Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of 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	)))))))))	ET Docket No. 14-165

PETITION FOR RULEMAKING

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INTRODUCTION AND SUMMARY

Pursuant to Section 1.401 of the Commission's rules, Microsoft requests that the Federal Communications Commission ("FCC" or "Commission") launch a Further Notice of Proposed Rulemaking to make a set of improvements to its White Space device ("WSD") rules. As described in more detail below, these proposed changes are a logical outgrowth of the Commission's current White Space rules, and are the product of several years of on-the-ground experience with White Spaces deployments, improvements in technology, and meetings with Commission staff and other stakeholders. Indeed, although we do not agree on every issue, the National Association of Broadcasters has expressed its support for considering many of the proposals we describe below.[1] These changes will support the expansion and affordability of broadband service in rural communities and enable innovative use of White Space channels for narrowband Internet of Things ("IoT") devices. Together, these changes will improve the quality of life of rural Americans and strengthen the rural economy.

Today, at least 24 million Americans still lack access to a broadband internet connection.[2] Over 19 million of these people live in rural areas. This means that roughly 30 percent of Americans living in rural areas lack access to broadband. Microsoft applauds

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1 *See* Letter from Patrick McFadden, Associate General Counsel, National Association of Broadcasters, to Marlene Dortch, Secretary, Federal Communications Commission, ET Docket Nos. 16-56, 14-165 (filed Mar. 21, 2019).

2 *Inquiry Concerning Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion*, 2018 Broadband Deployment Report, 33 FCC Rcd. 1660, 1681 (2018) ("2018 Broadband Deployment Report"). The FCC is currently working on finalizing its 2019 Broadband Deployment Report, which may amend these numbers. *See* Press Release, Federal Communications Commission, *Revised Draft Broadband Deployment Report Continues to Show America's Digital Divide Narrowing Substantially* (May 1, 2019), https://docs.fcc.gov/public/attachments/DOC-357271A1.pdf.

Chairman Pai for making the elimination of the digital divide in rural America one of his priorities, and our objective in recommending these changes is to advance that goal.[3]

As the Commission has recognized, advancements in technology and business model innovations offer the promise of addressing today's broadband disparity. In partnership with private and public sector stakeholders, Microsoft is working to harness the power of White Spaces technologies to drastically improve the economics of delivering connectivity to rural America.

To achieve this goal, Microsoft launched the Airband Initiative. Airband includes direct investment in partnerships with Internet Service Providers ("ISPs") to provide broadband access to at least two million unserved and underserved people in rural America by July 4, 2022. Microsoft has no intention of becoming an ISP itself. Rather, for each deployment, we work with a local ISP partner.

To date, we have launched commercial partnerships in eleven states. Building these partnerships has given us insight into the real-world challenges that rural ISPs face every day—and has revealed pragmatic, long-overdue changes to the Commission's rules that would support more investment, innovation, and connectivity, while ensuring that incumbent licensees remain protected from harmful interference.

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[3] *See, e.g.*, 2018 Broadband Deployment Report at 1740, Statement of Chairman Ajit Pai ("Far too many Americans still lack access to high-speed Internet. That's why the FCC's top priority under my leadership remains bridging the digital divide and bringing digital opportunity to all Americans."); *Connect America Fund*, Report and Order, Third Order on Reconsideration, and Notice of Proposed Rulemaking, FCC 18-29, WC Docket Nos. 10-90, 14-58, 07-135, CC Docket No. 01-92, Statement of Chairman Ajit Pai (rel. Mar. 23, 2018) ("[T]he Commission's overarching objective is simple: to expedite broadband deployment and deliver digital opportunity to more rural Americans.").

The 2014 Notice of Proposed Rulemaking ("2014 NPRM") in this proceeding focused primarily on changes needed to ensure a smooth incentive auction. The auction closed in April 2017, two years ago. The time is now right to address a limited number of refinements to the rules to promote further rural deployment. Based on our experience working with our partners, Microsoft proposes that the Commission make the following improvements to its rules:

- Permit fixed WSDs in the second-adjacent channel to broadcasters in less congested areas to operate at a higher radiated power limit, consistent with the methodology used in Section 15.712(a)(2)(iv);
- Permit fixed WSDs to operate at greater than 40 mW on the first-adjacent channel at locations within the protected contour where the potential for harmful interference is low;
- Permit fixed WSDs to operate at heights above average terrain of up to 500 meters, consistent with the methodology used in Section 15.712(a)(2)(iv) and subject to a special set of coordination procedures modeled on the Commission's Part 101 rules;
- Foster the development of narrowband WSDs that can support IoT applications by modifying existing technical and operational rules and providing licensees the same level of protection from harmful interference as the rules for broadband WSDs; and
- Permit geofenced operation of fixed WSDs on mobile platforms.

Together, these changes to the Commission's rules will eliminate needless red tape in the current White Space regulations, allow Microsoft to partner with companies across the country to advance affordable rural broadband and open White Spaces technologies to new classes of uses and users in the rural economy, and provide the needed regulatory framework to stimulate innovative IoT applications that leverage the properties of White Spaces spectrum.

This petition complies with Section 1.401(c) of the Commission's rules, because it sets forth the text and substance of the proposed rule changes, provides the facts, arguments, and data supporting the requested rule changes, and makes clear how Microsoft will be affected.

I. The Commission Should Permit Higher Radiated Power Limits in Less Congested Areas to Support Broadband Expansion in Rural America.

The Commission's rules limit fixed WSDs to a maximum conducted power of 1 W (30 dBm) and require that transmitter power be reduced by the same amount in dB that the maximum antenna gain exceeds 6 dBi, or 10 dBi in less congested areas. Except in less congested areas, fixed WSDs are limited to 4 W (36 dBm) EIRP.[4] WSDs may operate at up to 10 W (40 dBm) EIRP in less congested areas.[5] In permitting 10 W EIRP in less congested areas, the Commission maintained its existing conducted power limits, but allowed the signal to be amplified by an antenna with up to a 10 dBi gain.

Based on the experience of our ISP partners in providing broadband service using White Spaces frequencies in rural areas, Microsoft proposes that the Commission increase its EIRP limit for fixed WSDs operating in less congested areas from 40 dBm to 42 dBm. We are not seeking an increase in the conducted power limits. Increasing the EIRP limit will provide rural broadband network designers with another tool to draw upon in providing access in often geographically challenging areas. Higher-power fixed WSDs can operate both point-to-multipoint and point-to-point. Operating point-to-multipoint, higher-EIRP WSDs can provide greater coverage area or greater bandwidth within a coverage area. We also request that if the gain of the antenna operating in less congested areas is increased above 12 dBi, the rules require a commensurate decrease in the conducted power limit so that the EIRP limit remains 42 dBm. Accordingly, there would be an increase in the separation distance beyond the distance for WSDs operating at 42 dBm, consistent with the methodology used in Section 15.712(a)(2)(iv). In

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4 *See Unlicensed Operation in the TV Broadcast Bands*, Second Memorandum Opinion and Order, 25 FCC Rcd. 18,661, 18,690 ¶ 69 (2010).

5 *See* 47 C.F.R § 15.709(a)(2)(i).

Microsoft's conversations with rural broadband providers, Microsoft has consistently found that a 2 dB increase in maximum power will allow a significant improvement in the economics of rural coverage. And our work with device manufacturers has shown that this increase is practical and feasible with current and planned equipment. Microsoft would welcome the flexibility to operate at radiated power levels greater than 42 dBm, and we encourage the Commission to explore this possibility. Based on our conversations with other stakeholders, however, 42 dBm (30 dBm conducted power with 12 dBi antenna gain) appears to offer an optimum balance between greater coverage and larger antenna sizes and higher equipment costs, which both also increase with higher gain.

The Commission previously has not permitted higher EIRP limits because it was "concerned that at power levels above 10 watts EIRP, the increased propagation distance would make it difficult to identify signal sources if any interference were to occur." [6]

Microsoft believes the time is right for the Commission to reexamine this issue in light of changes and experience gained in the intervening years. First, the Commission has improved the mechanisms in place to address a broadcaster's substantiated claim of harmful interference. Second, in each rural area there will likely be only a small number of ISPs utilizing the White Spaces in this way, making identification straightforward. If an issue does arise due to increasing the EIRP limit from 40 dBm to 42 dBm, it can be corrected quickly. Notably, no such issues have arisen in connection with deployments by Microsoft's partners in the three years since the current rules were adopted.

[6] *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*, Report and Order, 30 FCC Rcd. 9551, 9574–76 ¶ 56 (2015) ("2015 R&O").

II. THE COMMISSION SHOULD EXAMINE THE POSSIBILITY OF AUTHORIZING HIGHER-POWER WSD OPERATIONS ON FIRST-ADJACENT CHANNELS TO BROADCASTERS, WITH APPROPRIATE SAFEGUARDS.

The Commission's existing rules require fixed WSDs operating at power levels greater than 100 mW to either observe at least 6 MHz spectral separation from nearby broadcasters or to observe large geographic separation distances from the edge of broadcasters' protected contours.[7] This is a result of both the out-of-band emissions mask that the Commission adopted for WSDs, which may allow a small amount of noise into first-adjacent channels, as well as the relatively poor selectivity of some digital television ("DTV") receivers, which render them susceptible to noise even outside their desired channels of operation.[8] The result of these rules, however, is substantially restricted access to spectrum for rural broadband providers.

Even in rural areas where broadcasters use only a relatively small portion of the available spectrum, the need to achieve 6 MHz separation from any nearby broadcaster can meaningfully restrict the number of channels available for the White Space transmissions required to cover these areas economically. Indeed, because broadcasters are often dispersed throughout the band, rather than being efficiently packed, broadcasters can effectively restrict three times more spectrum than they actually use, from the perspective of a rural ISP, since each broadcaster is currently entitled to a 6 MHz buffer on either side of it its own 6 MHz channel of operation.

WSDs must, of course, protect broadcasters from harmful interference. But the Commission should explore options for maintaining this protection while correcting today's highly inefficient use of spectrum. The considerations described above present two options. The

7 47 C.F.R. § 15.712(a)(2).

8 *See Unlicensed Operation in the TV Broadcast Bands*, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd. 16,807, 16,867 ¶ 171 (2008) ("Second R&O"); *Unlicensed Operation in the TV Broadcast Bands*, Third Memorandum Opinion and Order, 27 FCC Rcd. 3692, 3703 ¶ 29 (2012) ("Third MO&O").

Commission should assess the feasibility of allowing first-adjacent operations at higher powers for WSDs that comply with a more stringent out-of-band emissions mask. On the receiver side, broadcasters intend to migrate transmitters and receivers to the new ATSC 3.0 standard, which broadcasters state will make more efficient use of spectrum.[9] Accordingly, it appears likely that ATSC 3.0 receivers will be more robust to adjacent-channel interference than the ATSC 1.0 receivers that the Commission's previous analysis assumed. Moreover, irrespective of the inherent spectral efficiency of ATSC 3.0, the impending need to upgrade the installed base of DTV receivers to ATSC 3.0 may present an opportunity to reduce their susceptibility to adjacent-channel interference and thereby improve spectral efficiency.[10]

The Commission has recognized that White Space operations on first-adjacent channels to broadcasters should, in principle, be possible without causing harmful interference, so long as these operations are only permitted where the received adjacent-channel White Spaces signal does not exceed the received DTV signal level by more than a given margin.[11] Thus, in an inversion of the usual concept of separation distances, the WSD could operate without causing harmful interference to a broadcaster if that WSD operates relatively *close* to the broadcast transmitter, where the DTV signal will be sufficiently strong that there is no chance of harmful interference from the adjacent-channel WSD. Indeed, as the Commission is aware, Microsoft and

[9] Joint Petition for Rulemaking of America's Public Television Stations, The AWARN Alliance, The Consumer Technology Association, and The National Association of Broadcasters, GN Docket No. 16-142, at 2 (filed Apr. 13, 2016).

[10] *See* Second R&O at 16,867 ¶ 169 (encouraging "TV receiver performance standards-setting by industry").

[11] *Id.* at 16,869 ¶ 178 ("We agree in principle that fixed TVBDs could operate on an adjacent channel where the adjacent channel signal level is strong and an adequate margin is established to ensure against harmful interference to nearby viewers.").

other companies demonstrated high-power fixed White Space operations on a first-adjacent channel to broadcasters without reports of harmful interference.[12]

However, the Commission also surmised that it would be difficult to adopt rules implementing this concept given the significant uncertainty in propagation models used to predict received TVWS and DTV signal strengths.[13] In particular, because this analysis requires the identification of the *minimum* likely DTV received signal strength—rather than the maximum signal strength, which ordinarily is used to predict harmful interference—a model that does not take into account specific terrain features, clutter, and other sources of loss that may be specific to a given location may be prone to overestimate received DTV signal strength, and therefore underestimate the risk of interference. To compensate, the Commission previously concluded that rules for first-adjacent channel operations would have to be, in effect, padded to account for 20 to 30 dB of uncertainty in the received DTV signal strengths.[14]

In light of the now demonstrated value of this spectrum in serving rural areas, however, the Commission should take a fresh look at ways of solving this problem—including whether significant spectrum could be made available to rural operators even if uncertainty cannot be reduced and adjacent-channel operations were correspondingly restricted. Even the addition of one or two channels in rural areas may result in a several-fold increase in the number of consumers that a rural ISP can connect using existing infrastructure, and at little additional

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12 *See, e.g.*, James Carlson et al., *Studies on the Use of Television White Spaces in South Africa: Recommendations and Learnings from the Cape Town Television White Spaces Trial* 38–40 & Diagram 8.6.2, *available at* https://www.tenet.ac.za/tvws/recommendations-and-learnings-from-the-cape-town-tv-white-spaces-trial/view (last visited May 3, 2019).

13 Second R&O at 16,869 ¶ 178.

14 *Id*.

expense. These improved economies of scale can significantly improve the economics of closing the digital divide in rural areas.

The Commission should also evaluate means of improving the accuracy of its propagation modeling to reduce uncertainty, thereby expanding the areas where fixed White Space devices can operate, and further improving the economics of rural deployment. In particular, it should consider allowing White Space database ("WSDB") operators to use the Longley-Rice model to predict DTV and higher-power White Space propagation instead of the Commission's F-Curve model. Not only does Longley-Rice yield more accurate propagation predictions overall, it also specifically accounts for the most important source of uncertainty in the propagation modeling that would underpin the authorization of higher-power operations on first-adjacent channels: propagation losses due to terrain.

The Commission previously decided not to authorize WSDB operators' use of Longley-Rice, merely because it would be "computationally intensive" for them to implement.[15] But it is now clear that, while Longley-Rice may be more computationally intensive to implement than the Commission's F-Curve model, modern computing techniques are more than up to the task of calculating separation distances using this more accurate model. Moreover, if only fixed WSD can operate at greater than 40 mW on a first-adjacent channel these calculations need not be performed in real-time for the large majority of applications that relate to rural broadband deployment, rendering the Commission's concern about "slow[ing] the ongoing real-time determination of available TV channels by the white space databases"[16] less significant than it may have seemed in 2015. Broadcast propagation can be precomputed in nearly every case and

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15 2015 R&O at 9579 ¶ 66.

16 *Id.*

computations relating to fixed devices, while they must be completed promptly, will require only infrequent analyses by the WSDB. Open source libraries and tools have been available since at least 1997 that provide accurate, high-performance Longley-Rice implementations,[17] based on the original NTIA Technical Note defining the Longley-Rice model.[18] Privately maintained websites exist that offer signal contours generated using Longley-Rice, for viewers seeking to maximize their DTV reception.[19] These and other indicia clearly establish the feasibility of using Longley-Rice to determine separation distances in the WSDB. Meanwhile, the experiences of Microsoft, its partners, and others in deploying rural White Spaces networks make clear the significant value of further evaluating the use of Longley-Rice to more accurately model DTV and White Spaces propagation to predict the onset of harmful interference—even if only to facilitate higher-power operations on first-adjacent channels.

Moreover, the Commission need not mandate the use of Longley-Rice. It should merely offer WSDB operators the *option* of calculating separation distances using this more sophisticated and more accurate model—and perhaps only for certain classes of devices in certain areas (e.g., only for fixed devices in less congested areas). Thus, the market and White Space database operators themselves can make their own decisions about whether Longley-Rice is feasible to implement, and whether the expanded access to spectrum in rural areas is worth the increased costs of using this model.

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[17] *See* Stylianos Kasampalis et al., *Comparison of Longley-Rice, ITM and ITWOM propagation models for DTV and FM broadcasting* (June 2013), *available at* https://www.researchgate.net/publication/250615289_Comparison_of_Longley-Rice_ITM_and_ITWOM_propagation_models_for_DTV_and_FM_broadcasting (using SPLAT! as a Longley Rice reference implementation).

[18] P.L. Rice et al., *Transmission loss predictions for tropospheric communications circuits*, Technical Note No. 101, U.S. Department of Commerce, National Bureau of Standards (rev. Jan. 1967).

[19] TV Fool, https://www.tvfool.com/ (last visited May 3, 2019).

III. The Commission Should Permit Fixed WSD Operations at Up to 500 Meters Height Above Average Terrain to Improve Rural Coverage, Under Certain Conditions.

The existing White Space rules allow fixed operations with antennas of up to 250 meters height above average terrain ("HAAT"). Although the Commission's method for calculating HAAT is complex,[20] the essential difference between HAAT and other ways of measuring height is that HAAT takes into account not just the height of the antenna mast but also its height relative to the surrounding terrain. This means that a fixed WSD often cannot operate *at all* on terrain features or towers, even if operation at this location creates little risk of harmful interference.[21]

Microsoft's experience in working with its Airband partners demonstrates that the FCC's existing HAAT limit unduly restricts the ability of ISPs to provide broadband service in rural America. Elevated terrain features, such as ridges, are often the only places where existing towers are sited and backhaul is available and are often the location that allows the best coverage for a community. In certain circumstances these elevated terrain features are the only locations available because of restrictive siting rules or the lack of alternative structures. But the Commission's rules prevent ISPs from using these locations even if they are far beyond the separation distances required to protect the nearest broadcasters. Our Airband ISP partners' inability to place White Space base stations on such towers or elevated terrain features significantly and needlessly increases costs, reducing their ability to expand broadband in rural communities.

Microsoft therefore requests that the Commission authorize fixed White Space operations at HAATs of up to 500 meters, subject to a two-part protection regime: (1) conservative

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[20] *See* 47 C.F.R. § 73.684(d).

[21] *See, e.g.*, *id.* § 15.712(a)(2)(iv).

separation distances that are consistent with the FCC's existing methodology; and (2) a special coordination requirement for all operations above 250 meters.

The Commission should adopt the following separation distances:

	Required separation in km from co-channel digital or analog TV (full service or low power) protected contour						
Antenna HAAT of unlicensed device	20 dBm (100 mW)	24 dBm (250 mW)	28 dBm (625 mW)	32 dBm (1.6 W)	36 dBm (4 W)	40 dBm (10 W)	42 dBm (16 W)
250-300 meters	*16.4*	*20*	*23.9*	*29.4*	*35.4*	*42.1*	*45.9*
300-350 meters	*17.9*	*21.7*	*25.7*	*31.4*	*37.6*	*44.5*	*48.4*
350-400 meters	*19.3*	*23.2*	*27.3*	*33.3*	*39.7*	*46.9*	*51.0*
400-450 meters	*20.4*	*24.4*	*28.7*	*35.1*	*41.9*	*49.4*	*53.8*
450-500 meters	*21.4*	*25.5*	*30.1*	*36.7*	*43.7*	*51.4*	*55.9*

	Required separation in km from adjacent channel digital or analog TV (full service or low power) protected contour						
Antenna HAAT of unlicensed device	20 dBm (100 mW)	24 dBm (250 mW)	28 dBm (625 mW)	32 dBm (1.6 W)	36 dBm (4 W)	40 dBm (10 W)	42 dBm (16 W)
250-300 meters	*0.7*	*0.8*	*1*	*1.3*	*1.6*	*2.1*	*2.3*
300-350 meters	*0.7*	*0.9*	*1.1*	*1.4*	*1.8*	*2.2*	*2.4*
350-400 meters	*0.8*	*1*	*1.2*	*1.5*	*1.9*	*2.4*	*2.7*
400-450 meters	*0.8*	*1*	*1.3*	*1.6*	*2.1*	*2.6*	*2.9*
450-500 meters	*0.8*	*1.1*	*1.4*	*1.7*	*2.1*	*2.7*	*2.9*

These distances were calculated using the methodology described in the Commission's Third White Spaces Memorandum Opinion and Order[22] with adjustments to reflect the distances in the existing table for a HAAT of 250 meters and extrapolated to the higher radiated power

[22] *See id.* § 15.709(b)(2).

level of 42 dBm. Consistent with that Order, these calculations include a 23 dB D/U protection ratio assumption for co-channel stations (i.e., at a 41 dBμV/m protection contour, a White Space signal may not exceed 18 dBμV/m). They also assume 14 dB attenuation due to the typical back-to-front ratio of UHF DTV receiver antennas specified in OET Bulletin No. 69. As the Commission has recognized, such DTV receivers are typically pointed towards a broadcast transmitter near the center of the contour, and away from a WSD operating outside the protected contour.[23]

Consistent with the Third White Spaces Memorandum Opinion and Order, adjacent-channel separation distances were calculated using TM 91-1, because the Commission's F-Curves are undefined for the low field strength values and resulting separation distances involved in most adjacent-channel separation-distance calculations.[24] The nominal D/U ratio required for adjacent-channel protection of DTV signals is -33 dB,[25] resulting in a permissible White Space signal level of 74 dBuV/m at UHF. Considering the front-to-back ratio of the assumed receive antenna and the assumed polarization mis-match yields an equivalent field strength of 87 dBuV/m for adjacent-channel protection of DTV signals.

In addition to these highly protective separation distances, the Commission should also require all fixed WSDs with antenna heights above 250 meters HAAT to comply with a special coordination system akin to the coordination process for fixed point-to-point devices under Part 101.[26]

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23 Third MO&O at 3700 ¶ 17.

24 *Id.* at 3698–99 ¶ 16.

25 *See* ATSC, *ATSC Recommended Practice: Receiver Performance Guidelines* 15, Doc. A/74:2010 (Apr. 7, 2010), https://www.atsc.org/wp-content/uploads/2015/03/Receiver-Performance-Guidelines.pdf.

26 *See* 47 C.F.R. § 101.103(d).

Specifically, the FCC's rule should set forth that before any entity begins operation of fixed WSDs where the HAAT is above 250 meters:

- The installing party must contact a WSDB Administrator and identify all broadcast contours that would be within the applicable separation distance if the WSD was operating at a HAAT of 50 meters above the planned height at the proposed power level; for example, an operator planning to deploy a WSD at 350 meters would be required to coordinate with licensees within the separation distance applicable to operations at 400 to 450 meters; and

- The installing party must notify each of these licensees and provide the geolocation coordinates of the WSD, relevant technical parameters of the proposed deployment, and contact information, and must receive confirmation that each such licensee has received this information.

Commission rules should require that no earlier than 48 hours after this notification, the installing party may commence operations on a test basis, pursuant to a 30-day trial authorization from the WSDB and the WSDB Administrator must coordinate notice of the trial with other WSDB providers. In addition, the rules should state that:

- The installing party must provide each potentially affected licensee with information on the time periods of tests operations;

- During this test period, any licensee may submit substantiated claims of harmful interference either directly to the installing party or to the Commission;

- The installing party must investigate and resolve each such complaint before beginning permanent operations; and

- Once the 30-day trial period expires and all timely interference reports are resolved, the WSDB Administrator will provide the WSD operator a list of available channels at that location for the proposed radiated power level.

The rules should also require that if the installing party seeks to modify its operations by increasing its power level by moving more than 50 meters horizontally from its location or by increasing the height of the WSD, it must conduct a new coordination.

This process, combined with the increased separation distances above, creates a conservative layered interference protection approach. It addresses both the technical possibility of harmful interference, and any perceived difficulty identifying the source of interference in the unlikely event that it occurs. At the same time, it will allow significantly improved White Space signal coverage in rural areas, and better facilitate White Space operators' use of existing antenna structures (including those on elevated terrain features), thereby reducing deployment cost and time. As with increasing the EIRP limit for fixed WSDs in less congested areas, increasing the HAAT up to 500 meters provides broadband network designers with another important tool that will allow them to provide affordable broadband coverage to rural customers.

IV. THE COMMISSION SHOULD ADJUST ITS RULES TO SUPPORT THE USE OF WHITE SPACE CHANNELS FOR NARROWBAND IOT.

Microsoft's experimental deployments have demonstrated that White Spaces spectrum holds great promise for IoT applications in agriculture, particularly in the VHF band.[27] Based on our experience, we believe that IoT WSDs can leverage the greater range afforded by lower transmission frequencies, better penetration through foliage, and non-line-of-sight operation to also support large-scale environmental monitoring as well as applications in extractive industries that operate predominantly in rural areas. For example, Microsoft has briefed Commission staff on our "FarmBeats" projects, performed under an experimental license, demonstrating the economic benefits and improvements to sustainable agriculture that narrowband utilization of TVWS can bring to rural economies.[28] The limited set of rule changes detailed below would permit effective use of such narrowband White Spaces devices for farmers across the country, all while ensuring protection of licensees.

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[27] *See* Application of Microsoft Corporation, ELS File No. 0049-EX-CM-2018, Call Sign WJ2XCD (filed Mar. 7, 2018).

[28] *See, e.g.,* Letter from Paul Caritj, Counsel for Microsoft Corporation, to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 12-268, ET Docket No. 14-165, MB Docket No. 14-165, attachment at 19 (filed Sept. 6, 2017).

Over a decade ago, the Commission designed its TV White Spaces rules with broadband operations in mind. Narrow channels or narrowband uses were not even on the horizon. Today, there is great interest in IoT applications. The ideal spectrum band for a given IoT application depends on requirements such as range, capacity, data rates, and line-of-sight requirements. The VHF and UHF TV bands have less path loss and better penetration through foliage and natural materials than higher frequencies. Thus, there are a range of IoT applications that may be well suited for the White Space frequencies. Unfortunately, some of the technical rules put in place to provide protections from a higher-power WSD operating on a full 6 MHz channel unduly restrict the utility and undermine the economics of narrowband uses such as IoT applications. Microsoft therefore proposes that the Commission define a new type of WSD—the narrowband WSD. Changes to existing rules would support the use of these devices for a wide range of economically important operations while ensuring that licensees are protected from harmful interference by narrowband WSDs to the same extent as they are protected from harmful interference by broadband WSDs.

The primary challenge that existing White Spaces rules present for narrowband operations is that power spectral density ("PSD") limits assume that all White Space transmissions will occupy an entire 6 MHz channel. For a WSD operating at 1 W conducted power, the maximum permissible conducted PSD limit is 12.6 dBm/100 kHz.[29] The same table of power limits categorizes a device emitting *only* 12.6 dBm conducted power as a 12.6 dBm device with respect to a full 6 MHz channel regardless of whether the emission bandwidth is 100 kHz, 500 kHz, 1 MHz, 2 MHz, etc. The PSD limit that the rules prescribe for a 12.6 dBm

[29] 47 C.F.R. § 15.709(b)(1)(ii).

device (in 6 MHz) is considerably lower than the maximum of 12.6 dBm: approximately -4.8 dBm.[30] This is insufficient for rural IoT applications.

The current rules permit a 12.6 dBm/100 kHz conducted PSD limit for each 100 kHz segment of a 6 MHz-wide channel but do not permit a 12.6 dBm conducted power limit in a 100 kHz-wide channel, even though the conducted PSD limit would also be 12.6 dBm/100 kHz. This needlessly reduces the conducted power limit for sensors and other narrowband devices operating in a hypothetical 100 kHz channel, even though they present no greater risk of harmful interference than a WSD operating in a 6 MHz channel with a conducted power limit of 1 W (and a conducted PSD limit of 12.6 dBm/100 kHz).

Furthermore, the Commission's conducted adjacent-channel emission limits impose a 72.8 dB reduction in the first 100 kHz beyond the channel edge from the in-band conducted power limit. For a narrowband WSD channel within a 6 MHz channel, the 72.8 dB power reduction 100 kHz from the channel edge requires an emissions mask that will increase prohibitively the cost of producing narrowband IoT devices. This limitation is unnecessary. For example, while a WSD operating at 12.6 dBm in a 100 kHz channel located in the center of a 6 MHz channel may have a conducted adjacent-channel emission above the limit prescribed in 47 C.F.R. 15.709(b)(1)(ii), 100 kHz beyond the edge of the narrowband channel, it would not have a conducted adjacent-channel emission above the limit 100 kHz beyond the edge of the 6 MHz channel. Thus, as explained below, Microsoft believes the key performance metric should be compliance with the existing emissions limit of -42.8 dBm at 100 kHz beyond the edge of the applicable 6 MHz channel, not within the channel in the case of narrowband operations.

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30 *See id.*

Microsoft proposes that the Commission address these issues, and thereby support IoT investment and deployment, with a small number of targeted rules to enable narrowband devices, without causing harmful interference to licensees.

First, the Commission should define a "narrowband WSD" as a fixed or personal/portable WSD operating in a bandwidth of no greater than 100 kHz that incorporates a listen-before-talk spectrum access mechanism. The incorporation of a listen-before-talk requirement, in concert with the measures described below, will help to ensure that simultaneous narrowband transmissions will not aggregate to produce total conducted power levels above what the Commission allows today in a 6 MHz-wide channel. Narrowband WSDs are client devices that will communicate back to a fixed master (broadband) WSD, which in turn will contact the WSDB to obtain a list of channels available at that location for a given radiated power level.

Second, the Commission should clarify that PSD limits apply to narrowband WSDs such that a device operating in a 100 kHz channel may operate at a conducted PSD level of 12.6 dBm/100 kHz—the same as is currently permitted for 1 W devices in a 6 MHz channel. Similarly, it should clarify that the existing adjacent-channel PSD limits only apply to emissions outside of a given 6 MHz channel and not to emissions into other White Spaces channels—i.e., other narrowband subchannels within a given 6 MHz channel, or adjacent 6 MHz channels that are not occupied by licensees. Finally, the FCC should subject narrowband devices to the same antenna gain limits that would apply to an equivalent device operating in a 6 MHz channel.[31]

Third, the FCC should limit narrowband devices to low-bandwidth data applications using rules that mirror certain provisions of Section 15.231. FCC rules should prohibit narrowband devices from transmitting continuous audio or video information, or controlling

[31] *See id.* § 15.709(c)(1).

toys.[32] Moreover, each narrowband transmitter should be limited in its total airtime consumption to only ten seconds per hour. This will prevent proliferation of narrowband WSDs for data-intensive applications while still allowing them to be used for important, but less data-intensive, IoT applications.

Fourth, in addition to these transmission limits, the Commission should require narrowband devices to adhere to a channel plan that limits total transmitted power in a 6 MHz channel to no higher than the existing limits for a broadband WSD. Rules should prohibit WSDs from operating within 250 kHz from the band edge (except band edges that form the boundary between adjacent 6 MHz White Space channels) and permit them to operate only on channels centered at integral multiples of 100 kHz from the edge of those 250 kHz guard bands. In other words, narrowband devices should operate in one of fifty-five 100 kHz channels in the center 5.5 MHz of each 6 MHz channel.

The Commission has previously raised concerns that accommodating narrowband devices with higher PSD levels "would allow devices to operate at maximum power in a bandwidth of much less than 6 MHz, thus making it possible for multiple devices to share a channel with a total power greater than the limits currently allowed for an individual device."[33] The rules described above would more than address that concern by strictly limiting narrowband emissions. In fact, setting aside the airtime limits and usage restrictions described above, the channelization requirement would limit total emissions in a 6 MHz channel to no more than 36 dBm (30 dBm conducted)—the same power level that applies to a single broadband WSD.[34] Thus, in the worst case scenario with all 55 channels occupied by narrowband devices operating

[32] *See id.* § 15.231(a).

[33] Third MO&O at 3704 ¶ 30.

[34] 47 C.F.R. § 15.709(b)(1)(ii).

at full power, the interference risk to incumbent licensees would be no greater than that posed by a single broadband WSD operating at a radiated power level of 4 W.

The imposition of significant separation distances for all narrowband WSDs should further alleviate this concern. Since the maximum aggregate energy in a 6 MHz channel from narrowband devices will be no greater than that produced by a single broadband device operating at 4 W, the Commission can produce robust protection for licensees by requiring *all* narrowband WSDs to comply with the separation distances that apply to 4 W devices.[35] In addition to ensuring that narrowband devices will observe highly conservative separation distances, this will also effectively confine most narrowband operations to rural areas where the interference risk is minimal.

Finally, narrowband IoT applications also highlight the importance of permitting geofenced operations under the technical rules for fixed devices, as will be described below. At this time, Microsoft sees three likely network topologies or combinations thereof for these IoT applications. The first would place a base station at a farmhouse (or central office for an extractive industry) and allow a set of IoT sensors to communicate directly with this base station. The second would create a mesh network of narrowband IoT devices across a farm, mining area, or forestry area. The third would permit a signal passing a farm, mining area, or forestry area to trigger a response from distributed IoT sensors. But these networks are only the beginning—there is no doubt that innovators will devise additional topologies.

Power consumption is a significant consideration for IoT sensors in the field, particularly remote sensors that require long periods of operation without access to the electrical grid. For example, a representative narrowband IoT White Spaces sensor might wake from a "deep sleep"

[35] *See id.* § 15.712(a)(2)(i).

state only once every half hour to perform a measurement and transmit the results—which would often constitute only a few bytes of data and take no longer than a fraction of a second. In such a scenario, the power consumption of each byte of transmitted data may significantly exceed *all* the power consumed during the majority of the time that the device is operational but in sleep mode, which may be measured in the millionths of an amp. Requiring a WSDB recheck before each of these transmissions would increase by at least an order of magnitude the amount of data that must be transmitted and the amount of time that a device must remain awake—especially considering the need to remain awake while awaiting a response from the WSDB.

If the operational area for an IoT device operating in the TV White Spaces can be geofenced, the base station can check for updates as required. The base station can notify the IoT device of any change of frequency at the time of the next scheduled contact. Given the extremely low data rate we are proposing, the risk of harmful interference from a single blip of data is extremely low.

As reflected in the appendix attached, Microsoft proposes that the Commission implement this proposal with, in addition to a small number of other conforming revisions, the following addition to Section 15.709(a):

> <u>(4) Narrowband white space devices.</u>
>
> <u>(i) Narrowband white space devices shall operate on channel sizes that are no more than 100 kHz. The frequency channel selection shall be offset from the upper and lower band limits by 250 kHz, except in the case where bonded 6 MHz channels share a common band edge. In addition, channels of operation shall be offset from the channel edge by an integral multiple of 100 kHz.</u>
>
> <u>(ii) The conducted power limit is 12.6 dBm in a 100 kHz segment. The EIRP limit is 18.6 dBm in a 100 kHz segment. The conducted power spectral density limit is 12.6 dBm in any 100 kHz band during any time interval of continuous transmission.</u>

(iii) Conducted adjacent channel emissions shall be limited to -42.8 dBm in 100 kHz in a first adjacent 6 MHz channel, starting at the edge of the 6 MHz 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 MHz channel that contains it.

(iv) 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.

(v) Total channel occupancy shall be limited to 10 seconds per hour. Continuous transmissions, voice, video and the radio control of toys are not permitted.

V. THE COMMISSION SHOULD PERMIT GEOFENCED FIXED WSD OPERATIONS AND FIXED WSD OPERATIONS ON MOVABLE PLATFORMS WITHIN GEOFENCED AREAS.

The Commission's existing rules allow for "geofenced" operation of Mode II personal/portable WSDs.[36] As Microsoft's experimental operations in rural Michigan and elsewhere have highlighted, however, an analogous rule for fixed devices holds significant promise for connecting rural communities, by allowing fixed devices to operate on moveable platforms such as school buses, agricultural equipment, and even livestock without increasing the potential for harmful interference. Such a rule would be a natural outgrowth of the waiver granted to Deere & Company for the use of fixed WSDs installed on mobile agricultural machinery.[37] It would also support a broad range of IoT applications utilizing White Space spectrum.

Under an experimental license, Microsoft, in conjunction with its local partner Allband Communications, conducted a pilot project in Hillman, Michigan to provide internet connectivity

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[36] *See id.* § 15.711(d)(5).

[37] *Deere & Company Request for Limited Waiver of Part 15 Rules for Fixed White Spaces Device*, Order, 31 FCC Rcd. 2131 (2016) ("Deere Waiver").

for students on school buses using on-board WSDs.[38] Allband Communications provides coverage to Hillman and the surrounding community over a heterogenous network using White Space links. The system obtains a list of available channels for the network's base stations and customer premise equipment by contacting the WSDB, permitting a school bus operated on routes under the canopy of the TV White Space network to offer broadband to students. Closing the link between the WSD located on the roof of the school bus and the TVWS network at all locations along the route required an EIRP greater than 100 mW.

The experimental license allowed Microsoft and its partners to operate the WSD on the roof of the bus at the higher EIRP limits associated with fixed WSDs within a well-defined area. Due to these higher EIRP limits for fixed WSDs, this grant allowed the bus to connect to White Space base stations over long distances and establish the backhaul link for a conventional Wi-Fi network within the bus. Students are then able to use this Wi-Fi network for high-speed internet connectivity, allowing them to complete school assignments during their bus ride to and from school—which, for some Hillman students, can be as long as two hours each way.

This opportunity to access internet connectivity is especially valuable in areas where students are less likely to have access to high-speed internet at home, making their bus ride one of their only chances to complete assignments that require such access. The requisite long-range backhaul connections are not possible, however, using a device operating under the existing personal/portable WSD rules, which significantly limit transmission power.[39]

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[38] *See* Application of Microsoft Corporation, Form 442 Exhibit 1: Experiment Description, ELS File No. 0049-EX-CM-2018, Call Sign WJ2XCD (filed Mar. 7, 2018).

[39] 47 C.F.R. § 15.709(b)(1)–(2) (authorizing radiated power levels of 100 mW for personal/portable devices and 10 W for fixed devices).

Microsoft's Michigan deployment has avoided causing any harmful interference to broadcasters and other incumbents by combining compliance with existing technical limits and separation distances, which the Commission has concluded will adequately protect licensees, with the use of geofencing. Likewise, no harmful interference has been reported in connection with Deere's use of mobile WSDs under the aforementioned waiver. Deere's operations are remarkably similar to the Michigan school bus project: the devices are attached to mobile vehicles that operate within a pre-defined area on channels determined using the interference protection rules as they would apply to fixed devices throughout that contour; and they operate primarily in rural areas where White Space spectrum is plentiful and can be put to good use to serve the public interest.[40] The success of Deere's operations and the Michigan project illustrate that the risk of harmful interference in adopting a fixed geofencing rule is low, and such advantageous use of White Space spectrum can produce substantial benefits to a variety of communities that would benefit from improved connectivity.

Accordingly, the Commission should authorize geofenced fixed operations. It can do so by adding a single new rule closely modeled on, but more restrictive than, the existing personal/portable geofencing rule. Microsoft proposes the following:

> 47 C.F.R. § 15.711(c)(3)—A fixed device installed on a moveable platform may load channel availability information for multiple locations in the vicinity of its current location. It may use that information to define a geographic area within which it can operate on the same available channels at all locations. A fixed white space device may not use channel availability information for multiple locations if/when it moves within 1.6 kilometers[41] of the boundary of the area where the channel availability data is valid, or outside that boundary. The location must be checked at least once every 60 seconds while the white space device is in operation, except while in sleep mode, i.e., in a mode in which the device is

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40 *See* Deere Waiver at 2133–34 ¶ 6.

41 A vehicle traveling at ordinary highway speeds, 60 miles per hour, will travel approximately 1.6 kilometers in 60 seconds. Therefore, this buffer ensures that a device on a moving platform does not leave the geofenced area between the once-per-minutes location checks.

> inactive but is not powered-down. Operation on board an aircraft or satellite is prohibited.

As with the personal/portable rule, this analogous rule for fixed devices would restrain operations to a pre-defined, polygonal area and prescribe similar interference rules. Unlike geofenced personal/portable operations, however, under the proposed new rule, a geofenced fixed device would continue to contact the WSDB to confirm that its pre-determined channel of operation remains available. This accounts for the possibility of, for example, changed channel availability due to wireless microphone registrations. Also, unlike geofenced personal/portable operations, a geofenced fixed device could be required to *cease operations* if it moves beyond the geofenced area, instead of simply checking the database for new channel availability information. Moreover, unlike other fixed devices, geofenced fixed devices would be very unlikely to operate at antenna heights of more than a few meters, and the rule would prohibit all operation on board aircraft or satellites. Together, these rules would create rigorous harmful interference protections, and would ensure that any harmful interference can be promptly remedied in the unlikely event that it occurs.

This robust combination of protections has allowed Microsoft's experimental operations to proceed with no reported incidents of harmful interference. With suitable rules, schools and ISPs will have the ability to replicate this success for rural students throughout the country. More generally, this framework would allow a wide variety of operators that operate in well-defined areas, such as those in the agricultural and extractive industries, the necessary flexibility to use long-range White Space links, while retaining the most important features of the Commission's fixed White Space rules. Adopting this proposal would allow sensors and telemetry systems mounted on vehicles and other moving platforms to operate within a predefined area at the power levels needed to successfully transmit this data across large rural areas. Broadband and narrowband WSDs should be able to take advantage of the applicable geofencing rules, whether they are operating as fixed or personal/portable devices.

CONCLUSION

Microsoft is working with rural ISPs, equipment makers, and local communities all across the country to help close the digital divide and improve local economies. Every day we are amazed by the creativity and dedication that our partners have in innovating to serve every part of our nation. The ideas proposed in this petition are the product of that hard work. Each change addresses a real-world barrier that companies face as they work to bring the power of White Spaces technologies to rural areas; deliver important new wireless uses to the education, healthcare, agriculture, and mining industries; and power the Internet of Things. Together, these changes will drive down costs and improve flexibility—all while protecting incumbent operations from harmful interference.

Respectfully submitted,

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Appendix A

Proposed Revisions to Part 15 subpart H

1. Section 15.703 is revised to add a new subsection (k) as follows:

§ 15.703 Definitions

* * * * *

<u>(k) Narrowband white spaces device. A fixed or personal/portable white space device operating in a bandwidth of no greater than 100 kHz that incorporates a listen-before-talk spectrum access scheme.</u>

2. Section 15.707 is revised to add new subsections (a)(7) and (c) as follows:

§ 15.707 Permissible channels of operation

(a)

* * * * *

<u>(7) Fixed white space devices may only operate above 10 W EIRP or at greater than 250 meters HAAT below channel 608.</u>

* * * * *

<u>(c) Narrowband white spaces devices cannot operate in frequencies above 608 MHz.</u>

3. Section 15.709 subsections (a)(2)(i), (b)(1)(ii), (c)(2), (g)(1)(ii) are revised, and new subsection (b)(4) is added, as follows:

§ 15.709 General technical requirements.

* * * * *

(a)

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(2)

* * * * *

(i) Fixed devices: Up to 4 W (36 dBm) EIRP, and up to ~~10 W (40 dBm)~~ 16 W (42 dBm) EIRP in less congested areas in the TV bands and 600 MHz service band at locations where they meet the co-channel and adjacent channel separation distances of §§ 15.712(a)(2) and 15.712(i) of this part, respectively. Operation in the 602–620 MHz band is limited to a maximum of 4 W (36 dBm) EIRP.

(b)

* * * * *

(1)

* * * * *

(ii) For operation at EIRP levels of 36 dBm (4000 mW) or less, fixed white space devices may operate at EIRP levels between the values shown in the table 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) shall follow the requirements for 40 dBm (10,000 mW).~~ 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).

EIRP (6 MHz)	**Conducted power limit (6 MHz)**	**Conducted PSD limit (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

* * * * *

(4) Narrowband white space devices.

(i) Narrowband white space devices shall operate on channel sizes that are no more than 100 kHz. The frequency channel selection shall be offset from the upper and lower band limits by 250 kHz, except in the case where bonded 6 MHz channels share a common band edge. In addition, channels of operation shall be offset from the channel edge by an integral multiple of 100 kHz.

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

(iii)Conducted adjacent channel emissions shall be limited to -42.8 dBm in 100 kHz in a first adjacent 6 MHz channel, starting at the edge of the 6 MHz 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 MHz channel that contains it.

(iv)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.

(v) Total channel occupancy shall be limited to 10 seconds per hour. Continuous transmissions, voice, video and the radio control of toys are not permitted.

* * * * *

(c)

* * * * *

(2) The conducted power, PSD and adjacent channel limits for fixed 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 ~~10~~ 12 dBi. If transmitting antennas of directional gain greater than ~~10~~ 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 ~~10~~ 12 dBi.

* * * * *

(g)

* * * * *

(1)

* * * * *

(ii) Height above average terrain (HAAT). The transmit antenna shall not be located where the height above average terrain is more than ~~250~~ 500 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 additional coordination procedures are required:

(A) The installing party must contact a WSDB Administrator and identify all broadcast contours that would be within the applicable separation distance if the WSD was operating at a 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 geolocation coordinates of the WSD, relevant technical parameters of the proposed deployment, and contact information, and must receive confirmation that each licenses has received this information.

(C) No earlier than 48 hours after this notification, the installing party may commence operations on a test basis, pursuant to a 30-day trial authorization from the WSDB.

(D) The WSDB Administrator must coordinate notice of the trial license with other WSDB providers.

(E) The installing party must provide each potentially affected licensee with information on the time periods of tests operations.

(F) During this test period, any licensee may submit substantiated claims of harmful interference either directly to the installing party or to the Commission.

(G) The installing party must investigate and resolve each such complaint before beginning permanent operations.

(H) Once the 30-day trial period expires and all timely interference reports are resolved, the WSDB Administrator will provide the WSD operator a list of available channels at that location for the proposed radiated power level. If the installing party seeks to modify its operations by increasing its power level, by moving more than 50 meters horizontally from its location, or by increasing the height of the WSD, it must conduct a new coordination.

4. Section 15.711 is revised to add a new subsection (c)(3) to read as follows:

§ 15.711 Interference avoidance methods.

* * * * *

(c)

* * * * *

(3) A fixed device installed on a moveable platform may load channel availability information for multiple locations in the vicinity of its current location. It may use that information to define a geographic area within which it can operate on the same available channels at all locations. A fixed white space device may not use channel availability information for multiple locations if/when it moves within 1.6 km of the boundary of the area where the channel availability data is valid, or outside that boundary. The location must be checked at least once every 60 seconds while the WSD is in operation except (i) while in sleep mode, i.e., in a mode in which the device is inactive but is not powered-down. Operation on board an aircraft or satellite is prohibited.

5. The introductory paragraph of § 15.712 as well as subsection (a)(2)(iv) are revised as follows:

§ 15.712 Interference protection requirements.

The separation distances in this section apply to fixed 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 spaces devices shall observe the separation distances applicable to a white space device operating at 30 dBm conducted power and 36 dBm EIRP across a 6 MHz channel.

* * * * *

(a)

* * * * *

(2)

* * * * *

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

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

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

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

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	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	1.2	1.5	1.9	2.4	2.7
400-450	0.8	1	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