolution.

Commercial stakeholders have established a multistakeholder group to study adjacent band compatibility at the 3700 MHz boundary.[28] The group has determined that "the absence of [TDD] synchronization could mutually degrade the performance of both CBRS and C-Band networks to varying degrees."[29] While TDD synchronization is an

[28] *See* C-Band Technical Working Group 4, *Report of the C-Band Technical Working Group 4 (5G / CBRS Coexistence)* (Oct. 6, 2020) (attachment to Letter from Peter Tenerelli, Distinguished Member of the Technical Staff, Verizon, and PJ Jayawardene, Senior Director, Charter Communications, to Marlene H. Dortch, Sec'y, FCC, in WT-Docket 18-122 (filed Oct. 12, 2020)).

[29] *See id.* at 9. The solution presumes that the systems being coordinated both use synchronization-capable technologies (e.g., 4G LTE, 5G NR). If the technologies are not both capable of supporting TDD synchronization, such as when one or both technologies relies upon a proprietary interface, the solution may not be viable. The solution also assumes that the two entities can use the same TDD configuration (i.e.,

effective method of mitigating interference, the study notes that it is not possible in all instances, and also that additional coexistence mechanisms, such as modifications to antenna pointing angles, are helpful.[30] In any event, working out such technical solutions requires good-faith coordination between the affected parties.

The multistakeholder group's conclusions and the need for good-faith coordination would apply equally to co-existence at the CBRS/3.45 GHz Service boundary if rules based on the 3.7 GHz Service are adopted. To facilitate mitigation of harmful interference to CBRS from 3.45 GHz Service transmissions, the Commission should adopt the following rule:

> **27.xxx** In the event that 3.45 GHz Service emissions are believed to be causing harmful interference to CBRS operations in the 3550-3700 MHz band, the 3.45 GHz Service operator shall coordinate in good faith with the affected CBRS operator or the Administrator of its affiliated Spectrum Access System to help mitigate the interference.

C. Interference from the 3.45 GHz Service into CBRS ESC Networks

CBRS employs networks of ESC sensors that detect dynamic DoD radar emissions and relay that information to one or more SASs, which in turn reconfigure CBRS devices to ensure that the DoD operations are protected from harmful interference. Because DoD radar operations are typically aboard U.S. Navy ships, most

relative fraction of uplink vs. downlink transmissions), and are running similar use cases, which in many cases is not a valid assumption.

[30] *Id.* at 15-16, 18, 21.

sensors are located in coastal areas. At present, a few hundred sensor sites are deployed along all coastlines of the contiguous U.S.[31]

Because ESC sensors listen for potentially weak signals from DoD radars, down to levels as low as -89 dBm per MHz, they must themselves be protected from interference. To obtain certification, ESC sensors are tested to detect radar waveforms at this level in the presence of noise at a level as high as -109 dBm/MHz rms.[32] Thus, deployed sensors must be protected from aggregate interference from CBRS devices at this same level. To that end, ESC operators should place their sensors away from heavily-populated areas in order to avoid major disruption to CBRS operations.

The proposed 3.45 GHz operations present a further challenge to ESC systems. ESC sensors operate in the 3550-3650 MHz band. There would be no guardband between ESC receivers and the 3.45 GHz Service. While SASs can manage interference from CBRS devices into ESC sensors, SASs have no proposed control over the 3.45 GHz Service, and will not be able to limit harmful interference to ESC sensors from 3.45 GHz Service transmissions. Furthermore, without a guardband, the sensors cannot rely on filters to mitigate interference.

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[31] Approximately 50 coastal DPAs are being monitored in the contiguous U.S., requiring approximately two sensors per ESC network per DPA, times two substantially-built ESC networks, yielding on the order of 200 total sensors. The number of sensors is actually larger when considering redundant/backup sensors, DPAs that require more than two sensors for coverage, and sensors dedicated to small port areas and other specialized DPAs. A third ESC network is also coming online.

[32] *See* U.S. Department of Commerce, *NTIA Technical Memorandum 18-527: Procedures for Laboratory Testing of Environmental Sensing Capability Sensor Devices*, at 3 (Nov. 2017), *available at* https://www.its.bldrdoc.gov/publications/details.aspx?pub=3184.

Consider a situation in which an ESC sensor receives strong signals from an adjacent-band 3.45 GHz Service base station. In rural areas, where many ESC sensors are located to avoid compromising urban commercial use of CBRS, 3.45 GHz Service base stations would be allowed an EIRP of up to 3280 W/MHz (65 dBm/MHz).[33] This requires a total of 174 dB of loss to meet the -109 dBm/MHz ESC interference criterion. Assuming that the antenna gain of the ESC antenna towards the 3.45 GHz Service transmitter is -10 dBi (an optimistic discrimination of about -27 dB from the typical main-beam gain of an ESC antenna), and that the discrimination of the 3.45 GHz antenna in the direction of the ESC sensor is -15 dBi, then the amount of propagation loss required between the two sites to meet the ESC protection criterion required by government testing standards is 174 dB - 10 dB - 15 dB = 149 dB.

At 3550 MHz, this corresponds to a free space loss distance of 190 km. Conservatively assuming 30 dB of clutter loss between the transmitter and the ESC sensor, the required additional path loss to meet the interference objective would be 119 dB, which corresponds to a distance of 6 km. This analysis considers interference from only a single 3.45 GHz Service transmitter. In reality, interference to ESC sensors would be greater as it would be caused by the aggregation of all 3.45 GHz Service transmitters in the area, and the existence of some 3.45 GHz Service transmitters with their main beams pointed generally in the direction of an ESC sensor.[34]

[33] *Further Notice* ¶ 73.
[34] In CBRS, where the maximum allowed power is only 5 W per MHz, the coordination distance for CBRS devices potentially impacting ESC sensors is 80 km, which accounts

Put simply, signals from 3.45 GHz Service transmitters have potential to cause interference at ESC sensors that exceeds the sensors' established interference criterion. This interference would cause massive disruption to CBRS. When such interference occurs, ESC sensors must alert the SAS of a fault condition and automatically activate the coastal DPA being monitored by that sensor. This is equivalent to a declaration that a DoD radar is operating in the DPA, regardless of whether a radar is actually operating. The SAS, in turn, would reconfigure all CBRS devices in the DPA's neighborhood to avoid causing interference to assumed radar activity. DPA neighborhoods can extend as far as 464 km inland, with areas approaching *150,000 square miles*. Thus, the number of potentially affected CBRS devices and customers would be exceedingly large.

Fault conditions from harmful interference to ESC sensors therefore can cause massive and widespread disruption to CBRS, and this disruption would be static and permanent when the interfering 3.45 GHz Service transmitters are turned on. Without prior coordination, an ESC operator, and therefore CBRS customers served by the SAS relying on the ESC sensor, will face permanent DPA activation caused by new 3.45 GHz Service transmitters. *This situation needs to be addressed in the 3.45 GHz Service rules.* Specifically, Google suggests that prior coordination between 3.45 GHz Service operators and ESC operators should be mandatory whenever a 3.5 GHz base station is to be placed within potential interference distance of an ESC sensor. In CBRS, the

for aggregation and cases in which the CBRS device is pointed directly toward the ESC sensor.

potential interference distance is taken to be 80 km for the highest-power (Category B) devices, which operate at a maximum EIRP of 47 dBm per 10 MHz—some 28 dB less than proposed for the 3.45 GHz Service. Scaling by a nominal r^4 propagation loss and accounting for the 28 dB difference in power yields a corresponding potential interference distance of 400 km for 3.45 GHz Service base stations. This distance is lower than the worst-case distance over which NTIA computes that aggregate interference from much lower power (50 W) CBRS devices can interfere with DoD radars.[35] Thus, the 3.45 GHz Service rules should require prior coordination with ESC Operators whenever a base station is to be located within 400 km of the coast:

> **§27.yyy** Protection of CBRS ESC Sensors
>
> (a) 3.45 GHz Service base stations located within 400 kilometers of the U.S. coastline must be prior coordinated with Citizens Broadband Radio Service (CBRS) Environmental Sensing Capability (ESC) operators prior to the base station being brought into use.
>
> (b) The operator of any 3.45 GHz Service base station that is believed to be causing harmful interference to an ESC sensor must coordinate in good faith with the ESC operator to mitigate the harmful interference. The 3.45 GHz Service base station shall suspend or delay operations while the harmful interference is being resolved, as necessary to avoid disruption to existing CBRS systems.
>
> (c) All 3.45 GHz Service base stations and ESC operators must cooperate fully and make reasonable efforts to resolve technical problems and conflicts that may inhibit the most effective and efficient use of the radio spectrum; however, the ESC operator is not obligated to suggest changes or re-engineer a proposal in cases involving conflicts.

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[35] *See* Category B DPA Neighborhood Sizes*, available at* https://www.ntia.doc.gov/fcc-filing/2015/ntia-letter-fcc-commercial-operations-3550-3650-mhz-band (last visited Nov. 20, 2020) (download the E-DPAS.kml file and refer to the catBNeighborhoodDistanceKm parameter for each DPA). The maximum value of this parameter is 464 km.

Note that interference to ESC sensors from 3.7 GHz Service transmitters is not expected to pose as much of an issue due to the presence of a 50 MHz guard band between the top of the sensors' band of operation and the beginning of the 3.7 GHz Service band. ESC sensors already employ filters to mitigate the impact of signals significantly beyond the 3650 MHz upper frequency range of the receivers. In addition, the SAS protects ESC sensors from CBRS emissions out to 3660 MHz (Category A) and 3680 MHz (Category B).[36] Although it is yet to be confirmed that 3.7 GHz Service transmissions won't in fact interfere with ESCs, the situation at the lower end of the ESC receiving band is much worse: There is neither a guard band nor SAS protection for potential 3.45 GHz Service interference at the 3550 MHz boundary.

CONCLUSION

The existing pipeline of mid-band spectrum for next-generation wireless and 5G services has created breathing room for the Commission to deliberately and carefully craft rules for the 3.45 GHz Service. The new rules should leverage Commission learnings from CBRS and operationalization of the 3.7 GHz Service, information about 3.45 GHz band clearing methodology, and details about the future of the 3.35-3.45 GHz band. The 3.45 GHz Service rules ultimately should contribute to maximizing efficient use of all 3 GHz spectrum, including by smaller or new entrants.

[36] *See* WInnForum, *Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band,* at 27-28 (Mar. 11, 2020), https://winnf.memberclicks.net/assets/CBRS/WINNF-TS-0112.pdf.

Because of the similarities between the 3.45 GHz and CBRS Service bands, the Commission should consider applying some CBRS concepts to the 3.45 GHz Service. Dynamic spectrum availability technologies, processes to account for upfront knowledge of when frequencies will be in use, and use-or-share principles hold particular promise for the 3.45 GHz Service. Moreover, the IIC framework should be adopted for the 3.45 GHz Service and should replace the flawed ESC regime in the CBRS band.

Finally, the 3.45 GHz Service rules should mitigate potential harms to operations in the adjacent CBRS band, especially from coexistence issues at the band edges. In formulating the rules, the Commission should address the potential for increased incumbent radar activations in the CBRS band from clearing of the 3.45 GHz band.

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