Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Unlicensed White Space Device Operations in the Television Bands	)	ET Docket No. 20-36
	)	

REPORT AND ORDER AND FURTHER NOTICE OF PROPOSED RULEMAKING

Adopted: October 27, 2020 **Released: October 28, 2020**

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By the Commission: Chairman Pai and Commissioners O'Rielly, Carr, Rosenworcel, and Starks issuing separate statements.

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I. INTRODUCTION

1. In this Report and Order, we revise our rules to expand the ability of unlicensed white space devices to deliver wireless broadband services in rural areas and areas where fewer broadcast television stations are on the air. We also modify our rules to facilitate the development of new and innovative narrowband Internet of Things (IoT) devices in TV white spaces. Unlicensed white space devices operate in the VHF and UHF broadcast TV bands, a spectral region that has excellent propagation

characteristics particularly attractive for delivering wireless communications services over long distances, varying terrain, and into and within buildings.[1] We adopt a number of changes to the white space device rules to spur continued growth of the white space ecosystem, especially for providing affordable broadband service to rural and unserved communities that can help close the digital divide, while at the same time protecting broadcast television stations in the band from harmful interference.

2. In addition to the Report and Order, we issue a Further Notice of Proposed Rulemaking to explore whether and if so how we can modify the rules to permit use of terrain-based models such as the Longley-Rice Irregular Terrain Model to determine available TV channels for white space devices. By accounting for terrain features, such models could make additional spectrum available for unlicensed broadband services.

II. BACKGROUND

3. Unlicensed white space devices, which operate at locations where frequencies are not in use by licensed services or by protected entities, provide a variety of wireless services to the public.[2] For example, Wireless Internet Service Providers (WISPs) use fixed white space devices to provide Internet connectivity in rural and underserved areas, including broadband data for schools and libraries. White space devices operate by obtaining a list of available channels and data on power levels that may be used at their particular locations from databases administered by private entities approved by the Commission.[3] Fixed white space devices must incorporate a geo-location capability and a means to access a database.[4] Personal/Portable white space devices can either acquire a list of available channels via another white space device (Mode I), or themselves include geo-location and database access capabilities (Mode II).[5]

4. In 2008, the Commission first authorized unlicensed white space device operations, both fixed and personal/portable, in portions of the VHF and UHF broadcast TV bands that were not being used by TV broadcasters and associated services.[6] In 2010 and 2012, the Commission took steps to promote additional opportunities for unlicensed white space devices to use spectrum in the broadcast television bands (TV bands) while still protecting broadcast television stations from harmful interference.[7] In addition, the 2015 *White Spaces Order* adopted rules to promote white space device usage in the

[1] The VHF TV band consists of Channels 2-6 (low VHF band) and Channels 7-13 (high VHF band). The UHF TV band consists of Channels 14-36.

[2] *See generally* 47 CFR Part 15 subpart H.

[3] 47 CFR §§ 15.711(c)(2), (d)(2) and 15.715.

[4] 47 CFR § 15.711(c)(1). Fixed devices must re-check the database for available channels at least once daily. 47 CFR § 15.711(c)(2).

[5] 47 CFR §§ 15.703(i) and 15.711(d)-(e). A Mode I device is not required to incorporate geo-location and database access capabilities.

[6] *Unlicensed Operation in the TV Broadcast Bands; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket Nos. 04-186 and 02-380, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd 16807 (2008) (*White Spaces Second Order*).

[7] *Unlicensed Operation in the TV Broadcast Bands; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket Nos. 04-186 and 02-380, Second Memorandum Opinion and Order, 25 FCC Rcd 18661 (2010); *Unlicensed Operation in the TV Broadcast Bands; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket Nos. 04-186 and 02-380, Third Memorandum Opinion and Order, 27 FCC Rcd 3692 (2012) (*White Spaces Third MO&O*); *Amendment of Part of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37; Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and the 600 MHz Duplex Gap, Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, ET Docket No. 14-165 and GN Docket No. 12-268, Report and Order, 30 FCC Rcd 9551 (2015) (*White Spaces Order*).

repacked TV bands following the 600 MHz incentive auction (which was completed in 2017).[8] The *White Spaces Order* also permitted white space device operation in portions of the 600 MHz band, the 600 MHz duplex gap, and Channel 37.[9] To promote more flexibility for white space device operators in rural areas, the Commission permitted fixed white space devices, which under then-existing rules were limited to no more than 4 watts EIRP, to operate at higher power levels of up to 10 watts EIRP in "less congested" areas, which are defined as those areas where at least half the television channels are unused for broadcast services and available for white space use.[10] In that order, the Commission retained the existing requirement that fixed devices operate on antennas that are no more than 30 meters above ground and no more than 250 meters height above average terrain (HAAT).[11] In March 2019, we adopted the *White Spaces Report and Order and Order on Reconsideration*, in which we provided additional flexibility for fixed white space devices to operate at up to 100 meters above ground in "less congested" areas, but retained the 250 meter HAAT limitation.[12]

5. On February 28, 2020, we adopted a Notice of Proposed Rulemaking that proposed targeted changes to the white space device rules in the repacked TV bands (Channels 2-35) to provide improved broadband coverage that would benefit American consumers in rural and underserved areas while still protecting broadcast television stations from harmful interference.[13] In the Notice, we proposed to: (1) increase the maximum permissible power for fixed white space devices operating in "less congested" areas from 10 watts to 16 watts EIRP; (2) increase the maximum permissible antenna height above average terrain for fixed white space devices from 250 meters to 500 meters, subject to a procedure to notify potentially affected TV broadcast stations; (3) increase the minimum required separation distances between protected services in the TV bands and white space devices operating with higher power/antenna heights; (4) allow higher power mobile operations within defined "geo-fenced" areas; and (5) establish rules for white space devices used in narrowband IoT applications.[14] We also sought comment on whether to revise the definition of "less congested" areas or to allow white space devices to operate with higher power at locations inside the service contour of an adjacent channel TV station.[15]

6. A total of 31 parties filed comments and 19 parties filed reply comments in response to the *Notice*. WISPs, equipment manufacturers, non-profit groups, and rural business interests generally

[8] Following the auction, TV channels 38-51 were repurposed, with most of the 600 MHz band reallocated for wireless services while also including a 600 MHz guard band and 600 MHz duplex gap. *Incentive Auction Closing and Channel Reassignment Public Notice - The Broadcast Television Incentive Auction Closes; Reverse Auction and Forward Auction Results Announced; Final Television Band Channel Assignments Announced; Post-Auction Deadlines Announced*, Public Notice, DA 17-314, 32 FCC Rcd 2786 (2017).

[9] *See generally White Spaces Order*.

[10] *White Spaces Order*, 30 FCC Rcd at 9572, para. 51.

[11] *White Spaces Order*, 30 FCC Rcd at 9573, para. 53.

[12] *Amendment of Part 15 of the Commission's Rules for Unlicensed White Space Devices; Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37; Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions,* ET Docket Nos. 16-56 and 14-165 and GN Docket No. 12-268, Report and Order and Order on Reconsideration, 34 FCC Rcd 1827, 1853, para. 67 (2019) (*White Spaces Order on Reconsideration*).

[13] *Unlicensed White Space Device Operations in the Television Bands*, ET Docket No. 20-36, Notice of Proposed Rulemaking, 35 FCC Rcd 2101 (2020) (*Notice*). Microsoft Corporation filed a petition for rulemaking seeking several changes to the band, largely supported by NAB. *See* Petition for Rulemaking, ET Docket No. 14-165 and RM-11840 (filed May 3, 2019) (Microsoft Petition); NAB Comments, ET Docket No. 14-165 and RM-11840, at 5 (rec. Jun. 10, 2019).

[14] *See generally Notice.*

[15] *Notice*, 35 FCC Rcd at 2113, para. 36.

support our proposals to increase the maximum EIRP and HAAT for fixed devices, and to allow higher power geo-fenced mobile operations and narrowband IoT operations. They argue that these changes will permit improved broadband access for Americans in rural and underserved areas. Many of these parties offer specific suggestions for changes to our proposals. Broadcasters, wireless microphone manufacturers and users, and public safety interests, however, express concerns about certain of our proposals.

III. REPORT AND ORDER

7. We adopt targeted changes to the Part 15 unlicensed device rules for white space devices in the TV bands to provide improved broadband coverage that will benefit American consumers in rural and underserved areas as well as improved access to narrowband IoT applications that will benefit consumers and businesses while still protecting broadcast television stations from harmful interference. Specifically, we permit higher EIRP and higher antenna HAAT for fixed white space devices in "less congested" geographic areas. In addition, we permit higher power mobile operation within "geo-fenced" areas in "less congested" areas.[16] We also adopt rule changes designed to facilitate the development of new and innovative narrowband IoT services.

8. We decline at this time to allow higher power operation by white space devices when operating within the service contour of an adjacent channel TV station or to change the methodology we use to protect authorized services within the TV bands. The changes we adopt apply only to white space devices operating on TV Channels 2-35.[17] We exclude channel 36 from these changes based on the need to protect Wireless Medical Telemetry Service and Radio Astronomy Service operations that operate on Channel 37 (608-614 MHz).[18]

A. Fixed white space devices in rural areas in the TV bands

9. We adopt rule changes for fixed white space devices that operate in the TV bands to enable improved broadband service in rural areas and underserved areas. Specifically, in "less congested" areas we will increase the maximum permissible radiated power from 10 to 16 watts EIRP, and increase the maximum permissible antenna HAAT from 250 meters to 500 meters.[19] Because the higher power and increased antenna limits will expand the maximum transmission range of white space devices, they will be able to provide broadband service over larger areas. Given these revisions, we are commensurately increasing the minimum required separation distances between white space devices operating at higher power/HAAT and protected services in the TV bands.

1. Higher power limits

10. Current rules permit fixed white space devices to operate on Channels 2-36 with a 4 watt EIRP maximum in any area, provided the device meets minimum separation distances from co-channel and adjacent channel users in the band.[20] In addition, a fixed white space device may operate with up to 10 watts EIRP on Channels 2-35 in "less congested" areas, defined as those areas where at least half the

[16] A "geo-fenced" area refers to a defined geographic area in which a mobile white space device may operate. A mobile white space device uses an incorporated geo-location capability such as GPS in conjunction with a database to determine the location of the device with respect to the boundaries of the defined area.

[17] We note that our Report and Order does not affect any of the pending petitions for reconsideration of the 2015 *White Spaces Order* (which concern the rules for unlicensed operation on Channel 37 and the "push notification" requirement regarding protecting registered licensed microphone operations at particular times and specified locations).

[18] 47 CFR § 15.709(a)(2)(i) (limiting the 602-620 MHz band to 4 watts EIRP).

[19] HAAT for fixed white space devices is calculated using the same method as used for television broadcast services and is based on the terrain profile between 3.2 km and 16.1 km from the device along eight radials. 47 CFR § 15.709(g)(1)(ii) (referencing 47 CFR § 73.684(d)).

[20] 47 CFR §§ 15.709(a)(2), 15.712.

television channels in the band of operation are not in use, provided the fixed device complies with larger separation distances from other users in the band.[21] Fixed white space devices are limited to one-watt maximum conducted transmitter power, requiring devices with radiated power levels above one-watt EIRP to use an antenna with directional gain, e.g., 6 dBi to produce 4 watts EIRP, and 10 dBi to produce 10 watts EIRP.[22]

11. In the Notice, we proposed to permit fixed devices to operate in the TV bands, up to Channel 35, with a maximum 16 watts EIRP (42 dBm) in "less congested" areas.[23] We proposed this change to permit fixed devices to reach users at greater distances in rural and other less congested areas, and thus enable improved broadband coverage at lower cost.[24] We proposed to maintain the one-watt transmitter conducted power limit for fixed devices and require instead that the higher power be achieved by using higher gain, more highly directional antennas to improve spectrum efficiency.[25] We proposed that in cases where an antenna with a gain higher than 12 dBi is used, the transmitter power must be reduced below one watt by the amount in dB that the antenna gain exceeds 12 dBi, in order to ensure that the EIRP from a fixed device does not exceed 16 watts EIRP.[26]

12. Many parties generally support our proposal to increase the maximum permissible EIRP to 16 watts in "less congested" areas, arguing that this change will help improve broadband access in rural areas.[27] For example, Microsoft argues that this change will allow significant improvement in the economics of rural coverage, and Adaptrum states that the ability to operate at increased power levels up to 16 watts enables networks to maximize their coverage and capacity.[28] PISC argues that allowing fixed white space devices to operate at a maximum 16 Watts EIRP is a modest change that allows operators to cover more customers with a given amount of investment, a critical factor in the availability and affordability of rural broadband.[29]

13. We adopt our proposal to permit fixed white space devices to operate in the TV bands on Channels 2-35 with a maximum 16 watts EIRP (42 dBm) in "less congested" areas. The record generally supports this action, and as we noted in the Notice, this change will permit fixed devices used in "less congested" areas (including rural areas) to reach users at greater distances, thus enabling improved broadband coverage at less cost in these hard-to-reach areas. In addition, higher power will enable signals to better penetrate foliage, buildings, and other obstacles, thus providing improved coverage at locations where there is not a direct line-of-sight to the transmitter. We also adopt our related proposals to maintain the transmitter conducted power limit of one watt, and to require that when an antenna with a directional

[21] 47 CFR §§ 15.703(h), 15.709(a)(2), 15.712. White space devices are not permitted to operate at the higher power EIRP on Channel 36 in less congested areas, in order to protect adjacent channel Wireless Medical Telemetry Service and Radio Astronomy Service. 47 CFR § 15.709(a)(2)(i).

[22] 47 CFR § 15.709(c)(1)-(2).

[23] Notice, 35 FCC Rcd at 2105, para. 12.

[24] *Id.*

[25] Notice, 35 FCC Rcd at 2105, para. 13.

[26] *Id.*

[27] ACT | The App Association Comments at 8; Adaptrum Comments at 2; Broadband Connects America Coalition Comments at 12; Cal.net, Inc. Comments at 1; Consumer Technology Association Comments at 4; Dynamic Spectrum Alliance Comments at 5; Microsoft Comments at 12; National Rural Education Association Comments at 1; Pennsylvania Farm Bureau Comments at 1; Public Interest Spectrum Coalition Comments at 13; RED Technologies Comments at 2; RTO Wireless Comments at 1; Western Governors' Association Comments at 1.

[28] Microsoft Comments at 13; Adaptrum Comments at 2.

[29] PISC Comments at 13.

gain of greater than 12 dB is used, the transmitter power must be reduced by the amount in dB that the antenna gain exceeds 12 dBi, thus ensuring that the maximum EIRP does not exceed 16 watts (42 dBm).

14. We limit higher power operation to "less congested" areas as proposed in the Notice. This is consistent with the Commission's actions in other white spaces proceedings in which it initially took a cautious approach when adopting white space rules.[30] This limitation will also minimize the likelihood of any potential harmful interference to authorized services in the TV bands since there are fewer authorized services in "less congested," typically rural, areas. We therefore decline requests by Broadband Connects America Coalition and Public Interest Spectrum Coalition to allow higher power in all areas, not just "less congested" ones.[31]

15. Restricting higher power operations only to "less congested" areas will also limit the potential impact on users of unlicensed wireless microphones (which share use of unused TV channels but are not entitled to any interference protection from unlicensed white space devices).[32] Higher power operation will be permitted only at locations where multiple vacant channels are available for use by varying types of unlicensed users. Our decision to limit the areas where higher power operations may occur should alleviate the concerns of wireless microphone operators about the potential impact that higher power white space devices would have on wireless microphone operations.[33]

16. We are not increasing the maximum permissible conducted transmitter power as requested by some parties.[34] NAB opposes this request, arguing that greater conducted power levels will inevitably lead to inadvertent or intentional overpowered operation and increased potential for interference.[35] We find that increasing conducted transmitter power limits could encourage the use of lower gain (i.e., less directional) antennas, resulting in less efficient spectrum use and also increase the potential for causing harmful interference to licensees and protected users. Requiring the use of more highly directional antennas will ensure that less white space device energy is directed outside the main antenna beam than would be the case if higher radiated power were achieved using lower gain, less directional antennas.

[30] For example, the Commission stated that it was taking a cautious approach when it established a four-watt EIRP limit for fixed white space devices to minimize the risk of harmful interference to authorized users of the TV bands, and then later increased the limit to 10 watts EIRP in "less congested" areas, and as discussed above we are further increasing the limit to 16 watts EIRP. *White Spaces Second Order*, 23 FCC Rcd at 16847, para. 106; *White Spaces Order*, 30 FCC Rcd at 9572, para. 51. In addition, the Commission initially took a cautious approach by prohibiting white space device operation on channels 3 and 4 due to possible interference to devices such as cable boxes and DVD players that connect to a TV receiver using channel 3 or 4, but later removed that prohibition due to changes in technology. *White Spaces Second Order*, 23 FCC Rcd at 16860, para. 150; *White Spaces Order*, 30 FCC Rcd at 9584-95, paras. 84-85.

[31] Broadband Connects America Coalition Comments at 13; Public Interest Spectrum Coalition Comments at 13.

[32] We note that licensed users of wireless microphones may register their operations in this spectrum to obtain protection from white space device operations. 47 CFR § 15.713(j)(8).

[33] *See* Edgar C. Reihl, P.E. Comments at 1 (the Commission must not proceed with power increases and other enhancements for white space devices until it effectively addresses white space database reliability issues); Sennheiser Comments at 3 (increased WSD power and antenna height and high power mobile geo-fenced WSD operation pose a significant threat of interference to microphone operations in rural areas).

[34] Adaptrum and Dynamic Spectrum Alliance request that we increase the transmitter conducted power limit from one watt to two watts. Adaptrum Comments at 2; Dynamic Spectrum Alliance Reply at 7.

[35] NAB Reply at 5.

2. Higher antenna height above average terrain limits

17. *HAAT limit.* The rules currently permit fixed white space devices to operate with a maximum 250-meter antenna HAAT.[36] A white space database will not provide a list of available channels to a fixed white space device with an antenna HAAT that exceeds 250 meters, and such devices are not permitted to operate. The Commission adopted this requirement to limit the distance over which the fixed white space devices would transmit and thus limit the distance at which harmful interference to other TV band users could occur.[37] The antenna HAAT limit also precludes white space devices from operating at certain locations, e.g., those where the ground HAAT exceeds 250 meters. In the *White Spaces Order on Reconsideration*, we upheld our previous decision to maintain a 250-meter antenna HAAT limit but stated that we might consider increasing the limit in the future if there were a more complete record addressing whether higher HAAT could be permitted without causing harmful interference.[38]

18. In the Notice, we proposed to increase the maximum permissible antenna HAAT for fixed white space devices operating on Channels 2-35 from 250 meters to 500 meters and sought comment on appropriate procedures that may be necessary to ensure that broadcast operations and other entities in the TV bands are protected from harmful interference.[39] We noted that increasing permissible antenna HAAT would improve broadband coverage in rural areas by enabling signals to reach greater distances and enable fixed white space devices to operate at locations where they are not currently permitted due to the 250-meter HAAT limit, such as existing towers located at higher ground elevations.[40] To protect Wireless Medical Telemetry Service and radio astronomy operations on Channel 37, we did not propose to permit operation with a higher HAAT in the adjacent Channel 36.[41]

19. Several commenters—including Adaptrum, Broadband Connects America Coalition, Consumer Technology Association, Dynamic Spectrum Alliance, Microsoft, Public Interest Spectrum Coalition, RADWIN, RED Technologies, RTO Wireless, and the Wireless Internet Service Providers Association (WISPA)—support our proposal to increase the maximum HAAT for fixed devices to 500 meters as a way of promoting expanded coverage.[42] Broadband Connects America Coalition, Microsoft, Public Interest Spectrum Coalition, and Dynamic Spectrum Alliance also recommend allowing higher HAAT in all areas, not just "less congested" ones.[43]

20. As proposed, we increase the HAAT limit for fixed white space devices that operate in the TV bands on Channels 2-35 from 250 to 500 meters in "less congested" areas. As with our decision to increase the maximum power allowed for fixed white space devices, this change will permit fixed

[36] 47 CFR § 15.709(g)(1)(ii).

[37] *White Spaces Order on Reconsideration*, 34 FCC Rcd at 1852-53, para. 67.

[38] *Id.*

[39] Notice, 35 FCC Rcd at 2106, paras. 16-17.

[40] Notice, 35 FCC Rcd at 2106, para. 17. We also noted that operation from a higher antenna site can help increase coverage by permitting devices to operate above the tree line to avoid signal losses through leaves and to avoid clutter such as buildings.

[41] Notice, 35 FCC Rcd at 2106, para. 17.

[42] ACT | The App Association Comments at 8; Adaptrum Comments at 3; Broadband Connects America Coalition Comments at 12; Cal.net Comments at 1; Consumer Technology Association Comments at 4; Declaration Networks Group Comments at 1; Dynamic Spectrum Alliance Comments at 9; Microsoft Comments at 15; Public Interest Spectrum Coalition Comments at 15; RADWIN Comments at 3; RED Technologies Comments at 2; RTO Wireless Comments at 1; WISPA Comments at 7.

[43] Broadband Connects America Coalition Comments at 13; Microsoft Comments at 16; Public Interest Spectrum Coalition Comments at 13; Dynamic Spectrum Alliance Reply at 8.

devices used in "less congested," including rural, areas to reach users at greater distances, thus enabling improved broadband coverage at less cost in these hard-to-reach areas. This change will also increase the number of locations where fixed white space devices can operate since it will permit white space device operators to use sites where the HAAT of the ground exceeds 250 meters, which would have been precluded under the current rules. Many parties support this change.[44]

21. While we recognize that some parties request that we not limit this higher HAAT to "less congested" areas, we believe that a more cautious approach is appropriate at this time due to the significant increase in HAAT we are allowing and the potential for harmful interference at greater distances, as noted by Smith and Fisher.[45] Therefore, consistent with our action increasing the maximum power limit for fixed white space devices, we are restricting operation of white space devices with an HAAT of greater than 250 meters to "less congested" areas where fewer authorized services and protected entities are expected to be operating in the TV bands. Relatedly, because there are expected to be fewer authorized services and protected entities operating in "less congested" areas, we expect that the separation distances between white space devices and authorized services and protected entities to generally be greater. This combination of fewer potential interactions between white space devices and authorized services and protected entities and greater distance separation minimizes the potential for harmful interference to such services. Moreover, these white space devices are still required to operate pursuant to the channel availability and power levels provided by a white space database which is designed to ensure that harmful interference does not occur. While wireless microphone interests express concern about the impact of increased HAAT on unlicensed wireless microphone operations, restricting higher HAAT operations to "less congested" areas will serve to limit any impact on users of unlicensed wireless microphones since by definition these areas have multiple vacant TV channels (i.e., at least half) available for use by other types of unlicensed operations.[46] We also note that the rules do not provide harmful interference protection between unlicensed devices. However, because fixed white space device locations are registered in a database, unlicensed wireless microphone users have the ability to check the database and avoid using channels where a higher probability of harmful interference is predicted. In addition to limiting the use of high HAAT to "less congested" areas, as discussed in more detail below, we are increasing the required separation distances between white space devices operating with higher HAAT and co-channel and adjacent channel TV contours to further minimize the likelihood of harmful interference.

22. *Coordination procedure with licensees.* We sought comment on whether to require a coordination procedure between white space device operators and broadcast licensees when fixed white space devices operate with an HAAT exceeding 250 meters.[47] In particular, we requested comment on

[44] ACT | The App Association Comments at 8; Adaptrum Comments at 3; Broadband Connects America Coalition Comments at 12; Cal.net Comments at 1; Consumer Technology Association Comments at 4; Declaration Networks Group Comments at 1; Dynamic Spectrum Alliance Comments at 9; Microsoft Comments at 15; Public Interest Spectrum Coalition Comments at 15; RADWIN Comments at 3; RED Technologies Comments at 2; RTO Wireless Comments at 1; WISPA Comments at 7.

[45] Broadband Connects America Coalition Comments at 13; Microsoft Comments at 16; Public Interest Spectrum Coalition Comments at 13; Dynamic Spectrum Alliance Reply at 8; Smith and Fisher Reply at 1-3 (the range at which interference can occur from a white space device with a high power and HAAT is significantly greater than the range at which it could provide service and that there are very small increases in coverage, when compared with the corresponding potential interference generated at higher antenna heights; concerned about the need to protect future television stations migrating to the ATSC 3.0 standard).

[46] Edgar C. Reihl, P.E. Comments at 2 (higher antenna and power limit can cause interference to other spectrum users such as wireless microphones at significantly greater distances); Sennheiser Comments at 3 (increased white space device power and antenna height and high power mobile geo-fenced white space device operation pose a significant threat of interference to microphone operations in rural areas).

[47] Notice, 35 FCC Rcd at 2106, para. 19.

Microsoft's suggested coordination procedure comprised of several steps, including notifying a white space database administrator, notifying broadcast licensees, operating on a test basis on a 30-day trial authorization, as well as a process to submit claims of harmful interference, investigate such claims, and upon satisfactorily addressing any such claims, permit authorization on a permanent basis.[48] We expressed concern about the complexity of Microsoft's suggested coordination procedure and whether such a procedure is even warranted given the existing obligations of unlicensed devices to protect authorized radio services and other protected users.[49] We also sought comment on a simpler alternative to this procedure. Specifically, we sought comment on whether a party wishing to operate a fixed white space device at an HAAT greater than 250 meters should be required to notify potentially affected, protected entities of their intended operation at least 48 hours in advance.[50] The notification would include the prospective white space device operator's contact information, geographic coordinates of the antenna, antenna height above ground and average terrain, EIRP and channel(s) of operation.[51] For notification purposes, a potentially affected TV station would be defined consistent with Microsoft's proposal, i.e., a station would receive notification if its broadcast contour was within the separation distance corresponding to an assumed HAAT 50 meters higher than the actual deployment.[52]

23. Adaptrum, Microsoft, and WISPA support the more streamlined coordination procedure with broadcasters that we proposed in the notice.[53] RADWIN, RED Technologies, and Dynamic Spectrum Alliance assert that no coordination procedure is necessary since unlicensed device operators already have an obligation to not interfere with authorized services, although RED Technologies states that it supports the Commission's proposed coordination procedure if one is required.[54]

24. We adopt the simpler procedures proposed in the Notice, except we will require that notifications be made four calendar days in advance of operating at an increased HAAT, in response to concerns raised by some parties that 48 hours is not sufficient notice.[55] We require this coordination procedure because white space devices operating at high HAAT have the potential to interfere with TV reception at large distances. Several parties support this simpler procedure,[56] which will ensure that TV broadcasters are aware of new white space device operations with high HAAT that have the potential to

[48] Notice, 35 FCC Rcd at 2107, n.37.

[49] Notice, 35 FCC Rcd at 2107, para. 19.

[50] Notice, 35 FCC Rcd at 2107, para. 20. If a response is not received within 48 hours, the party installing the fixed white space device would be permitted to commence operation.

[51] Notice, 35 FCC Rcd at 2107, para. 20.

[52] Notice, 35 FCC Rcd at 2107, para. 20. To accommodate actual deployments exceeding 450 meters where Microsoft did not provide a separation distance, the Commission would have to add an additional row to the table of separation distances with relevant values.

[53] Adaptrum Comments at 3; Microsoft Comments at 18; WISPA Comments at 7.

[54] RADWIN Comments at 3; RED Technologies Comments at 2 (sees no necessity for a coordination procedure with broadcast licensees because the existing regulations are enough for diagnosing most interference events; should the Commission deem a coordinate procedure to be necessary, strongly supports the revised coordination procedure proposed by the Commission); Dynamic Spectrum Alliance Reply at 9 (no coordination should be required because WSD operators must protect incumbents from receiving harmful interference).

[55] NPSTC Comments at 7 (if the Commission decides to require notifications to PLMRS licensees, the proposed 48-hour turnaround time is woefully inadequate); Sennheiser Reply at 8 (notifications should be sent to licensees with a greater lead time than 48 hours); Shure Reply at 21 (qualifying public safety users, Part 74 wireless microphone operators, and all other affected licensees should be notified at least 10 business days in advance); National Translator Association Comments at 6 (the proposed 48-hour notice requirement is inadequate); NAB Comments at 5.

[56] Adaptrum Comments at 3; Microsoft Comments at 18; WISPA Comments at 7.

affect broadcast operations at greater distances. This notice provides an opportunity for TV broadcasters to work with white space system operators to address any concerns regarding potential harmful interference situations.

25. Parties operating white space devices on an unlicensed basis have an ongoing obligation under the rules to cease operation if harmful interference occurs to any authorized service.[57] The complex multi-step procedure, including a 30-day trial period, initially suggested by Microsoft and supported by NAB is therefore unnecessary.[58] For example, requiring a 30-day trial period appears unnecessary since the unlicensed device operating parameters (location, channel, power, and antenna height) during a trial period would be no different than those planned for normal operation of the device. In addition, parties who believe that an unlicensed device is causing harmful interference may report this occurrence to the Commission and unlicensed device operator at any time, so there appears to be no need to require a specific time period for reporting and investigating interference complaints. An unlicensed device that causes harmful interference to an authorized service must cease operation regardless of whether the interference was found during the first 30 days of operation or sometime later.

26. As proposed in the Notice, we require that when a party plans to operate a fixed white space device with an HAAT greater than 250 meters, it must contact a white space database and identify all TV broadcast station contours that would be potentially affected by operation at the planned HAAT and EIRP. We will define a potentially affected TV station as one where the protected service contour would be within the applicable separation distance if the white space device were operating at an HAAT of 50 meters above the planned HAAT at the proposed power level.[59] We will also require that the installing party notify each of these broadcast licensees and provide the geographic coordinates of the white space device, relevant technical parameters of the proposed deployment, and contact information. We will permit this process to be automated through the white space database, with notifications sent to a TV station licensee's address of record with the Commission. The white space device may commence operations no earlier than four days after the notification.

27. We believe that increasing the notification period from two to four days balances broadcasters' concerns regarding having sufficient time to review proposed white space device operations when operating at high HAATs and the need for white space device operators to begin providing service.[60] Because these white space devices are restricted to "less congested" areas, we do not expect broadcasters to be overloaded with notification requests. Also, because device installation must generally be planned in advance, the four-day requirement should not unduly delay new broadband service to rural and underserved areas.

28. We also adopt the other elements of the coordination procedure proposed in the Notice. Specifically, we will require that, upon request, the installing party must provide each potentially affected licensee with information on the time periods of operations. This will help licensees investigate alleged harmful interference from white space devices. We will also require that if the installing party seeks to modify its fixed operations by (i) increasing its power level, (ii) moving more than 100 meters horizontally from its location, or (iii) making an increase in the HAAT or EIRP of the white space device that results in an increase in the minimum required separation distances from co-channel or adjacent

[57] 47 CFR § 15.5(b).

[58] NAB Comments at 4.

[59] To address situations where a white space device will operate between 450 and 500 meters HAAT, we will add an additional row to the table of separation distances for HAAT values between 500 and 550 meters that will be used only for the purpose of identifying potentially affected TV broadcast stations.

[60] *See* Letter from Patrick McFadden, Deputy General Counsel, NAB, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 20-36, at 2 (filed Sept. 2, 2020) (would support a requirement that would allow a white space device operator to commence operations no earlier than five business days following notification with no associated trial period).

channel TV station contours, then it must conduct a new coordination. This requirement will ensure that TV broadcast licensees have the most current information on white space device operations. We select 100 meters as the minimum change in location for which a new coordination is required since the tables of separation distances from TV station contours are rounded to the nearest 0.1 kilometer (100 meters). We see no benefit in requiring a new coordination for changes less than 100 meters.

29. We decline to require parties planning to operate white space devices with an HAAT above 250 meters to notify public safety or wireless microphone licensees prior to commencing operation, as requested by NPSTC, Sennheiser, and Shure.[61] Their services are very different from broadcast TV. In the case of broadcast TV, white space devices must protect a consumer receive-only service with very weak signal levels at long distances from the transmitter. By contrast, public safety licensees operate two-way voice and data systems, generally operate with much higher signal levels than those a consumer receives at the edge of a TV contour and could increase power if necessary. Wireless microphones also operate at significantly higher signal levels than those at the edge of a TV contour. In addition, the required separation distances from licensed wireless microphones are much shorter than those for broadcast TV and are in fact shorter than the distances over which HAAT is calculated (3 to 16 kilometers).[62] Therefore, we believe it is unnecessary to notify wireless microphone licensees of nearby white space devices operating at high HAAT since the HAAT is undefined at the wireless microphone's location.

30. *Antenna height above ground*. We previously increased the maximum permissible antenna height above ground from 30 meters to 100 meters in "less congested" areas in the *White Spaces Order on Reconsideration*.[63] We took this action to improve wireless broadband service to Americans in rural and other underserved areas, and stated that a 100-meter antenna height above ground limit will benefit wireless broadband providers and users by permitting antennas to be mounted on towers or other structures at heights sufficient to clear intervening obstacles such as trees and hills that would attenuate the transmitted signal, thereby increasing the range at which the signal can be received.[64]

31. In the Notice, we sought comment on whether to increase the antenna height above ground limit in addition to the HAAT limit, noting that antenna heights above ground and average terrain are directly related, in that any change to a device's antenna height above ground changes its HAAT by the same amount.[65] We further noted that limiting the antenna height above ground may also limit the maximum achievable HAAT in areas where the terrain is flat since in those areas the HAAT will be approximately the same as, or not significantly higher than, the antenna height above ground.[66] This means that the antenna height above ground limit (30 or 100 meters) may preclude white space device operators from taking advantage of a higher HAAT limit, or even the current 250-meter limit.[67] We

[61] NPSTC Comments at 7 (the Commission did not consider the need for notifications to T-Band PLMR licensees); Sennheiser Reply at 8 (the installing party should be required to notify all licensees in the area, including Part 74 licensed wireless microphone operators.); Shure Reply at 21 (qualifying public safety users, Part 74 wireless microphone operators, and all other affected licensees should be notified at least 10 business days in advance).

[62] To calculate the antenna HAAT, the average elevation of the surrounding terrain above mean sea level must be determined along at least 8 evenly spaced radials at distances from 3 to 16 kilometers from the transmitter site. The HAAT is the difference between the antenna height above mean sea level and the average elevation of the surrounding terrain. Thus, the HAAT calculation does not consider terrain at distances of less than 3 kilometers and greater than 10 kilometers. 47 CFR § 73.684(d).

[63] *White Spaces Order on Reconsideration*, 34 FCC Rcd at 1851, para. 64.

[64] *Id.*

[65] Notice, 35 FCC Rcd at 2108-09, paras. 24-25.

[66] Notice, 35 FCC Rcd at 2109, para. 25.

[67] *Id.*

sought comment on whether we should increase the antenna height above ground limit or remove it completely and rely only on HAAT since the separation distances from protected services are based on HAAT.[68] We also sought comment on whether modified rules should apply across the entire U.S. or only in certain areas, such as "less congested" areas.[69]

32. We eliminate the requirement that a fixed device's antenna height above ground may not exceed 30 meters generally or 100 meters in "less congested" areas.[70] Several parties support eliminating this requirement opining that it is unnecessary.[71] As we noted in the Notice, the separation distances from protected services are based on the antenna HAAT, and the HAAT already takes into account the antenna height above ground.[72] Therefore, there does not appear to be a need for a separate antenna height above ground limit, and limiting the height above ground can unnecessarily limit the maximum achievable HAAT. CP Communications and Sennheiser assert that the Commission has previously concluded that there is no general need to mount an antenna higher than the current limit to avoid shadowing by trees or other obstructions and that the current limit should therefore not be changed.[73] We acknowledge that the Commission did decide in the 2015 *White Spaces Order* that there was no need for a higher antenna height above ground limit. However, upon further consideration the Commission reversed its decision and decided that there was a need to increase this limit in "less congested" areas in the 2019 *White Spaces Order on Reconsideration*.[74] In that proceeding, the Commission stated "that real world experience has sufficiently demonstrated that increasing the allowable height above ground would be beneficial for operators in less congested areas" and that such a change would not increase the potential to cause harmful interference to other users.[75] In that same *White Spaces Order on Reconsideration,* the Commission noted Sennheiser's concern about potential interference to wireless microphones from a higher height limit, but concluded that limiting higher antenna height to less congested areas, where there are many vacant channels, ensures there will be sufficient spectrum resources in these areas for multiple spectrum users.[76] Finally, we note that no party provided specific information or analysis in response to the Notice showing that there is actually a need to retain an antenna height above ground limit.

33. However, we are not removing the 10-meter height above ground limit that applies to fixed white space devices operating within the protected contours of adjacent channel TV stations since

[68] Notice, 35 FCC Rcd at 2109, para. 26.

[69] *Id.*

[70] 47 CFR § 15.709(g)(1)(i).

[71] Broadband Connects America Coalition Comments at 12 (with higher HAAT and the adoption of terrain-based propagation modeling, there seems to be no reason to maintain a separate limit on height above ground level); Public Interest Spectrum Coalition Comments at 15 (since interference calculations are based upon HAAT instead of height AGL, a separate AGL metric is unnecessary); RADWIN Comments at 3 (supports allowing white space devices to operate at higher antenna heights above average terrain and above ground level); WISPA Comments at 8 (since interference calculations are based upon HAAT instead of height AGL, a separate AGL metric is unnecessary); Dynamic Spectrum Alliance Reply at 9 (the Commission should eliminate the height above ground level limit); Microsoft Reply at 10.

[72] Notice, 35 FCC Rcd at 2108-2109, para. 25.

[73] CP Communications Comments at 4 (the antenna height above ground level limit should remain unchanged since the Commission's previous reasoning for rejecting an increase remain valid); Sennheiser Comments at 5 (no changes should be made to height above ground level limit since there is no evidence of a need to change it at this time in any areas, rural or otherwise).

[74] *White Spaces Order*, 30 FCC Rcd at 9573, para. 57; *White Spaces Order on Reconsideration*, 34 FCC Rcd at 1851, para. 64.

[75] *White Spaces Order on Reconsideration*, 34 FCC Rcd at 1851, para. 66.

[76] *White Spaces Order on Reconsideration*, 34 FCC Rcd at 1851, para. 64.

the Notice did not seek comment on changing that limit and no party indicated a need to do so.[77] That height limit could be addressed at a future date.

3. Separation distances

34. We increase the minimum required separation distances between white space devices operating at higher power and HAAT and the following services in the TV bands: (1) broadcast television services, including low power; (2) receive sites of TV translators, low power TV stations, Class A TV stations, Multichannel Video Programming Distributors (MVPDs), and Broadcast Auxiliary Service (BAS) facilities; (3) private land mobile radio services and commercial mobile radio services (PLMRS/CMRS), and (4) licensed low power auxiliary service (LPAS) stations, including licensed wireless microphones. The increases we adopt today will protect these services from potentially receiving harmful interference as a result of expanded white space device operating parameters.

35. *Broadcast television services, including low power*. In the Notice, we proposed to expand the existing tables of minimum separation distances from broadcast television protected contours (both co-channel and adjacent channel) to include additional entries for fixed white space device operation at up to 500 meters HAAT and 42 dBm EIRP.[78] No party argues that the proposed separation distances from co-channel and adjacent channel TV station protected contours are inadequate to prevent interference to TV reception. However, several parties request that the Commission significantly change the methodology used to protect services in the TV bands. Dynamic Spectrum Alliance, WISPA, and Public Interest Spectrum Coalition argue that the Commission should determine white space channel availability using a terrain-based model, such as the Longley-Rice Irregular Terrain Model, which they assert will determine channel availability more accurately than the overly conservative current contour-based model.[79] NAB and Sennheiser, however, oppose using the Longley-Rice model due to concerns about its accuracy in protecting TV receivers and because it may slow operation of the white space database.[80]

36. We adopt the updated tables of separation distances from TV contours proposed in the Notice. As noted, NAB supported these proposed separation distances in its comments to Microsoft's petition.[81] In addition, we add a row at the end of each table (co-channel and adjacent channel) to include separation distances for white space devices with HAAT values over 500 meters and up to 550 meters,

[77] 47 CFR § 15.709(g)(1)(i). In the Notice, the Commission sought comment on whether to modify the 30 meter and 100-meter antenna height above ground limits that apply to fixed devices in general and did not address the 10-meter limit that applies to fixed devices operating inside the protected contour of adjacent channel TV stations. Notice, 35 FCC Rcd at 2109, paras. 25-26.

[78] Notice, 35 FCC Rcd at 2109-10, paras. 28-29.

[79] Dynamic Spectrum Alliance Reply at 4 (a terrain-based model can determine the separation distances to protect incumbent broadcasters with greater accuracy than the current methodology based on the F-curves and HAAT); WISPA Comments at 5 (the Longley-Rice ITM is a far more accurate method of predicting signal strength than the method currently used for white spaces); Public Interest Spectrum Coalition Comments at 11-12 (the Commission should authorize TV bands databases to employ terrain-based and other real-world propagation models such as the Longley-Rice Irregular Terrain Model methodology).

[80] NAB Reply at 2-3 (contour protection is the only reasonable way to adequately protect consumer TV receivers; television receiver protection requirements for TVWS devices are not overly conservative or based on worst-case assumptions and are already relaxed in comparison to other broadcast protection rules); Sennheiser Reply at 7 (no changes, i.e., Longley-Rice methodology, should be made that slow down the database system).

[81] NAB Comments, ET Docket No. 14-165 and RM-11840, at 3 (rec. Jun. 10, 2019) (Microsoft's petition sets forth its specific proposed separation distances, which appear to be correctly calculated based on the Commission's current rules.)

which will be used only for the purpose of determining which TV broadcast stations must be notified when a white space device operates with an HAAT of more than 450 meters and up to 500 meters.[82]

Fixed White Space Devices								
Antenna height above average terrain of unlicensed devices (meters)	**Required separation in kilometers from co-channel digital or analog TV (full service or low power) protected contour***							
	16 dBm (40 mW)	**20 dBm (100 mW)**	**24 dBm (250 mW)**	**28 dBm (625 mW)**	**32 dBm (1600 mW)**	**36 dBm (4 W)**	**40 dBm (10 W)**	**42 dBm (16 W)**
Less than 3	1.3	1.7	2.1	2.7	3.3	4.0	4.5	5.0
3 - 10	2.4	3.1	3.8	4.8	6.1	7.3	8.5	9.4
10 - 30	4.2	5.1	6.0	7.1	8.9	11.1	13.9	15.3
30 - 50	5.4	6.5	7.7	9.2	11.5	14.3	19.1	20.9
50 - 75	6.6	7.9	9.4	11.1	13.9	18.0	23.8	26.2
75 - 100	7.7	9.2	10.9	12.8	17.2	21.1	27.2	30.1
100 - 150	9.4	11.1	13.2	16.5	21.4	25.3	32.3	35.5
150 - 200	10.9	12.7	15.8	19.5	24.7	28.5	36.4	39.5
200 - 250	12.1	14.3	18.2	22.0	27.3	31.2	39.5	42.5
250 - 300	13.9	16.4	20.0	23.9	29.4	35.4	42.1	45.9
300 - 350	15.3	17.9	21.7	25.7	31.4	37.6	44.5	48.4
350 - 400	16.6	19.3	23.2	27.3	33.3	39.7	46.9	51.0
400 - 450	17.6	20.4	24.4	28.7	35.1	41.9	49.4	53.8
450 - 500	18.3	21.4	25.5	30.1	36.7	43.7	51.4	55.9
500 - 550	18.9	21.8	26.3	31.0	37.9	45.3	53.3	57.5

[82] As discussed above, a prospective white space device operator that plans to use an HAAT above 250 meters must notify potentially affected TV broadcast stations (both co-channel and adjacent channel) in advance of operation. Potentially affected stations are defined as those at less than the minimum required separation distance if the separation distance is calculated using the white space device's EIRP and an HAAT 50 meters higher than what the device will use. Because fixed white space devices in "less congested" areas may use an HAAT of up to 500 meters, it is necessary to include an additional row of separation distances in the table for an HAAT of up to 550 meters.

Fixed White Space Devices							
Antenna height above average terrain of unlicensed devices (meters)	**Required separation in kilometers from adjacent channel digital or analog TV (full service or low power) protected contour***						
	20 dBm (100 mW)	**24 dBm (250 mW)**	**28 dBm (625 mW)**	**32 dBm (1600 mW)**	**36 dBm (4 W)**	**40 dBm (10 W)**	**42 dBm (16 W)**
Less than 3	0.1	0.1	0.1	0.1	0.2	0.2	0.3
3 - 10	0.1	0.2	0.2	0.2	0.3	0.4	0.5
10 - 30	0.2	0.3	0.3	0.4	0.5	0.6	0.7
30 - 50	0.3	0.3	0.4	0.5	0.7	0.8	1.0
50 - 75	0.3	0.4	0.5	0.7	0.8	0.9	1.0
75 - 100	0.4	0.5	0.6	0.8	1.0	1.1	1.3
100 - 150	0.5	0.6	0.8	0.9	1.2	1.3	1.5
150 - 200	0.5	0.7	0.9	1.1	1.4	1.5	1.7
200 - 250	0.6	0.8	1.0	1.2	1.5	1.7	1.9
250 - 300	0.7	0.8	1.0	1.3	1.6	2.1	2.3
300 - 350	0.7	0.9	1.1	1.4	1.8	2.2	2.4
350 - 400	0.8	1.0	1.2	1.5	1.9	2.4	2.7
400 - 450	0.8	1.0	1.3	1.6	2.1	2.6	2.9
450 - 500	0.8	1.1	1.4	1.7	2.1	2.7	2.9
500 - 550	0.9	1.2	1.5	1.8	2.2	2.8	3.0

37. We decline at this time to alter the current method of protecting TV stations (i.e., minimum separation distances outside of defined protected contours) by changing to a terrain-based model as requested by some parties.[83] The Commission did not propose to make this change in the Notice. However, we recognize parties' arguments that more sophisticated propagation models could possibly identify unused TV spectrum more accurately than the current contour-based model while still protecting TV service from harmful interference.[84] In the Further Notice of Proposed Rulemaking, we seek comment on the use of terrain-based propagation models to develop a more complete record on the issue.

38. *Receive sites of TV translators, low power TV stations, Class A TV stations, MVPDs, and BAS facilities*. In the Notice, we proposed to modify the keyhole-shaped exclusion zone around receive

[83] Dynamic Spectrum Alliance Reply at 4 (a terrain-based model can determine the separation distances to protect incumbent broadcasters with greater accuracy than the current methodology based on the F-curves and HAAT); WISPA Comments at 5 (the Longley-Rice ITM is a far more accurate method of predicting signal strength than the method currently used for white spaces); Public Interest Spectrum Coalition Comments at 11-12 (the Commission should authorize TV bands databases to employ terrain-based and other real-world propagation models such as the Longley-Rice Irregular Terrain Model methodology).

[84] *Id.*

sites where white space devices may not operate.[85] For fixed devices operating with an EIRP of greater than 10 watts, we proposed to increase the minimum required separation distance from the receive site from 10.2 kilometers to 16.6 kilometers co-channel, and from 2.5 kilometers to 3.5 kilometers adjacent channel, over an arc of more than ±30 degrees outside the main lobe of the receive antenna.[86] We proposed no changes to the minimum required separation distances from a receive site (80 kilometers co-channel and 20 kilometer adjacent channel) within a ±30 degrees arc in the main lobe of the receive antenna.[87] No party argued that the proposed changes are insufficient to protect these receive sites from higher power white space device operation. As such, we adopt our proposal.

39. *Private land mobile radio services and commercial mobile radio services* (*PLMRS/CMRS*). We proposed to increase the minimum required separation distances between fixed white space devices operating at greater than 10 watts EIRP and PLMRS/CMRS operations, which include public safety operations, on TV channels 14-20 (the T-Band) in 11 major markets and in some additional areas under rule waivers.[88] In the 11 markets where PLMRS/CMRS stations are permitted to operate in the TV bands, we proposed to increase the minimum required separation distance beyond the defined city center coordinates from 136 kilometers to 139.2 kilometers co-channel, and from 131.5 kilometers to 132.2 kilometers adjacent channel.[89] We also proposed to increase the minimum separation distance from PLMRS/CMRS base stations operating under a waiver outside the 11 markets from 56 kilometers to 59.2 kilometers co-channel and from 51.3 kilometers to 52.2 kilometers adjacent channel.[90] NPSTC argues that these proposed separation distances need to be increased to reflect both the higher power and the higher HAAT proposed and provided a table of recommended separation distances.[91]

40. We will increase the proposed separation distances between PLMRS/CMRS operations and fixed white space devices operating with an HAAT of greater than 250 meters to properly reflect the increase in HAAT of up to 500 meters we are permitting in "less congested" areas.[92] No party objected to NPSTC's suggested separation distances, and we believe that they will adequately protect PLMRS/CMRS operations from white space device operations at the higher power and HAAT levels we are permitting. However, we also recognize Microsoft's suggestion that if the separation distances to protect PLMRS/CMRS are increased, they should be provided on a stepped basis, rather than based on the assumption that all white space devices operate at a maximum HAAT of 500 meters, to avoid needlessly making areas off limits to white space devices.[93] We agree that this approach will maximize the amount

[85] Notice, 35 FCC Rcd at 2111, para. 31. White space devices are prohibited from operating co-channel and adjacent channel to the TV channel(s) being received by these facilities over an arc of ±30 degrees from a line between the receive site and each associated transmitter, i.e., in the main lobe of the receive antenna. The protection zone extends to a maximum distance of 80 kilometers from the protected receiver toward its associated transmitter for co-channel operations and to 20 kilometers for adjacent channel operation. In addition, to prevent interference from white space device signals outside the main lobe of the protected receive antenna, white space devices are prohibited from operating within a circular area of 10.2 kilometers co-channel and 2.5 kilometers adjacent channel from the receive sites in all directions off the ±30 degree arc when a white space device operates at an EIRP between four and ten watts. 47 CFR § 15.712(b)-(c).

[86] Notice, 35 FCC Rcd at 2111, para. 32.

[87] *Id.*

[88] Notice, 35 FCC Rcd at 2111-12, para. 33. PLMRS/CMRS operations are protected from harmful interference from white space devices through a circular exclusion zone extending from the center of each market, or from specific geographic coordinates for operations under a waiver. 47 CFR § 15.712(d).

[89] Notice, 35 FCC Rcd at 2112, para. 33.

[90] *Id.*

[91] NPSTC Comments at 5; NPSTC Reply at 5-7.

[92] *Id.*

[93] Microsoft Reply at 8-9.

of spectrum available for white space devices while protecting the PLMRS/CMRS from white space devices operating at higher power and antenna heights. We will therefore specify protection distances for the PLMRS/CMRS for three power level ranges (i.e., up to 4 watts EIRP, greater than 4 and up to 10 watts EIRP, and greater than 10 watts and up to 16 watts EIRP), and for two ranges of HAAT (i.e., up to 250 meters, and greater than 250 meters and up to 500 meters). We adopt our proposed separation distances for the lower HAAT range, and NPSTC's suggested separation distances for the higher HAAT range.

41. In the *T-Band NPRM*, we sought comment on reallocating T-Band spectrum, assigning new licenses by auction for that spectrum in each of the 11 markets areas where the PLMRS/CMRS currently operates, and relocating "public safety eligibles" from this band.[94] We proposed rules that would allow for flexible use in the auctioned T-Band, including wireless use, and also proposed to permit broadcast operations. If we adopt rules to allow new types of licensed services in the T-Band, white space devices would operate on a non-interference basis to them as they do with the current PLMRS/CMRS services in the bands. To the extent that any future services in the T-Band have a different potential for receiving interference than the PLMRS/CMRS, we may need to adjust the minimum separation distances that white space devices must meet.

42. The following two tables show the minimum required separation distances from the 11 metropolitan areas where the PLMRS/CMRS can operate in the TV bands, and from PLMRS/CMRS operations authorized under waivers of the rules.

	Required separation in kilometers from the areas specified in §90.303(a) of this chapter			
	Co-channel operation		**Adjacent channel operation**	
White space device transmitter power	**Up to 250 meters HAAT**	**Greater than 250 meters HAAT**	**Up to 250 meters HAAT**	**Greater than 250 meters HAAT**
Up to 4 watts EIRP	134.0	158.0	131.0	155.4
Greater than 4 watts and up to 10 watts EIRP	136.0	169.8	131.5	166.0
Greater than 10 watts and up to 16 watts EIRP	139.2	171.1	132.2	166.2

	Required separation in kilometers from operations authorized by waiver outside of the areas specified in §90.303(a) of this chapter			
	Co-channel operation		**Adjacent channel operation**	
White space device transmitter power	**Up to 250 meters HAAT**	**Greater than 250 meters HAAT**	**Up to 250 meters HAAT**	**Greater than 250 meters HAAT**
Up to 4 watts EIRP	54.0	78.0	51.0	75.4
Greater than 4 watts and up to 10 watts EIRP	56.0	89.8	51.5	86.0

[94] *Reallocation of 470-512 MHz (T-Band) Spectrum,* PS Docket No. 13-42, Notice of Proposed Rulemaking, 35 FCC Rcd 6896 (2020) (*T-Band NPRM*).

Greater than 10 watts and up to 16 watts EIRP	59.2	91.1	52.2	86.2

43. *LPAS stations, including licensed wireless microphones.* We proposed an increase from one kilometer to 1.3 kilometers in the minimum required separation distance between fixed white space devices operating with greater than 10 watts EIRP and registered licensed wireless microphones.[95] Sennheiser and Shure argue that the proposed separation distances to protect licensed wireless microphones should be increased, and they provided a table of recommended distances.[96] Microsoft, however, argues that there is no need to increase the separation distances in the manner Sennheiser and Shure propose.[97]

44. We increase the minimum required separation distance between fixed white space devices operating with a power level greater than 10 watts EIRP and licensed wireless microphones as proposed in the Notice.[98] This will provide the same level of protection to wireless microphones as the current rules based on a conservative free space propagation model.[99]

45. We decline to require even greater separation distances from wireless microphones as suggested by Sennheiser and Shure.[100] We first note that no party challenged the Commission's 2015 decision to increase the maximum power for fixed white space devices to 10 watts in "less congested" areas without also increasing the one-kilometer separation distance from wireless microphones.[101] We also note that we did not propose to increase the existing one-kilometer separation distance in the Notice, and we believe it would be inappropriate in these circumstances to take such an action based on this record. As a separate and independent basis for our decision, we do not believe that Sennheiser's suggested increased separation distances for higher HAAT operations are appropriate. HAAT is defined and calculated along radials at a distance of three to 16 kilometers from a transmitter site, i.e., HAAT is not defined for distances less than three kilometers.[102] The majority of Sennheiser's suggested separation distances are at distances of less than three kilometers, which is shorter than the distance (3-16 kilometers) over which HAAT is defined.[103] Moreover, because higher HAAT operations are expected to be coupled with higher power operations to reach greater distances, the rules require use of a directional antenna which will both direct energy towards the horizon (rather than downward) and minimize the

[95] Notice, 35 FCC Rcd at 2112, para. 34.

[96] Sennheiser Comments at 5-7; Shure Reply at 30.

[97] Microsoft Reply at 9 (Sennheiser's proposed distances are substantially over-protective and are an attempt to re-litigate the existing 1-km separation distance for TVWS operations between 4 watts and 10 watts EIRP.)

[98] Notice, 35 FCC Rcd at 2112, para. 34.

[99] 47 CFR § 15.712(f). This section requires that fixed white space devices, which can operate with a power level of up to 10 watts EIRP, be separated from licensed low power auxiliary service stations (including wireless microphones) by 1 kilometer.

[100] Sennheiser Comments at 5-7; Shure Reply at 30-31.

[101] *White Spaces Order*, 30 FCC Rcd at 9575-77, para. 58-61. The Commission increased the minimum separation distances between white space devices operating at power levels above 4 watts EIRP and: 1) TV station contours; 2) the receive sites of broadcast auxiliary service facilities, TV translators, low power TV stations, Class A TV stations and multichannel video program distributors; and 3) the PLMRS/CMRS. The Commission also prohibited higher power white space device operation on channels 36 and 38 to protect radio astronomy and wireless medical telemetry services on channel 37. However, the Commission made no changes to the one-kilometer separation distance from wireless microphones.

[102] 47 CFR § 15.709(g)(1)(ii). This section refers to the methodology for calculating HAAT in Section 73.684(d).

[103] Sennheiser Comments at 7.

energy outside the main beam. This, in effect, will minimize white space signal strength at nearby wireless microphones. Thus, we do not believe there would be any benefit to wireless microphones by increasing the separation distance requirements. In fact, the directional antenna requirement may actually provide a better operating environment for wireless microphones in such situations.

B. Definition of "less congested" area

46. In the Notice, we sought comment on whether any changes are necessary to the definition of "less congested" area given that many of the proposals were limited to those areas.[104] "Less congested" locations are typically rural or semi-rural areas and are defined as those where at least half of the TV channels within a device's particular TV sub-band of operation (i.e., the low VHF (channels 2-6), the high VHF (channels 7-13), or the UHF (channels 14-36) band) are unused for broadcast and other protected services and are available for white space device use.[105] We sought comment on whether the current definition is still appropriate, and if not, what the appropriate metric for defining "less congested" area would be.[106] In addition, because the number of vacant channels at a location can vary based on the EIRP and HAAT of a white space device, we sought comment on whether we should define vacant channels depending on particular antenna height and power level.[107]

47. We will continue to define "less congested" areas as those where at least half of the TV channels in the bands that will continue to be allocated and assigned only for broadcast service are unused for broadcast and other protected services and available for white space device use. Areas where the spectrum is less congested generally correspond to rural and unserved areas that will benefit from improved broadband coverage, and the current definition provides a simple way for the white space database to identify these areas where we permit higher power and antenna heights to improve broadband coverage. In addition, in areas where the spectrum is less congested, there is less likelihood that white space devices operating at higher power and antenna heights will cause interference to protected services in the TV band. We agree with wireless microphone operators that the current definition should be retained because spectrum is a scarce resource and it is therefore appropriate to base the definition on how much spectrum is available at a given location rather than population density.[108]

48. Shure states that to the extent there are concerns about accounting for the number of vacant channels with variations in white space device EIRP and HAAT, we can address this by defining vacant channels at a particular antenna height and power level.[109] While no party suggested a specific white space device EIRP and HAAT that should be used in determining TV channel availability, we note that the Commission stated in the 2015 *White Spaces Order* that vacant channels would be defined as those available for fixed white space devices operating with an EIRP of 40 milliwatts and an HAAT of 3 meters, although it did not codify this decision.[110] Since no party suggested specific criteria for determining channel availability in response to the Notice, we retain and codify the Commission's 2015

[104] Notice, 35 FCC Rcd at 2113, para. 36.

[105] 47 CFR § 15.703(h). The requirement to identify "less congested" areas over three separate TV bands (low VHF, high VHF and UHF) was specified in the 2015 *White Spaces Order* but is not codified in the rules. *White Spaces Order*, 30 FCC Rcd at 9573, para. 54.

[106] *Id.*

[107] *Id.*

[108] CP Communications Comments at 5-6 (because the goal in this proceeding is to allocate limited spectrum resources, it is appropriate to define less congested areas in terms of spectrum use as opposed to population density); Edgar C. Reihl Comments at 3; Sennheiser Comments at 7; Shure Comments at 15 (a shift to a population-based definition would introduce too many complications and administrative burdens;); Lectrosonics Reply at 2 (the definition of "less congested" areas is correct and should remain unchanged).

[109] Shure Comments at 15.

[110] *White Spaces Order*, 30 FCC Rcd at 9574, para. 54.

decision by specifying the power and antenna heights used to determine TV channel availability in the definition of "less congested" area in Section 15.703.

49. In addition, we clarify the definition of "less congested" area by codifying the Commission's decision in the 2015 *White Spaces Order* that "less congested" areas are calculated by the white space database in the three TV bands separately: the low VHF band (channels 2-6), the high VHF band (channels 7-13) and the UHF band (channels 14-36).[111] We decline to significantly modify the definition of "less congested" areas as suggested by some parties.[112] For the reasons described above, we find that the current definition, with certain modifications, is the appropriate metric for determining which areas are "less congested". We also decline Dynamic Spectrum Alliance's request to modify the definition of "less congested" area to consider all TV bands together (low VHF, high VHF and UHF) in determining vacant channel availability and whether an area qualifies as less congested.[113] The higher frequency UHF TV band (470-608 MHz) is more heavily used by TV stations, white space devices, and wireless microphones than the lower frequency VHF TV bands (54-72 MHz, 76-88 MHz and 174-216 MHz) due to factors such as the shorter radio wavelengths and smaller required antennas. Moreover, because the TV bands are not contiguous, determining "less congested" areas based on considering all TV bands together may not produce a result that is representative of the actual spectrum congestion in the specific band where a white space device will operate. Thus, we believe it is appropriate to continue determining "less congested" areas on a band-by-band approach, rather than by considering all TV bands together.

C. Higher power mobile operation within "geo-fenced" areas

50. The white space rules permit two general classes of devices: fixed and personal/portable, with personal/portable devices further subdivided into two types: Mode I and Mode II.[114] Fixed and Mode II personal/portable devices must incorporate a geo-location capability to determine their coordinates and access a database to determine the available channels at those specific coordinates.[115] The current rules permit fixed white space devices to operate with up to 4 watts EIRP generally, and up to 10 watts in "less congested" areas, which we are increasing to 16 watts as discussed above. Personal/portable devices may operate with a maximum EIRP of 100 milliwatts.[116] A Mode II personal/portable device must re-check its coordinates every 60 seconds and contact the database for an updated list of available channels if it changes location by more than 100 meters.[117] Additionally, Mode II personal/portable devices may load channel availability information for multiple locations from the white space database and use that information to define a geographic area within which it can operate on a mobile basis (on the same available channels at all locations within that geographic area); the device must

[111] *White Spaces Order*, 30 FCC Rcd at 9573, para. 54.

[112] Public Interest Spectrum Coalition Comments at 14 (the definition is unnecessarily restrictive because it is tied to the number of TV stations in operation rather than the specific interference environment); RED Technologies Comments at 4 (does not support Nominet's proposal to redefine "less congested" in terms of population density but agrees that any definition which is subject to change without notice has the unintended and undesirable effect of intolerable risk to operators relying on it); WISPA Comments at 11 (if interference calculation is shifted to the irregular terrain model, then the "less congested" area approach should become unnecessary).

[113] Dynamic Spectrum Alliance Comments at 13.

[114] 47 CFR § 15.703(f),(m). There are two types of personal/portable devices. Mode II devices obtain a list of available channels directly from a white space database, and Mode I devices obtain a list of available channels through a fixed device or a Mode II portable device. 47 CFR § 15.703(i)-(j).

[115] 47 CFR § 15.711(c)(1), (d)(1).

[116] 47 CFR § 15.709(a)(2)(ii). The maximum permissible 100 milliwatts radiated power is the same for both Mode I and Mode II devices.

[117] 47 CFR § 15.711(d)(1)-(2).

contact the database again, however, if it moves beyond the boundary of the area where the channel availability information is valid.[118] No device manufacturers or database systems have yet implemented this provision.

51. In the Notice, we proposed to allow white space devices to operate on TV Channels 2-35 on mobile platforms within geo-fenced areas at higher power levels than the rules currently permit for personal/portable devices, and proposed to limit such operations to "less congested" areas to limit their potential for causing harmful interference.[119] We proposed to permit a higher power Mode II white space device installed on a movable platform to load channel availability information for multiple locations in the vicinity of its current location and to use that information to define a geo-fenced area within which it can operate on the same available channels at all locations.[120] We also proposed to require that the white space device's location be checked at least once every 60 seconds while in operation (unless in "sleep" mode).[121] We further proposed that a device may not use channel availability information for multiple locations if or when it moves closer than 1.6 kilometers to the boundary of the geo-fenced area in which the device operates, or at any point outside that boundary; this requirement would ensure that a device moving at 60 miles per hour (1.6 kilometers per minute) does not cross outside the boundary between device re-checks of its location.[122] Additionally, we proposed to prohibit operation on board aircraft or satellites to limit the range at which harmful interference could occur.[123]

52. We sought comment on a number of equipment issues for higher power geo-fenced mobile operations, including whether to permit fixed devices to operate on mobile platforms, the antenna and equipment authorization requirements that should apply, and whether we should establish a new class of higher power mobile device to distinguish such devices from personal/portable white space devices.[124] We also sought comment on other requirements for higher power mobile white space devices, including whether to place limitations on the size of the area over which a geo-fenced mobile device could operate, the appropriate maximum power, whether there is a need to specify how information on an area will be provided to the white space database, and any other safeguards needed to ensure that higher power mobile devices do not cause harmful interference to protected operations.[125] We further sought comment on whether there is a need to prohibit operation on other mobile platforms such as trains and boats.[126]

53. We permit the operation of higher power mobile devices within defined geo-fenced areas in "less congested" areas, as proposed in the Notice.[127] A number of parties support this change, stating that it will benefit Americans in rural and underserved areas by permitting new agricultural applications and enabling broadband communications with moving vehicles such as school buses.[128] We will

[118] 47 CFR § 15.711(d)(5). This provision applies to Mode II devices, which obtain a list of available channels directly from the white space database.

[119] Notice, 35 FCC Rcd at 2114, para. 39.

[120] Notice, 35 FCC Rcd at 2114, para. 40.

[121] *Id.*

[122] Notice, 35 FCC Rcd at 2114-15, para. 40.

[123] Notice, 35 FCC Rcd at 2115, para. 40.

[124] Notice, 35 FCC Rcd at 2115, para. 41.

[125] Notice, 35 FCC Rcd at 2115, para. 42.

[126] *Id.*

[127] Notice, 35 FCC Rcd at 2114, para. 39.

[128] ACT | The App Association Comments at 9-10; Connect Americans Now Comments at 1; Consumer Technology Association Comments at 4; Dynamic Spectrum Alliance Comments at 15; Microsoft Comments at 19; Public Interest Spectrum Coalition Comments at 16-17; RADWIN Comments at 4; RED Technologies Comments at 5.

implement this change by establishing a new class of higher power mobile white space device, rather than by modifying the Mode II personal/portable device rules as proposed in the Notice and supported by Shure and Sennheiser, or by allowing fixed devices to operate on mobile platforms as suggested by Microsoft in its petition and supported by RED Technologies.[129] We agree with commenters that establishing a new class of mobile white space device would be simpler than modifying the Mode II personal/portable device rules to permit higher power operation, and that this approach is more congruous than an approach providing for a fixed device on mobile platform as initially suggested by Microsoft.[130] We will use the term "mobile device" to refer to this class of white space devices to distinguish them from personal/portable white space devices. As suggested by Shure, we are clearly indicating in the rules that mobile devices may operate only in "less congested" areas by adding this requirement to the definition of "mobile white space device."[131]

54. We will permit mobile devices to operate at the same radiated power level permitted for fixed devices in "less congested" areas, i.e., up to 16 watts EIRP. This power level will enable the provision of new types of mobile broadband services in rural and other unserved areas. Because we are permitting power levels that are the same as fixed devices, we believe that many of the technical requirements that apply to fixed devices are also appropriate for the new class of mobile white space devices. Accordingly, we will require mobile devices to comply with the same transmitter power limits as fixed devices, including maximum in-band power, adjacent channel emissions, power spectral density, and out-of-band emissions, as well as require them to meet the same antenna gain requirements as fixed devices.[132] Under these requirements, a mobile device will be permitted to operate with a maximum transmitter power output of one watt, and can use an antenna with a gain of up to 12 dBi to achieve an EIRP of 16 watts. If the maximum gain of the antenna exceeds 12 dBi, then the transmitter power must be reduced by the same amount in dB that the antenna gain exceeds 12 dBi. Because mobile devices change direction as they travel, we will permit the use of electrically steerable directional antennas to help enable mobile devices to remain in contact with their associated base unit or another mobile device.

55. The white space database will determine channel availability over a defined geo-fenced area where a mobile device will operate. In order to provide flexibility for manufacturers and mobile device operators, we do not specify how the boundaries of an area are entered into and stored within the white space database or a mobile device. We do, however, require that both the white space database and mobile device contain the same boundary information. This requirement will ensure that mobile devices operate only where the database has determined available channels. Because mobile devices will operate at the same maximum power level as fixed devices, we will require that the database use the same minimum required separation distances from protected services in the TV bands as fixed devices in determining available channels. This includes all protected services, including the PLMRS/CMRS, as noted by NPSTC.[133] For simplicity of operation, we will require that any channel identified by the

[129] Notice, 35 FCC Rcd at 2114, para. 39; Sennheiser Reply at 6; Shure Reply at 6; Microsoft Petition at 22; RED Technologies Comments at 5 (classifying these as higher power Mode II devices would require substantial re-work of the rules; this use-case is best represented as a fixed device on a movable platform).

[130] Dynamic Spectrum Alliance Reply at 11 (creating a new category of white space device is cleaner than trying to fit this type of operation into existing WSD categories); Microsoft Comments at 23-24 (adding a new "mobile white space device" class to the rules would be simple and would not require as many modifications to the existing device class rules);; Microsoft Petition at 22.

[131] Letter from Catherine Wang, Counsel to Shure Incorporated, to Marlene H. Dortch, Secretary, FCC, dated Oct. 20, 2020 at 9-10 (Shure Oct. 20, 2020 *ex parte*). *See* Section 15.703 in Appendix A. We also make minor word edits to Section 15.709(a)(5).

[132] 47 CFR § 15.709(b)-(d).

[133] NPSTC Reply at 8.

database as available within the geo-fenced area must be available at the same power level over an entire geo-fenced area.[134]

56. We recognize that there are some complexities in determining the available channels over a contiguous geo-fenced area. The current white space database system determines channel availability at discrete locations since it was designed to implement rules that require devices to determine their geographic coordinates at a single location and submit those coordinates to the database when requesting a list of available channels.[135] The database system would have to use a modified methodology for determining available channels over a geo-fenced area. For example, it could divide the area into cells, e.g., 100 by 100-meters, and determine channel availability within each cell. We will not prescribe the exact method that database administrators must use to determine channel availability within geo-fenced areas, but mobile white space devices must comply with the minimum required separation distances from protected services at any point within a geo-fenced area. The white space database will have to consider a mobile device's HAAT in determining available channels and consider any variation in HAAT over a geo-fenced area to determine whether a channel is available over the entire area. To simplify calculations, we will permit the database to use only the highest, i.e., worst case, HAAT within a geo-fenced area in determining channel availability rather than having to calculate the HAAT at each location. We see no reason to limit the size of the geo-fenced area since mobile devices will only be permitted to operate in areas where the spectrum is "less congested." The requirement that a channel must be available over an entire geo-fenced area will tend to preclude extremely large areas since there is less likelihood that the same TV channel will be vacant over a very large contiguous area.

57. Because a mobile device must be able to accurately determine its location, we will require that a mobile device comply with similar geo-location requirements to fixed devices. Specifically, we will require that a mobile device incorporate a geo-location capability that is capable of determining its location and geo-location uncertainty (expressed in meters), with a confidence level of 95%.[136] To provide flexibility in the design of mobile devices, we will permit the use of a remote geo-location unit as the rules permit for fixed devices, provided the remote unit is located on the same moveable platform as the mobile device, e.g., bus or tractor.[137] To ensure that a mobile device is capable of determining whether it is within a geo-fenced area, we will require that a mobile device have the ability to store information on the boundaries of a geo-fenced area in which it will operate.

58. While we proposed in the Notice to require a mobile white space device operating within a geo-fenced area to re-check its geographic coordinates at least once every 60 seconds and to cease operation if it travels closer than 1.6 kilometers to the edge of the geo-fenced area or is outside the boundary of the area, we agree with Shure that this proposed distance should be slightly increased to account for vehicles traveling at allowable highway speed limits. The proposed buffer requirement was intended to ensure that a mobile white space device traveling at 60 miles per hour (1.6 kilometers per minute) does not cross outside the geo-fenced area between location checks. However, we recognize Shure's argument that many vehicles travel faster than this speed.[138] We disagree with Shure's contention that a 2.7-kilometer buffer is necessary because that corresponds to an atypical vehicle speed of more than 100 miles per hour, but note that Shure believes an increase in the buffer zone size to 1.9 kilometers (corresponding to a vehicle speed of just over 70 miles per hour) would be an improvement over the

[134] NAB Reply at 6-7 (allowing channel availability to vary as suggested by PISC would substantially increase complexity). As an example, if a channel is available at 4 watts in some portions of a geo-fenced area and 16 watts in others, the database would have to report the channel as being available at 4 watts since that power level would be available over the entire geo-fenced area.

[135] 47 CFR § 15.711(c)-(d).

[136] 47 CFR § 15.711(b).

[137] 47 CFR § 15.711(c).

[138] Shure Oct. 20, 2020 *ex parte* at 6-7.

Commission's proposal of 1.6 kilometers.[139] Accordingly, we adopt the proposed location re-check interval of 60 seconds, but increase the size of the geo-fenced area buffer from the proposed 1.6 kilometers to 1.9 kilometers.

59. We limit operation of mobile devices to "less congested" areas as proposed in the Notice.[140] We believe that the primary applications for mobile devices will be in more rural areas, and limiting the new class of higher power mobile device to areas with more available spectrum will limit the likelihood of interference to authorized services in the TV bands as well as enable all unlicensed devices, including other white space devices and unlicensed wireless microphones, to have an opportunity to access spectrum in the TV bands. To limit the distance at which mobile devices could cause interference to authorized services, we will prohibit their operation on satellites and aircraft as proposed in the Notice.[141] This prohibition of operation on aircraft will include unmanned aerial vehicles (e.g., drones).[142]

60. We see no reason to specially limit the maximum height above ground level for mobile devices or to preclude operation on cranes or bucket trucks as suggested by NAB and others.[143] We will require a mobile device to report its height above ground to the white space database as is required for fixed devices, and the database will take the antenna height above ground into consideration when calculating a mobile device's HAAT and the available channels within a geo-fenced area. Thus, a higher antenna height above ground will not increase the likelihood of interference to authorized services as parties suggest. We also see no reason to make any special requirements regarding the directivity of mobile device antennas, i.e., larger buffer zones, as suggested by Shure.[144] The required size of the buffer zone is a function of a mobile device's speed and re-check interval and is independent of the power level used.[145]

D. Narrowband IoT operations

61. Under current rules, fixed white space devices operating with 4 watts or greater EIRP must comply with a power spectral density (PSD) limit of 12.6 dBm per 100 kilohertz, which limits total conducted power within any 6-megahertz television channel to 30 dBm.[146] The PSD limit is proportionally lower for devices operating at lower EIRP levels.[147] The Commission established PSD limits to prevent multiple white space devices from simultaneously operating at the maximum allowable power with transmit bandwidths of less than six megahertz within a single television channel, which would result in a total transmitted power within that channel significantly greater than the limit.[148] The

[139] Shure Oct. 20, 2020 *ex parte* at 7-8. A vehicle would have to travel at greater than 2.7 kilometers per minute to pass beyond the edge of a 2.7-kilometer buffer zone between 60 second location checks. This corresponds to a vehicle speed of 162 kilometers per hour, or 100.7 miles per hour.

[140] Notice, 35 FCC Rcd at 2114, para. 39.

[141] Notice, 35 FCC Rcd at 2115, para. 40.

[142] NAB Reply at 7 (geo-fenced operations should not be permitted on drones).

[143] NAB Reply at 7; Sennheiser Reply at 6; NPSTC Comments at 9.

[144] Shure Reply at 11.

[145] A larger buffer zone would be required if a mobile device checked its position less frequently, or if the assumed maximum speed of the mobile device were greater.

[146] 47 CFR § 15.709(b)(1)(iii).

[147] *Id.*

[148] A PSD limit prohibits high power concentrations in a single channel, which reduces the interference potential to TV stations and other services in the TV bands. *Unlicensed Operation in the TV Broadcast Bands and Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket Nos. 04-186 and 02-380, Second Memorandum Opinion and Order, 25 FCC Rcd 18661, 18695, para. 83 (2010).

PSD limits were calculated based upon a single white space device spreading its energy uniformly across a 6-megahertz television channel bandwidth, excluding 250 kilohertz near each channel edge for roll-off, and serve to limit the maximum power of white space devices with bandwidths of less than 6-megahertz.[149]

62. In the Notice, we proposed changes to the white space rules to facilitate narrowband (e.g., 100 kilohertz) IoT device deployment on TV channels 2-35. The proposed rules would permit white space devices to operate with narrowband carriers rather than having to spread all of their energy across a six megahertz channel, and are designed to ensure that narrowband white space devices have no greater interference potential than wider bandwidth devices operating under the current rules. Specifically, we proposed to define a "narrowband white space device" as a type of fixed or personal/portable white space device operating in a bandwidth of no greater than 100 kilohertz.[150] We also proposed that narrowband white space devices be client devices that communicate with a fixed or Mode II master device that contacts the white space database to obtain a list of available channels and operating powers at its location.[151] In this connection, the Commission also sought comment on whether the proposed definition for narrowband white space device is appropriate for the intended IoT applications.[152]

63. We proposed to permit narrowband white space devices to operate with the same conducted PSD limit, adjacent channel emission limits, and antenna gain requirements as 4-watt fixed devices.[153] To ensure that the total energy in a single TV channel does not cause harmful interference, we proposed to limit each transmitter to transmissions totaling no more than 10 seconds per hour.[154] We further proposed to require narrowband devices to use a channel plan that limits total transmitted power in a six-megahertz channel to no higher than the existing limits for a four-watt EIRP broadband white space device.[155] Although we declined to propose requiring narrowband devices to use a listen-before-talk mechanism, we nonetheless sought comment on whether one would be necessary to prevent harmful interference to protected services in the TV bands.[156] We also sought comment on whether there is a need to increase the minimum separation distances from co-channel and adjacent channel TV station contours as the rules require for personal/portable devices operating as clients.[157]

64. We modify the rules to facilitate the development of new and innovative narrowband IoT devices in the TV bands. Specifically, we establish a new class of "narrowband white space device," which we define as a type of fixed or personal/portable white space device operating in a bandwidth of no greater than 100 kilohertz. A number of parties support our proposals to modify the white space rules to permit narrowband IoT operations.[158] In response to specific comment sought on the definition of a

[149] *White Spaces Third MO&O,* 27 FCC Rcd at 3703-04, para. 30.

[150] Notice, 35 FCC Rcd at 2117, para. 45.

[151] *Id.*

[152] Notice, 35 FCC Rcd at 2117, para. 49.

[153] Notice, 35 FCC Rcd at 2117, para. 46.

[154] *Id*. The Commission stated that this proposal would prevent narrowband IoT devices from being used for data intensive applications, including continuous transmissions, transmissions of audio and video or remote control of toys.

[155] Notice, 35 FCC Rcd at 2117, para. 47.

[156] Notice, 35 FCC Rcd at 2118, para. 48-49.

[157] Notice, 35 FCC Rcd at 2118, para. 49.

[158] ACT | The App Association Comments at 10; Broadband Connects America Coalition Comments at 16; Consumer Technology Association Comments at 4; Dynamic Spectrum Alliance Comments at 18; Microsoft Comments at 25; Midwest Food Products Association Comments at 1; NPSTC Comments at 10; Public Interest Spectrum Coalition Comments at 20; RED Technologies Comments at 8.

narrowband white space device, we expand that definition to include master devices as well as clients.[159] This change is suggested by Dynamic Spectrum Alliance and Microsoft to enable greater flexibility in the design of IoT networks.[160] No party opposed this change. A narrowband device that operates as a client must communicate with a master device that contacts the white space database to obtain a list of available channels and operating powers at its location, while a narrowband device that acts as a master must incorporate a geo-location mechanism and be capable of obtaining lists of available channels and operating powers from the white space database. We permit all types of white space devices that incorporate geo-location and have database access (fixed, Mode II, mobile and narrowband) to act as a master device to a narrowband client device. TV band frequencies are better able to penetrate foliage and other obstacles than higher frequencies, so this action will permit the development of IoT devices with improved transmission range.

65. As proposed in the Notice, we permit narrowband white space devices to operate with a conducted PSD of up to 12.6 dBm/100 kilohertz, which is the same maximum level permitted for fixed devices, and require narrowband devices to comply with the same maximum antenna gain requirements as fixed devices, i.e., a maximum antenna gain of 6 dBi with no reduction in transmitter conducted power, or higher antenna gain if the conducted power is proportionally reduced.[161] We will also require narrowband white space devices to comply with an emission limit of -42.8 dBm into adjacent channels, i.e., outside of the 6-megahertz channel in which they operate. These requirements will permit a white space device to operate with a single or several narrowband carriers rather than having to spread all of its energy across a six megahertz channel while ensuring that narrowband white space devices have no greater interference potential than wider bandwidth devices operating under the current rules.[162] To prevent narrowband devices from being used for data intensive applications and to limit the potential for these devices to cause harmful interference, we will limit transmissions on each narrowband channel to a total of 36 seconds per hour, as suggested by Dynamic Spectrum Alliance and Microsoft, i.e., a 1% duty cycle.[163]

66. We will not, however, increase this transmission time limit for narrowband devices to allow for signaling overhead as suggested by Microsoft.[164] Microsoft has not indicated how much additional transmission time would be necessary for this overhead. Further, to the extent that a narrowband device needs additional transmission time for functions such as contacting a white space database to obtain a list of available channels, there appear to be ways to perform these functions while still complying with the 36 second per hour per narrowband channel limit. For example, under the rules we are adopting there will be up to 55 narrowband channels within one six-megahertz TV channel, and a device could use one or more of these narrowband channels for signaling purposes.[165] In addition, any

[159] Notice, 35 FCC Rcd at 2118, para. 49.

[160] Dynamic Spectrum Alliance Comments at 20 (it is envisioned that narrowband white space devices will include master devices that incorporate geolocation and communicate directly with the white space database, client devices that incorporate geolocation, and client devices that do not incorporate geolocation); Letter from Paula Boyd, Sr. Director Government and Regulatory Affairs, Microsoft Corporation to Marlene Dortch, Secretary, FCC, ET Docket No. 20-36, at 1, 3-4 (filed Oct. 15, 2020) (Microsoft Oct. 15, 2020 *ex parte*.).

[161] If the maximum antenna gain exceeds 6 dBi, the white space device power must be reduced by the same amount in dB that the maximum gain exceeds 6 dBi. 47 CFR § 15.709(c)(1).

[162] We thus address National Translator Association's concern that narrowband white space devices have no greater interference potential than wider bandwidth devices. National Translator Association Comments at 7.

[163] Dynamic Spectrum Alliance Reply at 14; Letter from Paula Boyd, Sr. Director Government and Regulatory Affairs, Microsoft Corporation to Marlene Dortch, Secretary, FCC, ET Docket No. 20-36, at 2 (filed Aug. 19, 2020).

[164] Microsoft Oct. 15, 2020 *ex parte* at 5. Microsoft requests that the 36 second per hour transmission limit exclude signaling overhead necessary to comply with the Subpart H white space rules.

[165] Microsoft Oct. 21, 2020 *ex parte*.

overhead associated with contacting the database could be accomplished by other means, such as a non-narrowband white space channel, Wi-Fi, a fixed link, or a fiber connection.

67. We will also require narrowband devices to use the proposed channel plan that limits total transmitted power in a six-megahertz channel to no higher than the existing limits for a four-watt EIRP broadband white space device.[166] This channel plan requires narrowband white space devices to operate at least 250 kilohertz from the edge of a six-megahertz TV channel, unless the adjacent channel is also vacant, and requires narrowband white space devices to operate only on channels centered at integral multiples of 100 kilohertz between the 250 kilohertz guard bands. The net effect of these requirements is that narrowband devices will be permitted to operate within 55 possible 100-kilohertz channels in the center 5.5 megahertz of each six-megahertz channel. Even in the event that all 55 narrowband channels within a six-megahertz channel were occupied simultaneously by devices transmitting at maximum power, the total conducted and radiated power within that six-megahertz channel would be no greater than for a fixed device operating with one-watt conducted power and 4 watts EIRP. Because of the transmission time limit of thirty-six seconds per hour (a one-percent duty cycle), the interference potential of these narrowband white space devices will actually be significantly less than four-watt EIRP fixed devices in most cases since it is extremely unlikely that devices would transmit at maximum power on all 55 narrowband channels simultaneously, and even if they did, that would occur for no more than 36 seconds per hour.

68. We are not limiting operation of narrowband devices to "less congested" areas as suggested by wireless microphone interests.[167] Since narrowband devices will operate under control of a master device that accesses a white space database to determine available channels at its location, narrowband devices will not be permitted to operate on the channels at locations where registered licensed wireless microphones operate. Additionally, unlicensed wireless microphones and white space devices must already share spectrum with fixed white space devices operating at up to 4 watts EIRP in areas that do not meet the definition of "less congested." Even under worst-case conditions, narrowband devices will have no greater interference potential than four-watt fixed devices and will have a significantly lower interference potential in the vast majority of cases. For these reasons, we do not agree with RADWIN that a proliferation of narrowband devices will prevent spectrum use for Internet access.[168]

69. We decline to allow a greater transmission duty cycle for narrowband devices used only by public safety entities as requested by NPSTC.[169] While NPSTC does not indicate how much it wants the limit increased, the higher transmit duty cycle we are permitting will benefit all narrowband device applications, including those used by public safety entities. Allowing different technical requirements for public safety entities would complicate equipment certification and would be difficult to enforce since there could be multiple versions of the same device, some of which could be legally used only by specific types of entities. It is not clear how we could ensure that devices approved for use only by public safety entities would be marketed to, and operated by, only those entities.

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[166] Notice, 35 FCC Rcd at 2117, para. 47.

[167] CP Communications Comments at 6 (Narrowband white space devices for IoT should be limited to less congested areas, subject to stricter rules when in suburban and urban areas, or the issue should be addressed in a separate proceeding); Edgar C. Reihl Comments at 4 (Narrowband IoT devices should be limited to operation in less congested areas where there is more spectrum available for their operation); Sennheiser Comments at 9 (Narrowband WSDs should be limited to less congested areas, or the rules should be modified to enhance protection and spectrum sharing, or the issue should be considered in a separate proceeding); Lectrosonics Reply at 1 (Narrowband IoT whitespace devices should be limited to less congested areas); Shure Reply at 14 (Narrowband WSD deployments should be confined to less congested areas; there are many other bands available for IoT).

[168] RADWIN Comments at 5.

[169] NPSTC Comments at 11. Shure opposes this request, arguing that it is inappropriate and ill-advised. Shure Reply at 19-20.

E. Higher power on adjacent channels

70. White space devices must generally operate outside the protected contours of adjacent channel TV stations because a strong signal on an adjacent channel can cause interference to the reception of a channel being viewed.[170] The general requirement that white space devices avoid operation within the protected contours of a station operating on an adjacent channel means that, as a practical matter, a white space device may operate only at locations where there are three contiguous vacant channels, i.e., the channel used by the white space device plus both adjacent channels. The Commission's rules do, however, provide two exceptions that permit white space device operations at lower power levels when adjacent channels are occupied, based upon the shorter distances at which interference to adjacent channel TV stations could occur. First, both fixed and personal/portable white space devices may operate at up to 40 milliwatts EIRP at locations where both adjacent channels are occupied.[171] Second, fixed white space devices may operate within the protected contour of adjacent channel TV stations with a power level of 100 milliwatts EIRP when the white space device operates in a six-megahertz band centered on the boundary of two contiguous vacant channels, i.e., 50 milliwatts EIRP within a three-megahertz band in each channel.[172]

71. In the Notice, we sought comment on whether we could permit white space devices to operate at higher power levels than the rules currently permit when adjacent TV channels are occupied.[173] In particular, we sought comment on methods that could be used to determine the locations where we could permit higher power unlicensed operations on adjacent channels, and if so, what specific technical parameters would need to be considered or specified in such calculations.[174] We also sought comment on whether there is any information available on adjacent channel selectivity and interference rejection capabilities of next-generation TV receivers, such as manufacturers' specifications or actual measurement results, and whether there is any indication that next-generation TV receivers will have better adjacent channel interference rejection than current receivers.[175]

72. We do not increase the maximum permissible power for white space devices operating inside the protected contour of adjacent channel TV stations at this time. As an initial matter, we do not at this time have sufficient evidence in the record on which to change the manner of protecting broadcast services to a terrain-based model, as Microsoft and others suggest, but are seeking to develop a further record in the Further Notice of Proposed Rulemaking.[176] Microsoft argues that we should permit white

[170] 47 CFR § 15.712(a)(2)(ii).

[171] 47 CFR § 15.712(a)(2)(ii). Fixed white space devices operating at 40 milliwatts EIRP may not operate with an antenna height above ground level that exceeds 10 meters. 47 CFR § 15.709(g)(1)(i).

[172] 47 CFR § 15.712(a)(2)(iii). The slightly higher 50 milliwatt per channel power level is permitted due to the frequency separation of three megahertz from the edge of the adjacent channel that results in a slight improvement in receiver selectivity.

[173] Notice, 35 FCC Rcd at 2119, para. 52.

[174] *Id.* The technical parameters that may need to be considered in calculations include the desired TV signal strength, the grid size for determining where interference could occur, desired-to-undesired signal ratios at which interference occurs, white space device power and antenna height.

[175] *Id.*

[176] A number of parties including Adaptrum, Ark Multicasting, Dynamic Spectrum Alliance, PISC, RED Technologies, and WISPA also support increasing the white space device power limit on adjacent channels, although RED Technologies concurs with NAB that changing the rules in this regard is outside the scope of the present proceeding. Adaptrum Comments at 3 (Supports use of a terrain-based propagation model as a means of enabling increased power limits in first adjacent channels); Ark Multicasting Comments at 4 (The ability to open the first adjacent TV channels for wireless Internet access has been incontrovertibly proven through the comprehensive testing performed by ARK and Microsoft); Dynamic Spectrum Alliance Comments at 22; PISC Comments at 18; RED Technologies Comments at 8; WISPA Comments at 10.

space device operation within the protected contour of adjacent channel TV stations at higher power levels than the rules currently permit.[177] In so doing, Microsoft supplied a test report on the results of laboratory measurements of current model ATSC 1.0 TV receivers and next generation ATSC 3.0 TV receivers that it claims shows higher power adjacent channel operation is possible because these TV receivers have better selectivity than the Commission assumed in developing the current power limits and because the use of terrain-based propagation models (e.g., Longley-Rice) can provide a more accurate determination of where higher power adjacent channel white space device operation can be permitted without causing harmful interference.[178] Microsoft also supplied a test report on field measurements conducted with Ark Multicasting, a lower power TV network operator, that it claims validates its laboratory measurements and demonstrates that for the given parameters (e.g., fixed white space device EIRP and antenna pattern, DTV transmitter characteristics, adjacent channel selectivity of the newer model TV receivers with integral display tested, and distance between the DTV transmitter and the TV receiver) a white space device can operate within the protected contour on a first adjacent channel at higher powers than currently allowed.[179]

73. But while data supplied by Microsoft shows that some newer model TV receivers have better adjacent channel selectivity than the -33 dB D/U ratio the Commission assumed when it adopted the power limits for white space devices operating inside the protected contour of adjacent channel TV stations,[180] NAB disputes Microsoft's analysis, arguing that the TV receivers it used are not representative of the currently installed consumer base.[181] Microsoft's report shows that the average adjacent channel selectivity of tested ATSC 1.0 receivers is better than the value the Commission assumed, and that ATSC 3.0 receivers have a selectivity 10 dB better than that of ATSC 1.0 receivers at lower order modulations and similar to ATSC 1.0 receivers at higher order modulations.[182] In addition, the report shows that receiver adjacent channel selectivity improves by 5.7 dB on average when a white space device operates at a 3 megahertz offset from a TV channel edge.[183]

74. The improved receiver selectivity shown in Microsoft's testing could allow white space devices to operate within adjacent channel protected contours at higher power levels than the rules currently permit without increasing the potential for interference to TV reception. We recognize, however, NAB's concern that Microsoft's testing was performed with a limited number of TV receivers which may not be representative of the currently installed base. We encourage Microsoft and other parties to continue studies and white space device and TV receiver testing to determine whether or how we can permit higher power for white space devices without causing harmful interference to TV reception. The Commission welcomes interested parties to file a petition in the future when this work has been done.

F. Other matters

75. *Directional antennas.* Broadband Connects America Coalition, Public Interest Spectrum Coalition, and WISPA request that the white space database be allowed to consider the directivity of white space device transmit antennas in determining channel availability for white space devices.[184] NAB

[177] Microsoft Comments at 28.

[178] Microsoft Comments at 33.

[179] Microsoft Comments at 65.

[180] *White Spaces Order*, 30 FCC Rcd at 9563, para. 31.

[181] NAB Reply at 11.

[182] Microsoft Comments Appendix at 13.

[183] Microsoft Comments Appendix at 15.

[184] Broadband Connects America Coalition Comments at 13; Public Interest Spectrum Coalition Comments at 20; WISPA Comments at 13.

opposes this request, arguing that there is no way of determining whether a directional antenna has been installed properly without hiring a licensed land-surveyor, which it believes is unlikely to occur.[185] We previously considered and rejected requests to consider white space device transmit antenna directivity in the *White Spaces Order on Reconsideration* and did not make any proposals on this issue in the Notice.[186] We decline to take any action on these requests.

76. *Wireless microphone issues.* Wireless microphone interests request that we not take action to change the rules for white space devices until we act on the outstanding proceeding (GN Docket No. 14-166[187]) that proposed to expand the eligibility for obtaining a Part 74 license for wireless microphones and until we address difficulties with the white space database in registering licensed wireless microphones.[188]

77. We decline to defer action in this proceeding pending a decision in GN Docket No. 14-166 on expanding Part 74 licensing eligibility. Our actions in this proceeding will benefit Americans in rural and underserved areas by enabling improved broadband access. We do not wish to delay these public benefits until some unspecified point in the future. Further, our decision here will not adversely impact either licensed or unlicensed wireless microphone operations. For example, we are limiting higher power and antenna height operations, as well as higher power geo-fenced operations, to areas where the spectrum is less congested, which will limit the impact on wireless microphones that operate in the TV bands. Moreover, because white space devices operate on an unlicensed basis, they are obligated by the rules to protect licensed wireless microphone operations; unlicensed wireless microphones operate on a co-equal basis with white space devices. However, if the Commission decides to expand wireless microphone licensing eligibility in GN Docket No. 14-166, any newly licensed wireless microphone operation would receive the same protection from harmful interference, even if white space device operators need to adjust their systems. Thus, the actions we are taking in this Report and Order do not alter the relationship between wireless microphones and white space devices, including the obligation for unlicensed devices to protect licensed wireless microphones.

78. We appreciate parties bringing concerns about the white space database to our attention, and we are working with the database administrators to address them. We note that a new administrator, RED Technologies, has taken over operation of the Nominet white space database.[189] However, we believe that the concerns parties raised, e.g., improvements to the licensed wireless microphone registration procedure, can be addressed without a need to delay action in this proceeding.

IV. FURTHER NOTICE OF PROPOSED RULEMAKING

79. In this Further Notice of Proposed Rulemaking (Further Notice), we seek comment on the use of a terrain-based propagation model such as Longley-Rice for determining white space channel

[185] NAB Reply at 12.

[186] *White Spaces Order on Reconsideration*, 34 FCC Rcd at 1854, para. 71.

[187] *Promoting Spectrum Access for Wireless Microphone Operations*, ET Docket No. 14-166, Order on Reconsideration and Further Notice of Proposed Rulemaking, 32 FCC Rcd 6077 (2017).

[188] CP Communications Comments at 4 (the Commission should recognize the significant shortcomings in the database ecosystem and require that they are adequately addressed prior to any new WSD rules going into effect); Sennheiser Comments at 2 (The Commission should expand part 74 license eligibility because increased WSD power and antenna height and high power mobile geo-fenced WSD operation pose a significant threat of interference to microphone operations in rural areas); Shure Comments at 16 (The FCC should adopt the expansion of Part 74 eligibility and revisit the functioning of the white space databases); Lectrosonics Reply at 2 (The Commission should move on expanding part 74 license eligibility for wireless microphone users).

[189] *Office of Engineering and Technology Announces Transfer of Ownership and Control of White Space Database from Nominet UK to RED Technologies*, ET Docket No. 04-186, Public Notice (Aug. 26, 2020), https://docs.fcc.gov/public/attachments/DA-20-904A1.pdf.

availability. We seek to develop a record on whether or not to implement such a model. In particular, we seek comment on the effect use of such a model would have on availability of channels for white space devices, how a terrain-based model such as Longley-Rice could be implemented within the current white space device framework, the technical parameters necessary to use such a model for identifying available spectrum while protecting incumbents from harmful interference, and various database and device implementation issues.

80. Dynamic Spectrum Alliance, WISPA, and Public Interest Spectrum Coalition argue that the Commission should determine white space channel availability using a terrain-based model, such as the Longley-Rice Irregular Terrain Model, which they assert will determine channel availability more accurately than the current contour-based model used by the Commission.[190] For example, a terrain-based model could permit a white space device to deploy at a location where the television signal is shielded by a large hill or mountain, whereas the existing methodology does not account for such shielding. National Association of Broadcasters and Sennheiser, however, oppose using the Longley-Rice model due to concerns about its accuracy in protecting TV receivers and because it may slow operation of the white space database.[191]

81. *Current protection model*. Under current rules, white space devices must generally operate outside the defined co-channel and adjacent channel television station protected contours.[192] The rules provide a table of separation distances beyond the protected contour that white space devices must meet that is based on the white space device's equivalent isotropic radiated power (EIRP) and height above average terrain (HAAT).[193] These distances are based on a desired-to-undesired (D/U) signal ratio of 23 dB at the edge of the protected contour for co-channel operation, and -33 dB at the edge of the protected contour for adjacent channel operation, with a 14 dB allowance for TV receive antenna front-to-back ratio.[194] The distances were calculated using the F(50,10) curves for separation distances of greater than 15 kilometers, the F(50,50) curves for separation distances of 1.5 to 15 kilometers, and the TM-91-1 model for separation distances of less than 1.5 kilometers.[195]

82. *Longley-Rice model*. The Longley-Rice propagation model is used to make predictions of radio signal field strength using the median attenuation calculated as a function of distance and the signal variability in time and space.[196] The model can be run in point-to-point mode where it examines a specific radio signal path between a transmitter and a receiver, or in area mode in which it predicts field

[190] Dynamic Spectrum Alliance Reply at 4 (a terrain-based model can determine the separation distances to protect incumbent broadcasters with greater accuracy than the current methodology based on the F-curves and HAAT); WISPA Comments at 5 (the Longley-Rice ITM is a far more accurate method of predicting signal strength than the method currently used for white spaces); Public Interest Spectrum Coalition Comments at 11-12 (the Commission should authorize TV bands databases to employ terrain-based and other real-world propagation models such as the Longley-Rice Irregular Terrain Model methodology); Letter from Louis Peraertz, Vice President of Policy, WISPA, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 20-36, at 3 (filed Oct. 19, 2020); Letter from Michael Calabrese, Director Wireless Future Program, New America's Open Technology Institute, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 20-36, at 2 (filed Oct. 21, 2020).

[191] NAB Reply at 2-3; Sennheiser Reply at 7.

[192] 47 CFR § 15.712(a).

[193] *Id.*

[194] *White Spaces Third MO&O*, 27 FCC Rcd at 3699, para. 17.

[195] *White Spaces Third MO&O*, 27 FCC Rcd at 3698-99, para. 16 & n.43. The F-curves define field strength contours around a transmitter based on statistical properties. For example, the F(50,10) curve is based on whether a signal can be received at a specified field strength at 50% of the receivers, 10% of the time. *See, e.g.,* 47 CFR § 73.699 for TV engineering charts.

[196] *See* A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode, NTIA Report 82-100; https://www.ntia.doc.gov/files/ntia/publications/ntia_82-100_20121129145031_555510.pdf.

strength at many geographic points within a specified area. Each operational mode uses a terrain elevation profile in making predictions; in the point-to-point mode path-specific parameters can be determined from the terrain profile between the transmitter and receiver, and in area mode the elevation profile between the transmitter and each specific reception point is examined. The model may require a large number of reception points to be individually examined. It also requires a large set of input parameters encompassing system parameters (e.g., frequency, polarization, antenna heights), environmental parameters (e.g., terrain irregularity, electrical ground constants, surface refractivity, climate information), deployment parameters, and statistical parameters (e.g., reliability and confidence level).[197] Based on the predicted radio signal attenuation and using additional factors such as transmitter power and antenna directivity, the D/U signal ratio can be estimated and compared against the 23 dB co-channel and -33 dB adjacent channel standards used as the basis when developing the white space device rules to predict whether harmful interference is likely to occur to television reception.

83. The Longley-Rice model can be implemented using a variety of methodologies. For example, the area subject to calculation can be divided into rectangular cells, e.g., a 1 by 1-kilometer grid, and the field strength predictions are calculated at a point in each cell, such as the geographic center or the population centroid. We note that as computing power has increased over the years, it is most common to execute the model in point-to-point mode and use a batch process to evaluate each grid cell within a specified area. Nevertheless, we seek comment on various implementations for white space device evaluation which include both area and point to point mode as we are concerned about the available processing power, capabilities and time requirements to run many simultaneous batch processes to evaluate a large number of white space devices that may query the database for available channel information at the same time. We seek comment on whether we should specify a specific operational mode and how the model should be implemented under a specific mode or both operational modes.

84. As a threshold matter, we seek comment on whether using a terrain-based model, and in particular the Longley-Rice model, would better serve the white space device community as well as television broadcasters and other protected entities in the television bands.[198] Commenters should specify the pros and cons of their preferred approach as it relates either to the Commission's existing contour method or other terrain-based propagation models. We seek comment on how the Longley-Rice propagation model could be used to determine available white space channels. Would it be used only to determine if a white space device at a specific geographic location and power level meets the co- and adjacent channel D/U ratios? Or should the propagation model be used for wider applicability such as for determining separation distances necessary to ensure other protected entities such as licensed wireless microphones, television translator receive sites, cable headends, and land mobile stations do not experience harmful interference? In such cases, what criteria should be used to determine the protection distances? Should D/U ratios be used here too, or some other metric such as an interference-to-noise ratio? Commenters should provide detailed technical reasoning regarding how the metric they support achieves the necessary protection levels. In addition, we seek comment on whether the propagation model can be used to determine which areas are "less congested" and thus subject to more flexible rules. In this case, what criteria should be used as the basis for determining a "less congested" area as it relates to use of the propagation model?[199] Could using the Longley-Rice propagation model for this purpose

[197] *Id.*

[198] In addition to licensed television stations, white space devices must also protect translator receive operations; fixed broadcast auxiliary service links; private land mobile radio service/commercial mobile radio service (PLMRS/CMRS) operations; offshore radiotelephone service; low power auxiliary services, including licensed wireless microphones; MVPD receive sites; wireless medical telemetry service (WMTS); radio astronomy service (RAS); and 600 MHz service band licensees where they have commenced operations. 47 CFR § 15.711(a).

[199] In the Report and Order, we decline to modify the definition of "less congested" area and retain the methodology which is based on whether at least half of the TV channels in the bands that are allocated and assigned only for broadcast service are unused for broadcast and other protected services and available for white space device use. These areas are separately defined for the lower VHF (channels 2-6), upper VHF (channels 7-13), and UHF

(continued….)

permit additional areas to be designated as "less congested" to provide more flexibility for white space devices? Similarly, we seek comment on whether the propagation model can be applied not only to fixed white space devices, but also to personal/portable, mobile and narrowband IoT white space devices. In each context, are there specific provisions required for how the model is implemented to account for the different white space device operational modes and use cases?

85. What mode–point-to-point or area–is appropriate for each situation? For fixed white space devices, it would seem intuitive to use the point-to-point mode to examine a specific radio path to the television station contour. However, we seek comment on what specific path should be examined–the shortest path to the contour or possibly a different path where the white space device and television contour are further apart, but due to terrain shielding effects, may have less attenuation. How would each path be determined and how many specific paths would need to be evaluated before a determination can be made as to whether a channel is available for white space device use? Or would it be better to run the propagation model in area mode to determine the points along the television contour with the highest co- and adjacent channel D/U ratios and then run the model again in point-to-point mode for those specific transmission paths? Should a D/U threshold be set to determine which paths need further examination? If so, how close to the 23 dB co-channel and -33 dB adjacent channel thresholds do they need to be? And if an initial area mode calculation must be performed, what grid size is appropriate and what point within each grid cell should be used for analysis purposes? Using similar logic, how could the model be applied to determine "less congested" areas and operating locations for personal/portable, mobile or narrowband white space devices? Should it be run only in area mode or must additional point-to-point calculations also be performed? Commenters should provide detail regarding how the model can be applied to each of the situations likely to be encountered for various white space device types.

86. We also seek comment on whether the Longley-Rice model would always determine the same or shorter separation distances from a TV contour than the current model, or whether there are cases where it could require greater separation distances, and therefore reduce white space device channel availability. How justified are the concerns expressed by the NAB regarding the use of Longley-Rice to protect television reception? NAB argues that the Longley-Rice model requires transmitter and receiver locations to be known with precision, while television receiver locations are not reflected in any database and cannot be passively detected, and that current television receiver protection requirements for white space devices are not overly conservative or based on worst-case assumptions.[200] We seek comment on NAB's assertions. Commenters that favor use of the Longley-Rice model should provide specific reasons regarding how NAB's concerns can be addressed.

87. We further seek comment on whether the Longley-Rice model should be the exclusive means of determining white space channel availability, or whether it should be an optional alternative to the current protection model. As an alternative model, would it be more appropriate to use the Longley-Rice model in combination with other propagation models in some circumstances such as we require for 6 GHz unlicensed devices, where different propagation models are specified at different distances?[201] Finally, we seek comment on whether the Longley-Rice propagation model can or should be used for modeling the TV coverage itself, and therefore possibly allowing white space device operation within a TV protected contour as calculated using the F(50,90) curves so long as the minimum D/U ratios are met.

88. We also seek comment on the technical requirements that need to be specified if we permit the use of the Longley-Rice model. What inputs are necessary for using the model in either point-

(Continued from previous page)
(channels 14-36) television bands and are based on a white space device operating with a 40 milliwatt EIRP and 3 meter HAAT. *See* Report and Order at paras. 46-49. *See also* 47 CFR § 15.703.

[200] NAB Reply at 3.

[201] 47 CFR § 15.407(l)(1). A free space model is specified at distances of up to 30 meters, the WINNER II model is specified at distances of greater than 30 meters and up to one kilometer, and the Irregular Terrain Model with the appropriate clutter model is specified at distances of greater than one kilometer.

to-point mode or area mode for each white space device type, potential use situation as well as for determining "less congested" areas and protection distances for each type of protected entity? Which of these inputs should be specified by rule and which can be determined either by the white space device operator or the database? Commenters should be as specific as possible regarding their preference for input parameters and provide engineering justification for those preferences. What grid size and which location within each grid cell should be used for determining white space channel availability?

89. We further seek comment on the terrain database that should be used with the Longley-Rice model or any alternative terrain-based model that the Commission specifies. Should we require the use of a particular terrain database, such as one based on 3-arc second data or 1-arc second data? Should we instead simply specify some minimum criteria for a terrain database, e.g., granularity, and allow the use of any terrain database that meets or exceeds that criteria?

90. *Model Implementation.* We seek comment on the various implementation factors that must be considered if we adopt rules to allow the use of Longley-Rice or another terrain-based propagation model. As an initial matter, the white space database administrator would need time to implement this change to its system. How long should we provide for the database administrator to implement these necessary changes? What type of testing should be performed to ensure that a white space database using a terrain-based model provides accurate results? Should the Commission perform its own testing or should we require public testing as we did when initially designating white space database administrators? We also seek comment on any effect that these changes might have on database and network performance. If the amount of overhead data necessary to use the Longley-Rice propagation model significantly increases over what is necessary under the existing rules, would the result be slower response times as Sennheiser suggests?[202] If so, would this detrimentally affect the utility of white space devices? Would such changes affect the capacity of the database to handle large numbers of white space devices simultaneously?

91. Are changes needed to white space devices if the database is modified to base channel availability on the Longley-Rice propagation model? Does the information sent from white space devices to the database need to change from the data set currently sent? If so, could all existing devices be updated? If not, how should the database deal with devices that can send the necessary data and those that cannot? Should we require that devices be updated within a specific time period? What should that time period be? Would any of the needed changes to a white space device affect its emissions and necessitate a change to its equipment authorization records?

92. How would the database using the Longley-Rice propagation model account for any device location uncertainty?[203] What actions should be taken if the propagation model determines that an existing operational white space device on a specific channel based on current protection distances no longer meets the D/U ratios after performing the required calculations? Should that device no longer be permitted to operate on that channel at its current power level or could the existing separation distances specified in the rules be considered a safe harbor for operations?

93. The operational changes and effects of implementing the Longley-Rice propagation model for determining white space device channel availability range from technical and modelling considerations to specific model implementation factors to database and device matters. We ask that commenters comprehensively examine all aspects of the rule changes that would be needed and the effect they would have if we were to modify the white space device rules to specify use of the Longley-Rice propagation model rather than the current contour-based method of protecting television stations and other protected entities in the TV bands.

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[202] Sennheiser Reply at 7 (no changes, i.e., Longley-Rice methodology, should be made that slow down the database system).

[203] Fixed white space devices that incorporate a geo-location capability and Mode II devices shall determine their location and their geo-location uncertainty (in meters), with a confidence level of 95%. 47 CFR § 15.711(b)(1).

V. PROCEDURAL MATTERS

94. *Paperwork Reduction Act Analysis.* This document contains new or modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. It will be submitted to the Office of Management and Budget (OMB) for review under Section 3507(d) of the PRA. OMB, the general public, and other Federal agencies will be invited to comment on the new or modified information collection requirements contained in this proceeding. In addition, we note that pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4), we previously sought specific comment on how the Commission might further reduce the information collection burden for small business concerns with fewer than 25 employees.

95. *Final Regulatory Flexibility Analysis*. As required by the Regulatory Flexibility Act of 1980 (RFA),[204] as amended, the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) regarding the possible significant economic impact on small entities of the policies and rules adopted in this Report and Order, which is found in Appendix C. The Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, will send a copy of the Report and Order, including the FRFA, to the Chief Counsel for Advocacy of the Small Business Administration.[205]

96. *Initial Regulatory Flexibility Analysis*. As required by the Regulatory Flexibility Act,[206] the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on a substantial number of small entities of the proposals addressed in this Notice. The IRFA is found in Appendix D. We request written public comment on the IRFA. Comments must be filed in accordance with the same filing deadlines as comments filed in response to the NPRM and must have a separate and distinct heading designating them as responses to the IRFA. The Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, will send a copy of this Notice, including the IRFA, to the Chief Counsel for Advocacy of the Small Business Administration, in accordance with the Regulatory Flexibility Act.[207]

97. *Congressional Review Act.* The Commission has determined, and the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, concurs that this rule is non-major under the Congressional Review Act, 5 U. S.C. § 804(2). The Commission will send a copy of this *Report and Order* to Congress and the Government Accountability Office pursuant to 5 U.S.C. § 801(a)(1)(A).

98. *Ex Parte Presentations*. The proceeding this Notice initiates shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules.[208] Persons making *ex parte* presentations must file a copy of any written presentation or a memorandum summarizing any oral presentation within two business days after the presentation (unless a different deadline applicable to the Sunshine period applies). Persons making oral *ex parte* presentations are reminded that memoranda summarizing the presentation must (1) list all persons attending or otherwise participating in the meeting at which the *ex parte* presentation was made, and (2) summarize all data presented and arguments made during the presentation. If the presentation consisted in whole or in part of the presentation of data or arguments already reflected in the presenter's written comments, memoranda or other filings in the proceeding, the presenter may provide citations to such data or arguments in his or her prior comments, memoranda, or other filings (specifying the relevant page and/or paragraph numbers where such data or

[204] *See* 5 U.S.C. § 603.

[205] *See* 5 U.S.C. § 603(a). In addition, the *Report and Order* and RFA (or summaries thereof) will be published in the Federal Register.

[206] 5 U.S.C. § 603.

[207] 5 U.S.C. § 603(a).

[208] 47 C.F.R. §§ 1.1200 *et seq.*

arguments can be found) in lieu of summarizing them in the memorandum. Documents shown or given to Commission staff during *ex parte* meetings are deemed to be written *ex parte* presentations and must be filed consistent with rule 1.1206(b). In proceedings governed by rule 1.49(f) or for which the Commission has made available a method of electronic filing, written *ex parte* presentations and memoranda summarizing oral *ex parte* presentations, and all attachments thereto, must be filed through the electronic comment filing system available for that proceeding, and must be filed in their native format (*e.g.*, .doc, .xml, .ppt, searchable .pdf). Participants in this proceeding should familiarize themselves with the Commission's *ex parte* rules.

99. *Filing Requirements.* Pursuant to sections 1.415 and 1.419 of the Commission's rules, 47 CFR §§ 1.415, 1.419, interested parties may file comments and reply comments on or before the dates indicated on the first page of this document. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS). *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 FR 24121 (1998).

- Electronic Filers: Comments may be filed electronically using the Internet by accessing the ECFS: http://apps.fcc.gov/ecfs/.
- Paper Filers: Parties who choose to file by paper must file an original and one copy of each filing.
- Filings can be sent by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail. All filings must be addressed to the Commission's Secretary, Office of the Secretary, Federal Communications Commission.
- Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9050 Junction Drive, Annapolis Junction, MD 20701.U.S. Postal Service first-class, Express, and Priority mail must be addressed to 45 L Street NE, Washington, DC 20554.
- Effective March 19, 2020, and until further notice, the Commission no longer accepts any hand or messenger delivered filings. This is a temporary measure taken to help protect the health and safety of individuals, and to mitigate the transmission of COVID-19. See FCC Announces Closure of FCC Headquarters Open Window and Change in Hand-Delivery Policy, Public Notice, DA 20-304 (March 19, 2020). https://www.fcc.gov/document/fcc-closes-headquarters-open-window-and-changes-hand-delivery-policy.

100. *People with Disabilities*: To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an e-mail to fcc504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (tty).

101. *Additional Information*. For additional information on this proceeding, contact Hugh L. Van Tuyl, Hugh.VanTuyl@fcc.gov, (202) 418-7506.

VI. ORDERING CLAUSES

102. Accordingly, IT IS ORDERED, pursuant to Sections 4(i), 201, 302, and 303 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), 201, 302a, 303, that this *Report and Order and Further Notice of Proposed Rulemaking* is hereby ADOPTED.

103. IT IS FURTHER ORDERED that the amendments of the Commission's rules as set forth in Appendix A ARE ADOPTED, effective thirty days from the date of publication in the Federal Register, except for the amendment to Section 15.709(g)(1)(ii), which contains new or modified information collection requirements that require approval by the OMB under the PRA and WILL BECOME EFFECTIVE after the Commission publishes a notice in the *Federal Register* announcing such approval and the relevant effective date.

104. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this *Report and Order and*

Further Notice of Proposed Rulemaking, including the Initial and Final Regulatory Flexibility Analyses, to the Chief Counsel for Advocacy of the Small Business Administration.

105. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this *Report and Order and Further Notice of Proposed Rulemaking*, including the Initial and Final Regulatory Flexibility Analyses, to Congress and the Government Accountability Office pursuant to the Congressional Review Act, *see* 5 U.S.C. § 801(a)(1)(A).

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

Appendix A

Final Rules

Part 15 of Title 47 of the Code of Federal Regulations is amended as follows:

PART 15 – RADIO FREQUENCY DEVICES

The authority citation for Part 15 continues to read as follows:

AUTHORITY: 47 U.S.C. 154, 302a, 303, 304, 307, 336, 544a, and 549.

1. Amend section 15.703 by removing the paragraph designations, revising the definition of "Less congested area" and adding new definitions in alphabetical order to read as follows:

§ 15.703 Definitions.

* * * * *

Geo-fenced area. A defined geographic area over which the white space database has determined the set of available channels.

Less congested area. Geographic areas where at least half of the TV channels within a specific TV band are unused for broadcast and other protected services and available for white space device use. Less congested areas are determined separately for each TV band -- the low VHF band (channels 2-6), the high VHF band (channels 7-13) and the UHF band (channels 14-36); i.e., one, two or all three bands or any combination could qualify as less congested. White space devices may only operate at the levels permitted for less congested areas within the area and the specific TV band(s) that qualify as a less congested area. For the purpose of this definition, a channel is considered available for white space device use if it is available for fixed devices operating with 40 milliwatts EIRP at 3 meters HAAT. Less congested areas in the UHF TV band are also considered to be less congested areas in the 600 MHz service band.

Mobile white space device. A white space device that transmits and/or receives radiocommunication signals on available channels within a defined geo-fenced area. A mobile white space device uses an incorporated geo-location capability to determine its location with respect to the boundaries of the defined area. A mobile white space device may operate only in less congested areas.

Narrowband white space device. A fixed or personal/portable white space device operating in a bandwidth of no greater than 100 kilohertz.

* * * * *

2. Amend section 15.707 to read as follows:

§ 15.707 Permissible channels of operation.

(a)(1) *470-614 MHz band.* Fixed and personal/portable white space devices are permitted to operate on available channels in the frequency bands 470-614 MHz (TV channels 14-37), subject to the interference protection requirements in §§15.711 and 15.712.

(2) *600 MHz duplex gap.* Fixed and personal/portable white space devices may operate in the 657-663 MHz segment of the 600 MHz duplex gap.

(3) *600 MHz service band.* Fixed and personal/portable white space devices may operate on frequencies in the bands 617-652 MHz and 663-698 MHz in areas where 600 MHz band licensees have not commenced operations, as defined in §27.4 of this chapter.

(4) *Channel 37 guard band.* White space devices are not permitted to operate in the band 614-617 MHz.

(b) Only mobile white space devices and fixed white space devices that communicate only with other fixed or mobile white space devices may operate on available channels in the bands 54-72 MHz (TV channels 2-4), 76-88 MHz (TV channels 5 and 6), and 174-216 MHz (TV channels 7-13), subject to the interference protection requirements in §§15.711 and 15.712.

(c) Narrowband and mobile white space devices may only operate on frequencies below 602 MHz.

3. Amend section 15.709 by adding new paragraphs (a)(5) and (b)(4) and revising paragraphs (a)(2), (b)(1)(ii)-(iii), (c)(2), (g)(1)(i)-(ii) to read as follows:

§ 15.709 General technical requirements.

(a) * * *

(2) *TV bands and 600 MHz service band.* (i) (A) Fixed devices in the TV bands below 602 MHz: Up to 4 W (36 dBm) EIRP, and up to 16 W (42 dBm) EIRP in less congested areas. Fixed devices in the 602-608 MHz band may operate with up to 4 W (36 dBm) EIRP.

(B) Fixed devices in the 600 MHz service bands above 620 MHz: Up to 4 W (36 dBm) EIRP, and up to 10 W (40 dBm) EIRP in less congested areas. Fixed devices that operate in any portion of the 614-620 MHz band may operate with up to 4 W (36 dBm) EIRP.

(ii) * * *

* * * * *

(5) Mobile devices in the TV bands below 602 MHz: Up to 16 W (42 dBm) EIRP in less congested areas. Mobile device operation is not permitted above 602 MHz. Mobile devices may operate only in less congested areas.

(b) * * *

(1) *Fixed and mobile white space devices*.

(i) Technical limits for fixed and mobile white space devices are shown in the table in paragraph (b)(1)(iii) of this section and subject to the requirements of this section.

(ii) For operation at EIRP levels of 36 dBm (4,000 mW) or less, fixed and mobile white space devices may operate at EIRP levels between the values shown in the table in paragraph (b)(1)(iii) of this section provided that the conducted power and the conducted power spectral density (PSD) limits are linearly interpolated between the values shown and the adjacent channel emission limit of the higher value shown in the table is met. Operation at EIRP levels above 36 dBm (4000 mW) but not greater than 40 dBm (10,000 mW) shall follow the requirements for 40 dBm (10,000 mW). Operation at EIRP levels above 40 dBm (10,000 mW) shall follow the requirements for 42 dBm (16,000 mW).

(iii) The conducted power spectral density from a fixed or mobile white space device shall not be greater than the values shown in the table in this paragraph (b)(1)(iii) when measured in any 100 kilohertz band during any time interval of continuous transmission.

Table 1 to Paragraph (b)(1)(iii)

EIRP (6 MHz)	Conducted power limit (6 MHz)	Conducted PSD limit[1] (100 kHz)	Conducted adjacent channel emission limit (100 kHz)
16 dBm (40 mW)	10 dBm (10 mW)	-7.4 dBm	-62.8 dBm
20 dBm (100 mW)	14 dBm (25 mW)	-3.4 dBm	-58.8 dBm
24 dBm (250 mW)	18 dBm (63 mW)	0.6 dBm	-54.8 dBm
28 dBm (625 mW)	22 dBm (158 mW)	4.6 dBm	-50.8 dBm
32 dBm (1600 mW)	26 dBm (400 mW)	8.6 dBm	-46.8 dBm
36 dBm (4000 mW)	30 dBm (1000 mW)	12.6 dBm	-42.8 dBm
40 dBm (10000 mW)	30 dBm (1000 mW)	12.6 dBm	-42.8 dBm
42 dBm (16000 mW)	30 dBm (1000 mW)	12.6 dBm	-42.8 dBm

(2) * * *

(3) * * *

(4) *Narrowband white space devices.*

(i) A narrowband white space device that operates as a client must communicate with a master device (fixed, Mode II, mobile or narrowband) that contacts the white space database to obtain a list of available channels and operating powers at its location. A narrowband white space device that acts as a master must incorporate a geo-location mechanism and be capable of obtaining lists of available channels and operating powers from the white space database.

(ii) Narrowband white space devices shall operate on channel sizes that are no more than 100 kilohertz. The edge of a narrowband channel shall be offset from the upper and lower edge of the 6 megahertz channel in which it operates by at least 250 kilohertz, except in the case where bonded 6 megahertz channels share a common band edge. Narrowband operating channels shall be at integral multiples of 100 kilohertz beginning at a 250 kilohertz offset from a 6 megahertz channel's edge, or with no offset at the common band edge of two bonded 6 megahertz channels.

(iii) The conducted power limit is 12.6 dBm in a 100 kilohertz segment. The EIRP limit is 18.6 dBm in a 100 kilohertz segment. The conducted power spectral density limit is 12.6 dBm in any 100 kilohertz band during any time interval of continuous transmission.

(iv) Conducted adjacent channel emissions shall be limited to -42.8 dBm in 100 kilohertz in a first adjacent 6 megahertz channel, starting at the edge of the 6 megahertz channel within which the narrowband device is operating. This limit shall not apply between the edge of the narrowband channel and the edge of the 6 megahertz channel that contains it.

(v) If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted power output shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(vi) Total occupancy for each narrowband channel shall be limited to 36 seconds per hour.

(c) * * *

(1) * * *

(2) The conducted power, PSD and adjacent channel limits for fixed and mobile white space devices operating at greater than 36 dBm (4000 milliwatts) EIRP shown in the table in paragraph (b)(1) of this section are based on a maximum transmitting antenna gain of 12 dBi. If transmitting antennas of directional gain greater than 12 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 12 dBi.

* * * * *

(g) * * *

(1) * * *

(i) *Above ground level*. The transmit antenna height shall not exceed 10 meters above ground level in any area for fixed white space devices operating in the TV bands at 40 mW EIRP or less or operating across multiple contiguous TV channels at 100 mW EIRP or less.

(ii) *Height above average terrain (HAAT)*. For devices operating in the TV bands below 602 MHz, the transmit antenna shall not be located where its height above average terrain exceeds 250 meters generally, or 500 meters in less congested areas. For devices operating in all other bands the transmit antenna shall not be located where its height above average terrain exceeds 250 meters. The HAAT is to be calculated by the white space database using the methodology in § 73.684(d) of this chapter. For HAAT greater than 250 meters the following procedures are required:

(A) The installing party must contact a white space database and identify all TV broadcast station contours that would be potentially affected by operation at the planned HAAT and EIRP. A potentially affected TV station is one where the protected service contour is within the applicable separation distance for the white space device operating at an assumed HAAT of 50 meters above the planned height at the proposed power level.

(B) The installing party must notify each of these licensees and provide the geographic coordinates of the white space device, relevant technical parameters of the proposed deployment, and contact information.

(C) No earlier than four calendar days after this notification, the installing party may commence operations.

(D) Upon request, the installing party must provide each potentially affected licensee with information on the time periods of operations.

(E) If the installing party seeks to modify its operations by increasing its power level, by moving more than 100 meters horizontally from its location, or by making an increase in the HAAT or EIRP of the white space device that results in an increase in the minimum required separation distances from co-channel or adjacent channel TV station contours, it must conduct a new notification.

(F) All notifications required by this section must be in written form (including e-mail). In all cases, the names of persons contacted, and dates of contact should be kept by the white space device operator for its records and supplied to the Commission upon request.

* * * * *

4. Amend section 15.711 by adding a new paragraph (k) and revising paragraphs (j)(3) and (j)(4) to read as follows:

§ 15.711 Interference avoidance methods.

* * * * *

(j) * * *

(1) * * *

(2) * * *

(3) A white space database shall be protected from unauthorized data input or alteration of stored data. To provide this protection, the white space database administrator shall establish communications authentication procedures that allow fixed, mobile and Mode II white space devices to be assured that the data they receive is from an authorized source.

(4) Applications for certification of white space devices shall include a high level operational description of the technologies and measures that are incorporated in the device to comply with the security requirements of this section. In addition, applications for certification of fixed, mobile and Mode II white space devices shall identify at least one of the white space databases operated by a designated white space database administrator that the device will access for channel availability and affirm that the device will conform to the communications security methods used by that database.

(k) *Requirements for mobile white space devices.*

(1) Mobile white space devices shall operate within geo-fenced areas over which the white space database has determined channel availability. A mobile white space device shall have the capability to internally store the boundaries of a geo-fenced area and determine its location with respect to those boundaries. The area boundaries stored within a mobile white space device must be the same as those used by the white space database to determine channel availability.

(2) A mobile white space device shall incorporate a geo-location capability to determine its geographic coordinates. A mobile white space device may obtain its geographic coordinates through an external geo-location source, provided that source is on the same vehicle or other mobile platform as the mobile device. An external geo-location source may be connected to a mobile device through either a wired or a wireless connection, and a single geo-location source may provide location information to multiple mobile devices on the same mobile platform. An external geo-location source must be connected to a mobile device using a secure connection that ensures that only an external geo-location source that has been approved with a particular mobile device can provide geographic coordinates to that device. The geographic coordinates must be provided automatically by the external geo-location source to the mobile device; users may not manually enter them. Alternatively, an extender cable may be used to connect a remote receive antenna to a geo-location receiver within a mobile device.

(3) The applicant for certification of a mobile device must demonstrate the accuracy of the geo-location method used and the location uncertainty as defined in paragraph (b) of this section. For mobile devices that are not using an internal geo-location capability, this uncertainty must account for the accuracy of the geo-location source and the separation distance between such source and the white space device.

(4) The antenna height above ground shall be determined by the operator of the device, or by an automatic means. The mobile device shall provide this information to the white space database when it requests a list of available channels for the geo-fenced area in which it will operate.

(5) Each mobile device must access a white space database over the Internet to determine the available channels and the maximum permitted power for each available channel within the geo-fenced area in

which it will operate. The white space database must take into consideration the mobile device's antenna height above ground level and geo-location uncertainty in determining the list of available channels. It must also take into consideration any variation in mobile device HAAT throughout the geo-fenced area and must use the highest HAAT within the geo-fenced area in determining channel availability. Operation is permitted only on channels that are indicated by the database as being available at the same power level throughout the entire geo-fenced area in which the mobile device will operate.

(6) Mobile devices must comply with the same separation distances from protected services in § 15.712 as fixed devices.

(7) Mobile devices may use electrically steerable directional antennas, but a device's maximum EIRP in any direction must be used by the white space database in determining channel availability.

(8) A mobile device must re-check its coordinates at least once every 60 seconds while in operation except while in sleep mode, i.e., in a mode in which the device is inactive but is not powered down. It must cease operation if its location is within 1.9 kilometers of the boundary, or outside the boundary, of the geo-fenced area over which the white space database has determined the available channels.

(9) Each mobile white space device shall access the white space database at least once a day to verify that the operating channels within the geo-fenced area continue to remain available. Each mobile white space device must adjust its use of channels in accordance with channel availability schedule information provided by its database for the 48-hour period beginning at the time the device last accessed the database for a list of available channels.

(10) Operation of mobile white space devices on satellites and aircraft, including unmanned aerial vehicles, is prohibited.

5. Amend section 15.712 by revising the introductory text and paragraphs (a)(2), (b)(3)(ii)-(iii), (c)(2)(ii), (d), (f), (g), (h)(1), (i)(1) and inserting new paragraphs (b)(3)(iv) and (c)(2)(iii) to read as follows:

§ 15.712 Interference protection requirements.

The separation distances in this section apply to fixed, mobile and personal/portable white space devices with a location accuracy of ±50 meters. These distances must be increased by the amount that the location uncertainty of a white space device exceeds ±50 meters. Narrowband white space devices shall comply with the separation distances applicable to a fixed white space device operating with 30 dBm conducted power and 36 dBm EIRP across a 6 megahertz channel.

(a) * * *

(2) *Required separation distance.* White space devices must be located outside the contours indicated in paragraph (a)(1) of this section of co-channel and adjacent channel stations by at least the minimum distances specified in the tables in paragraph (a)(2)(v).

(i) If a device operates between two defined power levels, it must comply with the separation distances for the higher power level.

(ii) White space devices operating at 40 mW EIRP or less are not required to meet the adjacent channel separation distances.

(iii) Fixed white space devices operating at 100 mW EIRP or less per 6 megahertz across multiple

contiguous TV channels with at least 3-megahertz separation between the frequency band occupied by the white space device and adjacent TV channels are not required to meet the adjacent channel separation distances.

(iv) Fixed white space devices may only operate above 4 W EIRP in less congested areas as defined in § 15.703.

(v) The following are the tables of minimum required separation distances outside the contours of co-channel and adjacent channel stations that white space devices must meet.

Table 2 to Section 15.712(a)(2)(v)

Mode II Personal/Portable White Space Devices		
	Required separation in kilometers from co-channel digital or analog TV (full service or low power) protected contour	
	16 dBm (40 mW)	**20 dBm (100 mW)**
Communicating with Mode II or Fixed device	**1.3**	**1.7**
Communicating with Mode I device	**2.6**	**3.4**

Table 3 to Section 15.712(a)(2)(v)

Fixed White Space Devices								
Antenna height above average terrain of unlicensed devices (meters)	**Required separation in kilometers from co-channel digital or analog TV (full service or low power) protected contour***							
	16 dBm (40 mW)	**20 dBm (100 mW)**	**24 dBm (250 mW)**	**28 dBm (625 mW)**	**32 dBm (1600 mW)**	**36 dBm (4 W)**	**40 dBm (10 W)**	**42 dBm (16 W)**
Less than 3	1.3	1.7	2.1	2.7	3.3	4.0	4.5	5.0
3 - 10	2.4	3.1	3.8	4.8	6.1	7.3	8.5	9.4
10 - 30	4.2	5.1	6.0	7.1	8.9	11.1	13.9	15.3
30 - 50	5.4	6.5	7.7	9.2	11.5	14.3	19.1	20.9
50 - 75	6.6	7.9	9.4	11.1	13.9	18.0	23.8	26.2
75 - 100	7.7	9.2	10.9	12.8	17.2	21.1	27.2	30.1
100 - 150	9.4	11.1	13.2	16.5	21.4	25.3	32.3	35.5
150 - 200	10.9	12.7	15.8	19.5	24.7	28.5	36.4	39.5
200 - 250	12.1	14.3	18.2	22.0	27.3	31.2	39.5	42.5
250 - 300	13.9	16.4	20.0	23.9	29.4	35.4	42.1	45.9

300 - 350	15.3	17.9	21.7	25.7	31.4	37.6	44.5	48.4
350 - 400	16.6	19.3	23.2	27.3	33.3	39.7	46.9	51.0
400 - 450	17.6	20.4	24.4	28.7	35.1	41.9	49.4	53.8
450 - 500	18.3	21.4	25.5	30.1	36.7	43.7	51.4	55.9
500 - 550	18.9	21.8	26.3	31.0	37.9	45.3	53.3	57.5

*When communicating with Mode I personal/portable white space devices, the required separation distances must be increased beyond the specified distances by 1.3 kilometers if the Mode I device operates at power levels no more than 40 mW EIRP or 1.7 kilometers if the Mode I device operates at power levels above 40 mW EIRP.

Table 4 to Section 15.712(a)(2)(v)

Personal/Portable White Space Devices	
	Required separation in kilometers from adjacent channel digital or analog TV (full service or low power) protected contour
	20 dBm (100 mW)
Communicating with Mode II or Fixed device	**0.1**
Communicating with Mode I device	**0.2**

Table 5 to Section 15.712(a)(2)(v).

Fixed White Space Devices							
Antenna height above average terrain of unlicensed devices (meters)	**Required separation in kilometers from adjacent channel digital or analog TV (full service or low power) protected contour***						
	20 dBm (100 mW)	**24 dBm (250 mW)**	**28 dBm (625 mW)**	**32 dBm (1600 mW)**	**36 dBm (4 W)**	**40 dBm (10 W)**	**42 dBm (16 W)**
Less than 3	0.1	0.1	0.1	0.1	0.2	0.2	0.3
3 - 10	0.1	0.2	0.2	0.2	0.3	0.4	0.5
10 - 30	0.2	0.3	0.3	0.4	0.5	0.6	0.7
30 - 50	0.3	0.3	0.4	0.5	0.7	0.8	1.0
50 - 75	0.3	0.4	0.5	0.7	0.8	0.9	1.0
75 - 100	0.4	0.5	0.6	0.8	1.0	1.1	1.3
100 - 150	0.5	0.6	0.8	0.9	1.2	1.3	1.5
150 - 200	0.5	0.7	0.9	1.1	1.4	1.5	1.7

200 - 250	0.6	0.8	1.0	1.2	1.5	1.7	1.9
250 - 300	0.7	0.8	1.0	1.3	1.6	2.1	2.3
300 - 350	0.7	0.9	1.1	1.4	1.8	2.2	2.4
350 - 400	0.8	1.0	1.2	1.5	1.9	2.4	2.7
400 - 450	0.8	1.0	1.3	1.6	2.1	2.6	2.9
450 - 500	0.8	1.1	1.4	1.7	2.1	2.7	2.9
500 - 550	0.9	1.2	1.5	1.8	2.2	2.8	3.0

*When communicating with a Mode I personal/portable white space device that operates at power levels above 40 mW EIRP, the required separation distances must be increased beyond the specified distances by 0.1 kilometers.

(3) *Fixed white space device antenna height.* Fixed white space devices must comply with the requirements of §15.709(g).

* * * * *

(b) * * *

(3) * * *

(ii) White space devices operating with more than 4 watts EIRP and up to 10 watts EIRP may not operate within 10.2 kilometers from the receive site for co-channel operation and 2.5 kilometers from the receive site for adjacent channel operation.

(iii) White space devices operating with more than 10 watts EIRP may not operate within 16.6 kilometers from the receive site for co-channel operation and 3.5 kilometers from the receive site for adjacent channel operation.

(iv) For purposes of this section, a TV station being received may include a full power TV station, TV translator station or low power TV/Class A TV station.

(c) * * *

(2) * * *

(ii) White space devices operating with more than 4 watts EIRP and up to 10 watts EIRP may not operate within 10.2 km from the receive site for co-channel operation and 2.5 km from the receive site for adjacent channel operation.

(iii) White space devices operating with more than 10 watts EIRP may not operate within 16.6 kilometers from the receive site for co-channel operation and 3.5 kilometers from the receive site for adjacent channel operation.

(d) *PLMRS/CMRS operations.* (1) White space devices may not operate at distances less than those specified in the table below from the coordinates of the metropolitan areas and on the channels listed in §90.303(a) of this chapter.

Table 6 to Section 15.712(d)(1).

White space device transmitter power	Required separation in kilometers from the areas specified in §90.303(a) of this chapter			
	Co-channel operation		Adjacent channel operation	
	Up to 250 meters HAAT	Greater than 250 meters HAAT	Up to 250 meters HAAT	Greater than 250 meters HAAT
Up to 4 watts EIRP	134.0	158.0	131.0	155.4
Greater than 4 watts and up to 10 watts EIRP	136.0	169.8	131.5	166.0
Greater than 10 watts and up to 16 watts EIRP	139.2	171.1	132.2	166.2

(2) White space devices may not operate at distances less than those specified in the table below from PLMRS/CMRS operations authorized by waiver outside of the metropolitan areas listed in §90.303(a) of this chapter.

Table 7 to Section 15.712(d)(2).

White space device transmitter power	Required separation in kilometers from operations authorized by waiver outside of the areas specified in §90.303(a) of this chapter			
	Co-channel operation		Adjacent channel operation	
	Up to 250 meters HAAT	Greater than 250 meters HAAT	Up to 250 meters HAAT	Greater than 250 meters HAAT
Up to 4 watts EIRP	54.0	78.0	51.0	75.4
Greater than 4 watts and up to 10 watts EIRP	56.0	89.8	51.5	86.0
Greater than 10 watts and up to 16 watts EIRP	59.2	91.1	52.2	86.2

* * * * *

(f) *Low power auxiliary services, including wireless microphones.* White space devices are not permitted to operate within the following distances of the coordinates of registered low power auxiliary station sites on the registered channels during the designated times they are used by low power auxiliary stations.

(1) Fixed white space devices with 10 watts EIRP or less: 1 kilometer

(2) Fixed white space devices with greater than 10 watts EIRP: 1.3 kilometers

(3) Personal/portable white space devices: 400 meters

(g) Border areas near Canada and Mexico: Fixed, mobile and personal/portable white space devices shall comply with the required separation distances in §15.712(a)(2) from the protected contours of TV stations in Canada and Mexico. White space devices are not required to comply with these separation distances

from portions of the protected contours of Canadian or Mexican TV stations that fall within the United States.

(h) * * *

(1) Operation of fixed, mobile and personal/portable white space devices is prohibited on all channels within 2.4 kilometers at the following locations.

* * * * *

(i) * * *

(1) Fixed white space devices may only operate above 4 W EIRP in less congested areas as defined in §15.703.

* * * * *

6. Amend section 15.713 by revising paragraphs (a)(1), (e)(1), (e)(2), (e)(3), (e)(6), (h) and (l)(2) to read as follows:

§ 15.713 White space database.

(a) * * *

(1) To determine and provide to a white space device, upon request, the available channels at the white space device's location in the TV bands, the 600 MHz duplex gap, the 600 MHz service band, and 608-614 MHz (channel 37). Available channels are determined based on the interference protection requirements in §15.712. A database must provide fixed, mobile and Mode II personal portable white space devices with channel availability information that includes scheduled changes in channel availability over the course of the 48-hour period beginning at the time the white space devices make a recheck contact. In making lists of available channels available to a white space device, the white space database shall ensure that all communications and interactions between the white space database and the white space device include adequate security measures such that unauthorized parties cannot access or alter the white space database or the list of available channels sent to white space devices or otherwise affect the database system or white space devices in performing their intended functions or in providing adequate interference protections to authorized services operating in the TV bands, the 600 MHz duplex gap, the 600 MHz service band, and 608-614 MHz (channel 37). In addition, a white space database must also verify that the FCC identifier (FCC ID) of a device seeking access to its services is valid; under the requirement in this paragraph (a)(1) the white space database must also verify that the FCC ID of a Mode I device provided by a fixed or Mode II device is valid. A list of devices with valid FCC IDs and the FCC IDs of those devices is to be obtained from the Commission's Equipment Authorization System.

* * * * *

(e) * * *

(1) Fixed, mobile and Mode II white space devices must provide their location and required identifying information to the white space database in accordance with the provisions of this subpart.

(2) Fixed, mobile and Mode II white space devices shall not transmit unless they receive, from the white space database, a list of available channels and may only transmit on the available channels on the list provided by the database.

(3) Fixed and mobile white space devices register and receive a list of available channels from the database by connecting to the Internet, either directly or through another fixed white space device that has a direct connection to the Internet. Fixed devices must also register with the database in accordance with paragraph (g) of this section.

(4) * * *

(5) * * *

(6) A fixed device with an antenna height above ground that exceeds 30 meters or an antenna height above average terrain (HAAT) that exceeds 250 meters generally, or 500 meters in less congested areas shall not be provided a list of available channels. The HAAT is to be calculated using computational software employing the methodology in §73.684(d) of this chapter.

* * * * *

(h) Mode II personal/portable and mobile device information to database.

(1) A mobile device and a personal/portable device operating in Mode II shall provide the database its FCC Identifier (as required by §2.926 of this chapter) and serial number as assigned by the manufacturer.

(2) A personal/portable device operating in Mode II shall provide the database, and the device's geographic coordinates (latitude and longitude (NAD 83)).

(3) A mobile device shall provide the database with the boundaries of the geo-fenced area in which it will operate. Alternatively, the boundaries of the geo-fenced area may be loaded from the database into the mobile device.

* * * * *

(l) * * *

(1) * * *

(2) A white space database shall verify that the FCC identification number supplied by a fixed, mobile or personal/portable white space device is for a certified device and may not provide service to an uncertified device.

* * * * *

7. Amend section 15.714 by revising paragraph (a) to read as follows:

§ 15.714 White space database administration fees.

(a) A white space database administrator may charge a fee for provision of lists of available channels to fixed, mobile and personal/portable devices and for registering fixed devices. This paragraph (a) applies to devices that operate in the TV bands, the 600 MHz service band, the 600 MHz duplex gap, and 608-614 MHz (channel 37).

* * * * *

8. Amend section 15.715 by revising paragraph (e) to read as follows:

§ 15.715 White space database administrator.

* * * * *

(e) Provide accurate lists of available channels and the corresponding maximum permitted power for each available channel to fixed, mobile and personal/portable white space devices that submit to it the information required under §15.713(e), (g), and (h) based on their geographic location and provide accurate lists of available channels and the corresponding maximum permitted power for each available channel to fixed, mobile and Mode II devices requesting lists of available channels for Mode I devices. Database administrators may allow prospective operators of white space devices to query the database and determine whether there are vacant channels at a particular location.

* * * * *

Appendix B

List of Parties Filing Comments

Comments

1. ACT | The App Association
2. Adaptrum Inc.
3. American Farm Bureau Federation
4. American Society for Health Care Engineering of the American Hospital Association
5. ARK Multicasting, Inc.
6. Broadband Connects America Coalition
7. Cal.net, Inc.
8. Citizens Against Government Waste, et. al.
9. Connect Americans Now, et. al.
10. Consumer Technology Association
11. CORF - National Academy of Sciences
12. CP Communications, LLC
13. Declaration Networks Group, Inc, Robert Nichols
14. Dynamic Spectrum Alliance (DSA)
15. Edgar C. Reihl, P.E.
16. Microsoft Corporation
17. Midwest Food Products Association
18. National Association of Broadcasters (NAB)
19. National Public Safety Telecommunications Council (NPSTC)
20. National Rural Education Association
21. National Translator Association
22. ONE Media 3.0, LLC
23. Pennsylvania Farm Bureau
24. Public Interest Spectrum Coalition (PISC)
25. RADWIN Ltd.
26. RED Technologies
27. RTO Wireless, LLC
28. Sennheiser Electronic Corporation
29. Shure Incorporated
30. Western Governors' Association
31. Wireless Internet Service Providers Association (WISPA)

Reply comments

1. ACT | The App Association
2. Ark Multicasting, Inc.
3. Connect Americans Now
4. Dynamic Spectrum Alliance (DSA)
5. Goodspeed Musicals
6. Lectrosonics, Inc.
7. Microsoft Corporation
8. National Association of Broadcasters (NAB)
9. National Public Safety Telecommunications Council (NPSTC)
10. New America's Open Technology Institute
11. ONE Media 3.0, LLC
12. Public Interest Spectrum Coalition (PISC)
13. RED Technologies
14. Sennheiser Electronic Corp.

15. Shure Incorporated
16. Small Business Innovator Multistakeholder Group
17. Smith and Fisher, LLC
18. Voices for Innovation
19. Wireless Internet Service Providers Association (WISPA)

Appendix C

FINAL REGULATORY FLEXIBILITY ANALYSIS

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[1] an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Notice of Proposed Rule Making* (NPRM) in ET Docket No. 20-36.[2] The Commission sought written public comment on the proposals in the *NPRM*, including comment on the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.[3]

A. Need for, and Objectives of, the Report and Order

The Report and Order adopts targeted changes to the rules for white space devices operating on TV Channels 2-35 to provide improved broadband coverage that will benefit American consumers in rural and underserved areas. It permits higher radiated power and higher antenna heights for fixed white space devices in "less congested" areas, which are defined as those areas in which at least half the TV channels in a device's band of operation are vacant. In addition, the Report and Order permits higher power mobile operation within defined geographic areas in "less congested" areas.[4] It also adopts rule changes designed to facilitate the development of new and innovative narrowband Internet of Things (IoT) services.

B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA

There were no comments filed that specifically addressed the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

Pursuant to the Small Business Jobs Act of 2010, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

D. Description and Estimate of the Number of Small Entities to Which the Rules Will Apply

The RFA directs agencies to provide a description of and, where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.[5] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[6] In addition, the term "small business" has the

[1] 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601 – 612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[2] *Unlicensed White Space Device Operations in the Television Bands*, ET Docket No. 20-36, Notice of Proposed Rulemaking, 35 FCC Rcd 2101 (2020) (*Notice*).

[3] *See* 5 U.S.C. § 604.

[4] A "geo-fenced" area refers to a defined geographic area in which a mobile white space device may operate. The white space device uses an incorporated geo-location capability such as GPS in conjunction with a database to determine the location of the device with respect to the boundaries of the defined area.

[5] *See* 5 U.S.C. § 603(b)(3).

[6] *See* 5 U.S.C. § 601(6).

same meaning as the term "small business concern" under the Small Business Act.[7] A "small business concern" is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).[8]

Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing. This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment.[9] Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.[10] The SBA has established a small business size standard for this industry of 1,250 or fewer employees.[11] U.S. Census Bureau data for 2012 show that 841 establishments operated in this industry in that year.[12] Of that number, 828 establishments operated with fewer than 1,000 employees, 7 establishments operated with between 1,000 and 2,499 employees and 6 establishments operated with 2,500 or more employees.[13] Based on this data, we conclude that a majority of manufacturers in this industry are small.

Television Broadcasting. This Economic Census category "comprises establishments primarily engaged in broadcasting images together with sound."[14] These establishments operate television broadcast studios and facilities for the programming and transmission of programs to the public.[15] These establishments also produce or transmit visual programming to affiliated broadcast television stations, which in turn broadcast the programs to the public on a predetermined schedule. Programming may originate in their own studio, from an affiliated network, or from external sources. The SBA has created the following small business size standard for such businesses: those having $41.5 million or less in annual receipts.[16] The 2012 Economic Census reports that 751 firms in this category operated in that

[7] *See* 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register."

[8] *See* 15 U.S.C. § 632.

[9] *See* U.S. Census Bureau, *2017 NAICS Definitions, "334220 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing*", https://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=334220&search=2017.

[10] *Id*.

[11] *See* 13 CFR § 121.201, NAICS Code 334220.

[12] *See* U.S. Census Bureau, *2012 Economic Census of the United States*, Table ID: EC1231SG2, *Manufacturing: Summary Series: General Summary: Industry Statistics for Subsectors and Industries by Employment Size: 2012*, NAICS Code 334220, https://data.census.gov/cedsci/table?text=EC1231SG2&n=334220&tid=ECNSIZE2012.EC1231SG2&hidePreview=false.

[13] *Id*. Available census data does not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with "1000 employees or more."

[14] *See* U.S. Census Bureau, *2017 NAICS Definition, "515120 Television Broadcasting*", https://www.census.gov/cgi-bin/sssd/naics/naicsrch?input=515120&search=2017+NAICS+Search&search=2017.

[15] *Id.*

[16] *See* 13 CFR § 121.201, NAICS Code 515120.

year.[17] Of that number, 656 had annual receipts of $25,000,000 or less, and 25 had annual receipts between $25,000,000 and $49,999,999.[18] Based on this data we therefore estimate that the majority of commercial television broadcasters are small entities under the applicable SBA size standard.

The Commission has estimated the number of licensed commercial television stations to be 1,377.[19] Of this total, 1,258 stations (or about 91 percent) had revenues of $38.5 million or less, according to Commission staff review of the BIA Kelsey Inc. Media Access Pro Television Database (BIA) on November 16, 2017, and therefore these licensees qualify as small entities under the SBA definition. In addition, the Commission has estimated the number of licensed noncommercial educational television stations to be 384.[20] Notwithstanding, the Commission does not compile and otherwise does not have access to information on the revenue of NCE stations that would permit it to determine how many such stations would qualify as small entities. There are also 2,300 low power television stations, including Class A stations (LPTV) and 3,681 TV translator stations.[21] Given the nature of these services, we will presume that all of these entities qualify as small entities under the above SBA small business size standard.

We note, however, that in assessing whether a business concern qualifies as "small" under the above definition, business (control) affiliations[22] must be included. Our estimate, therefore likely overstates the number of small entities that might be affected by our action, because the revenue figure on which it is based does not include or aggregate revenues from affiliated companies. In addition, another element of the definition of "small business" requires that an entity not be dominant in its field of operation. We are unable at this time to define or quantify the criteria that would establish whether a specific television broadcast station is dominant in its field of operation. Accordingly, the estimate of small businesses to which rules may apply does not exclude any television station from the definition of a small business on this basis and is therefore possibly over-inclusive. Also, as noted above, an additional element of the definition of "small business" is that the entity must be independently owned and operated. The Commission notes that it is difficult at times to assess these criteria in the context of media entities and its estimates of small businesses to which they apply may be over-inclusive to this extent.

E. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities

White space devices are unlicensed devices that operate in the television bands or 600 MHz band at locations where frequencies are not in use by licensed services. These devices may be either fixed or portable. Fixed devices may operate at power levels up to 4 watts EIRP, or up to 10 watts EIRP in less congested areas. Portable devices may operate at up to 100 milliwatts EIRP. To prevent harmful interference to broadcast television stations and other protected users of these bands, white space devices

[17] *See* U.S. Census Bureau, *2012 Economic Census of the United States*, Table ID: EC1251SSSZ4, *Information: Subject Series – Estab and Firm Size: Receipts Size of Firms for the U.S.: 2012,* NAICS Code 515120, https://data.census.gov/cedsci/table?text=EC1251SSSZ4&n=515120&tid=ECNSIZE2012.EC1251SSSZ4&hidePreview=false.

[18] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

[19] *Broadcast Station Totals* as of June 30, 2018, Press Release (MB, rel. Jul. 3, 2018) (June 30, 2018 Broadcast Station Totals Press Release), https://docs.fcc.gov/public/attachments/DOC-352168A1.pdf.

[20] *Id.*

[21] *Id.*

[22] "[Business concerns] are affiliates of each other when one concern controls or has the power to control the other or a third party or parties controls or has the power to control both." 13 C.F.R. § 21.103(a)(1).

must obtain a list of available channels that may be used at their location from databases administered by private entities selected by the Commission.

Most RF transmitting equipment, including white space devices, must be authorized through the certification procedure. Certification is an equipment authorization issued by a designated Telecommunication Certification Body based on an application and test data submitted by the responsible party (e.g., the manufacturer or importer). The Report and Order does not change the authorization procedure for white space devices, but it modifies certain technical requirements for them.

The Report and Order takes a number of steps to provide improved broadband coverage in areas where the TV spectrum is "less congested," meaning at least half the TV channels in a given range are unused for broadcast and other protected services and available for white space device use. These areas are typically rural and other underserved areas. The Report and Order increases the maximum permissible power level for fixed white space devices from 10 watts to 16 watts EIRP and increases the maximum permissible antenna height above average terrain from 250 meters to 500 meters. These changes, which are limited to "less congested" areas, will increase the maximum transmission range of fixed white space devices operating on TV channels 2-35, thus allowing the provision of broadband service over wider areas at lower costs. Parties operating fixed white space devices with an HAAT of greater than 250 meters will be required to notify potentially affected TV broadcast stations four days in advance of commencing operation. Potentially affected TV stations are defined as those that would be less than minimum required separation distances from white space devices if the white space devices operated with an HAAT 50 meters higher than the actual HAAT they will use.

The Report and Order also permits higher power mobile operation than the rules previously allowed, up to 16 watts EIRP, within defined geo-fenced areas. A geo-fenced area is one in which the white space database has determined that one or more TV channels are available for mobile white space devices over the entire defined area, and the mobile device incorporates a mechanism to determine its location and transmit on only the available channels within the defined area. This higher power mobile operation is permitted in "less congested" areas.

The Report and Order establishes rules for narrowband white space devices that can be used to provide new and innovative IoT services. These operations will be permitted any place, not just in "less congested" areas.

Additionally, the Report and Order removes the limit on fixed white space device antenna height above ground since the white space protection criteria are based on the antenna height above average terrain, rather than above ground.

F. Steps Taken to Minimize the Significant Economic Impact on Small Entities, and Significant Alternatives Considered

The RFA requires an agency to describe any significant, specifically small business, alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): "(1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance and reporting requirements under the rule for such small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part thereof, for such small entities."[23]

The rule changes that permit higher power and antenna heights for fixed white space devices, higher power mobile devices, and narrowband IoT operations would give greater flexibility to manufacturers and white space device operators. These changes are permissive, meaning that manufacturers of approved white space devices are not required to make any changes to their equipment,

[23] *See* 5 U.S.C. § 603(c)(1) – (c)(4).

nor are current operators of devices required to make any changes. Manufacturers that choose to make equipment that operates under the new narrowband IoT or high-power mobile rules, or that wish to make changes to existing equipment to increase power would have to obtain a new equipment certification.

The Commission believes that the requirement for parties planning to operate a fixed device with an HAAT above 250 meters to notify potentially affected TV broadcast stations is necessary to help broadcasters identify any interference that results from white space device operation at a high HAAT. The Commission considered whether to adopt a more complex coordination procedure supported by NAB but decided that the simpler procedure proposed in the Notice is less burdensome. The Commission also provided an option for the white space database administrator to fully automate this notification procedure.

Report to Congress: The Commission will send a copy of the Report and Order, including this FRFA, in a report to Congress pursuant to the Congressional Review Act.[24] In addition, the Commission will send a copy of the Report and Order, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the Report and Order and FRFA (or summaries thereof) will also be published in the Federal Register.[25]

[24] *See* 5 U.S.C. § 801(a)(1)(A).

[25] *See* 5 U.S.C. § 604(b).

Appendix D

INITIAL REGULATORY FLEXIBILITY ANALYSIS

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[1] the Commission has prepared this present Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on a substantial number of small entities by the policies and rules proposed in *Unlicensed White Space Device Operations in the Television Bands*, Further Notice of Proposed Rule Making (FNPRM). Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines for comments on the FNPRM provided in paragraph 99 of the item. The Commission will send a copy of the FNPRM, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA).[2] In addition, the FNPRM and IRFA (or summaries thereof) will be published in the Federal Register.[3]

A. Need for, and Objectives of, the Proposed Rules

The FNPRM responds to requests in this proceeding for the Commission to modify the white space rules to permit vacant channel availability to be determined using a terrain-based propagation model in place of the current protection model that uses pre-defined separation distances outside of a TV station's protected service contour.

B. Legal Basis

The proposed action is taken pursuant to Sections 4(i), 201, 302, and 303 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), 201, 302a, 303.

C. Description and Estimate of the Number of Small Entities to Which the Proposed Rules Will Apply

The RFA directs agencies to provide a description of, and where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.[4] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[5] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[6] A "small business concern" is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).[7]

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[1] 5 U.S.C. § 603. The RFA, 5 U.S.C. § 601 – 612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[2] 5 U.S.C. § 603(a).

[3] 5 U.S.C. § 603(a).

[4] 5 U.S.C. § 603(b)(3).

[5] 5 U.S.C. § 601(6).

[6] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register.".

[7] 15 U.S.C. § 632.

Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing. This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment.[8] Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.[9] The SBA has established a small business size standard for this industry of 1,250 or fewer employees.[10] U.S. Census Bureau data for 2012 show that 841 establishments operated in this industry in that year.[11] Of that number, 828 establishments operated with fewer than 1,000 employees, 7 establishments operated with between 1,000 and 2,499 employees and 6 establishments operated with 2,500 or more employees.[12] Based on this data, we conclude that a majority of manufacturers in this industry are small.

D. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities

White space devices are unlicensed devices that operate in the TV bands at locations where frequencies are not in use by licensed services. These devices may be either fixed or portable. To prevent harmful interference to broadcast television stations and other authorized users of these bands, white space devices must obtain a list of available TV channels that may be used at their location from databases administered by private entities selected by the Commission. The database determines channel availability using protection criteria specified in the rules.

Most RF transmitting equipment, including white space devices, must be authorized through the certification procedure. Certification is an equipment authorization issued by a designated Telecommunication Certification Body (TCB) based on an application and test data submitted by the responsible party (e.g., the manufacturer or importer).[13] The FNPRM does not propose to change the authorization procedure for white space devices, or the requirement for them to obtain a list of available channels from a database, but it does propose to modify the procedure that the white space database uses to determine channel availability for white space devices. Specifically, it proposes to allow the use of the Longley-Rice Irregular Terrain model to identify vacant TV channels in place of the current model that uses pre-defined separation distances outside a TV station's protected contour.

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[8] *See* U.S. Census Bureau, *2017 NAICS Definitions, "334220 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing*", https://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=334220&search=2017.

[9] *Id*.

[10] *See* 13 CFR § 121.201, NAICS Code 334220.

[11] *See* U.S. Census Bureau, *2012 Economic Census of the United States*, Table ID: EC1231SG2, *Manufacturing: Summary Series: General Summary: Industry Statistics for Subsectors and Industries by Employment Size: 2012*, NAICS Code 334220, https://data.census.gov/cedsci/table?text=EC1231SG2&n=334220&tid=ECNSIZE2012.EC1231SG2&hidePreview=false.

[12] *Id*. Available census data does not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with "1000 employees or more."

[13] 47 C.F.R. § 2.907. The Commission or a TCB may test a sample of a device to verify that it complies with the rules before granting approval for the equipment to be marketed. Examples of devices subject to certification include, but are not limited to, mobile phones; wireless local area networking equipment, remote control transmitters; land mobile radio transmitters; wireless medical telemetry transmitters; cordless telephones; and walkie-talkies.

E. Steps Taken to Minimize the Significant Economic Impact on Small Entities, and Significant Alternatives Considered

The RFA requires an agency to describe any significant, specifically small business, alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): "(1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance and reporting requirements under the rule for such small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part thereof, for such small entities."[14]

The white space database administrators would have to modify their database systems to calculate channel availability using the Longley-Rice or other terrain-based model and would therefore incur costs in doing so. It is not known whether white space device manufacturers would have to make any changes to their devices in terms of what information must be supplied to the white space database when requesting a list of available channels. The FNPRM seeks comment on whether the use of the Longley-Rice model should be mandatory or made as an option in addition to the current model. It also seeks comment on how any necessary changes to equipment should be handled.

F. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rules

None.

[14] 5 U.S.C. § 603(c)(1) – (c)(4).

STATEMENT OF
CHAIRMAN AJIT PAI

Re: *Unlicensed White Space Device Operations in the Television Bands*, ET Docket No. 20-36.

My top priority as FCC Chairman has been closing the digital divide. A critical part of our work on that front has been expanding the deployment of high-speed broadband in rural America. By modernizing our Universal Service Fund programs, reducing unnecessary regulatory burdens, making more spectrum available for commercial use, and reducing the cost of deploying broadband infrastructure, since January 2017, we've substantially reduced the number of rural Americans without broadband access. But we still have more work to do. And with broadband now more important than ever as a result of the pandemic, we must use every tool at our disposal to connect unserved Americans.

Today, we adopt rules that will expand the availability of wireless broadband connectivity through the use of TV white space devices—one such tool.

The TV white space spectrum—which includes unoccupied channels in the broadcast television bands—has several attributes that make it attractive for delivering wireless broadband service to rural areas. The signals propagate well over long distances, varying terrain, and even into and within buildings. The Commission first authorized unlicensed white space operations in 2008 and has expanded white space opportunities on several occasions since then, each time taking care not to interfere with broadcast television station operations. For example, in 2019, we modified our antenna height rules to allow for improved broadband coverage in rural areas.

Today, thanks in no small part to the collaborative work of key industry stakeholders such as Microsoft and the National Association of Broadcasters, we now adopt additional changes to the operating and technical rules for white space devices that will expand their ability to deliver wireless services in many rural and underserved areas.

We allow fixed white space devices in less congested areas to operate at higher power and increased height above average terrain. We create a new class of geo-fenced, mobile white space devices that may operate at higher power levels. And we reform our rules to allow for the deployment of narrowband IoT white space devices. These rules will permit operation in smaller, 100-kilohertz channels at the same maximum power level currently permitted for fixed devices.

At the same time, however, we take the critical steps necessary to ensure that these reforms don't end up causing harmful interference to broadcast television stations—which, after all, are the primary users of the band. For example, we increase the minimum required separation distances between white space devices operating at higher power or height above average terrain and protected services operating in the TV bands. And we adopt requirements for mobile white space devices to re-check their geographic coordinates at least once every 60 seconds and to cease operation if it they travel closer than 1.6 kilometers to the edge of the geo-fenced area or are outside the boundary of the area.

In short, we ably thread the needle, protecting the ability of broadcast television stations to serve their communities and helping bring digital opportunity to more rural Americans and close the digital divide. Not bad for a day's work—especially after a dozen years.

For all the help on this matter, I'd like to thank: From the Office of Engineering and Technology: Chrysanthos Chrysanthou, Martin Doczkat, David Duarte, Ira Keltz, Paul Murray, Siobahn Philemon, Jamison Prime, Ron Repasi, Tom Struble, Hugh Van Tuyl, and Sean Yun; from the Wireless Telecommunications Bureau: Chris Andes, Steve Buenzow, Melissa Conway, Lloyd Coward, Joel Taubenblatt, and Jennifer Tomchin; from the Enforcement Bureau: Daniela Arregui, Ricardo Durham, Shannon Lipp, David Marks, Neal McNeil, Janet Moran, and Ron Ramage; from the Office of General Counsel: David Horowitz, Doug Klein, and Bill Richardson; and from the Office of Economics and Analytics: Paul LaFontaine, Kate Matraves, and Patrick Sun.

STATEMENT OF
COMMISSIONER MICHAEL O'RIELLY

Re: *Unlicensed White Space Device Operations in the Television Bands,* ET Docket No. 20-36.

Making television white spaces available for wireless services – without disrupting the great work of America's broadcasters – has been a project of mine since well before I came to the Commission. It's been a pleasure to lead the charge on this effort, even if it faced initial reluctance within the agency, which appears to have dissipated.

Utilizing the "gaps" between TV stations provides a unique opportunity to expand wireless broadband services to those Americans without access to them. Foremost, it provides access to frequencies in rural America where there are fewer broadcasters, assisting our efforts to serve the unserved, especially with new broadband offerings, and to use spectrum as efficiently as possible. Everyone should celebrate the recently demonstrated benefits of white space usage, particularly those by Microsoft's AirBand initiative.

Today's action, which incorporates a collaborative agreement between Microsoft and America's broadcasters, will allow greater use of TV white spaces by increasing power limits in "less congested areas" and permitting higher antenna heights for fixed wireless equipment, allowing higher power for mobile operations within defined areas, and adopting rules for narrowband IoT operations. These rule changes, along with some other technical tweaks, will enable the provision of a wider variety of wireless services to Americans over a larger geographic area, while not harming incumbent broadcast service.

Although these are great developments, there are still some areas that need to be considered further. Terrain-based models are used for determining channel availability in several proceedings and services, such as the incentive auction, 3.5 GHz, and 6 GHz. In this case, it was determined that more information was needed before we could implement the Longley-Rice Irregular Terrain Model for TV white spaces. I thank my colleagues for agreeing to pursue this model and seek comment on its possible implementation, as taking terrain into consideration allows for the greater and more efficient use of spectrum. I also appreciate that my colleagues agreed to changes clarifying certain rules affecting the use of narrowband IoT devices.

There have also been continued discussions about whether higher power wireless offerings can be deployed in first adjacent channels. Microsoft has done significant field testing and the results sound promising, but they recognize that more testing is warranted. I hope that other stakeholders will assist such field testing, so that in the future we can make greater use of the TV white spaces. Hopefully, this testing will be completed as soon as feasibly possible, and the parties involved will come to the Commission with a technically-sound plan for expanded use of first adjacent channels, if appropriate.

While I will not be at the FCC to push for and resolve these last few issues, I am encouraged that my colleagues agreed to explore them. I look forward to following the developments of TV white space broadband offerings and seeing what other innovative services grow out of this proceeding. I approve.

STATEMENT OF
COMMISSIONER BRENDAN CARR

Re: *Unlicensed White Space Device Operations in the Television Bands*, ET Docket No. 20-36.

Blue Mountain is a ridgeline that rises about a thousand feet above the farms and small towns that are spread across Pennsylvania's Cumberland Valley. Up on top of the ridge, a few miles outside Carlyle, sits an old AT&T long line tower. It's a roughly five-story concrete structure first built in the 1940s. If you climb up to the top of that tower, the dusty and creaking ladders along the way serve as a constant reminder of its age. But it was cutting edge back in the day—part of the then high-tech network of microwave towers that connected the East and West Coasts of the country.

Today, a fixed wireless provider, CTI Networks, is putting this old infrastructure to a new use. Like many WISPs, CTI is a small and scrappy company. I met its owner, Allen, at the tower last week, and from up on top he pointed out all the farms and homes in the valley below that had been stuck with only slow DSL service for far too long. That is now changing. Allen has attached a couple of small antennas to the tower that are now beaming high-speed wireless service to these underserved communities.

I've seen essentially the same story play out in rural areas throughout the country, where WISPs are working tirelessly to provide life-changing Internet service to communities that have been left behind.

Stories like these are precisely why today's item is such a big win for consumers in these hard-to-reach communities. Fixed wireless services will continue to play an important role in the FCC's efforts to increase connectivity, and it is critical that we expand opportunities for white space devices, particularly in rural America. We can make even more progress towards closing the digital divide while empowering rural communities through high-speed wireless connections.

A big reason we are here today is because stakeholders got together, compromised, and identified a path forward. This item is a testament to their efforts, and I am hopeful that our action today will help accelerate fixed wireless builds in rural communities that find themselves on the wrong side of the digital divide.

I want to thank the Office of Engineering and Technology for its work on the item. It has my support.

STATEMENT OF
COMMISSIONER JESSICA ROSENWORCEL

Re: *Unlicensed White Space Device Operations in the Television Bands,* ET Docket No. 20-36.

The years 2008 and 2020 have a few things in common. Both feature a major election. Both have Tampa Bay playing in the World Series. And a bit further below the campaign and cultural radar, in both years we have decisions that are monumental for white spaces.

It was in 2008 that the Federal Communications Commission first decided to open up unused broadcast spectrum for unlicensed services. Instead of letting portions of traditional television airwaves lay fallow, we determined white spaces should be available for innovation.

In 2020 we are still enchanted with the opportunities for unlicensed services in these airwaves. We have explored a range of possibilities, including broadband access in underserved communities. But technical challenges have sometimes limited our progress. So today we make another important decision in the history of white spaces. Building on the work of a group of interests in this band that came together to hammer out their differences, we adopt rules that give devices using white spaces increased flexibility. Specifically, we increase permissible power levels for both fixed and mobile devices and remove existing restrictions on antenna heights on fixed devices in less congested areas. In addition, we revise our rules to authorize new narrowband services and applications.

Making these changes is the right move. Today's decision has my support. But here's my wish. Let's not wait another dozen years before making our next meaningful decision on white spaces. We have too much work to do to power the Internet of Things, extend the reach of broadband access, and expand the range of innovation possible in wireless service. So let's get to it.

STATEMENT OF
COMMISSIONER GEOFFREY STARKS

Re: *Unlicensed White Space Device Operations in the Television Bands*, ET Docket No. 20-36

Millions of Americans live in areas without any form of broadband service. The Commission has long sought to promote the use of white spaces as a broadband service option for these communities. Today's decision is a good step towards finally realizing the full potential of this important technology.

The rule changes adopted today reflect a commonsense agreement between the white space community and broadcasters that will allow for more robust service and efficient spectral use, particularly in rural areas, without increasing the risk of harmful interference to television broadcasters or other authorized services. With better access to broadband service, rural and Tribal communities will be able to strengthen their local economies, receive higher quality telehealth services, successfully participate in distance learning, and securely work from home during and after this pandemic.

I'm particularly pleased about how our new rules will expand the mobile use of white space devices. With the higher power levels authorized today, mobile devices will allow farmers to better manage their crops and livestock through precision agriculture. Additionally, mobile white space devices will be able to operate as school bus hotspots and allow children in rural areas without broadband at home to complete homework on their long bus rides to and from school.

I'm also looking forward to seeing how narrowband IoT devices will take advantage of the propagation characteristics of the low-band white spaces spectrum to enable new and innovative uses in the agriculture, mining, and environmental monitoring sectors. The rule changes we adopt today maintain a low risk of harmful interference while expanding the opportunities for IoT applications in rural environments.

Finally, I appreciate that the order reflects changes suggested by me and my colleagues, including seeking further comment on the use of terrain-based models to protect services in the TV bands. While there may still be questions about how these models would work in the white spaces context, they deserve further consideration because they reflect real-world conditions and are used for other bands. I look forward to reviewing the comments on these issues.

Thank you to the Office of Engineering and Technology for their work on this item.