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

REPLY COMMENTS OF MICROSOFT CORPORATION

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INTRODUCTION AND SUMMARY

The Commission's proposal to expand broadband and the Internet of Things by revising its TV White Spaces ("TVWS") rules has generated strong support. The record confirms the Commission's finding that these changes will facilitate continued growth of the TVWS ecosystem, improve service for rural and underserved communities, and support innovation.[1] Microsoft therefore encourages the Commission to quickly adopt new rules based on the robust record developed in this proceeding.

Comments filed by service providers, technology companies, businesses and schools in rural communities, public interest organizations, and other entities support the adoption of the Commission's proposed improvements to TVWS rules.[2] Many commenters explain that the

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1 *Unlicensed White Space Device Operations in the Television Bands*, Notice of Proposed Rulemaking, 35 FCC Rcd. 2101, ¶ 1 (2020) ("*TVWS NPRM*").

2 *See* Comments of ACT | The App Association at 2, 8, ET Docket No. 20-36 (filed May 4, 2020) ("App Association Comments"); Comments of Adaptrum, Inc. at 1, ET Docket No. 20-36 (filed May 4, 2020) ("Adaptrum Comments"); Comments of American Farm Bureau Federation at 1, ET Docket No. 20-36 (filed Apr. 9, 2020) ("American Farm Bureau Comments"); Comments of ARK Multicasting at 1, 5, ET Docket No. 20-36 (filed May 4, 2020) ("ARK Comments"); Comments of Broadband Connects America Coalition at 3, 5, ET Docket No. 20-36 (filed May 4, 2020) ("BCA Coalition Comments"); Comments of Cal.net at 1, ET Docket No. 20-36 (filed May 4, 2020) ("Cal.net Comments"); Comments of Citizens Against Government Waste, The American Consumer Institute, FreedomWorks, American Commitment, R Street Institute, The Committee for Justice, Taxpayers Protection Alliance, Lincoln Networks, Small Business & Entrepreneurship Council, Innovation Economy Institute, and Innovation Defense Foundation at 1, ET Docket No. 20-36 (filed Apr. 27, 2020) ("Taxpayers Coalition Comments"); Comments of Connect Americans Now et. al at 1, ET Docket No. 20-36 (filed May 4, 2020) ("CAN Joint Comments"); Comments of CP Communications, LLC at 1, 8, ET Docket No. 20-36 (filed May 4, 2020) ("CP Comments"); Comments of Consumer Technology Association at 2, ET Docket No. 20-36 (filed May 4, 2020) ("CTA Comments"); Comments of Declaration Networks Group, Inc at 1, ET Docket No. 20-36 (filed May 4, 2020) ("DNG Comments"); Comments of Dynamic Spectrum Alliance at 3-4, ET Docket No. 20-36 (filed May 4, 2020) ("DSA Comments"); Comments

changes would improve rural coverage. For example, Connect Americans Now, joined by thirty-five organizations from around the nation, explains that the rule changes the FCC proposes will "unleash the full potential of TV white space technology as a critical tool to help bridge the digital divide," and notes that networks incorporating innovative solutions like TVWS "can reduce the cost of bridging the digital divide by as much as 80 percent."[3] Similarly, Cal.net, a wireless internet service provider in rural California, explains that the proposed changes would "both improve our coverage potential and lower our overall costs," noting that, "[p]articularly in the heavily-forested areas of the Sierras . . . TVWS may truly be the only means by which some customers can be connected to the Internet."[4] The App Association explains that many of its members based in rural areas "depend on broadband to provide their innovative service," and that "[e]nsuring optimum use of the TVWS spectrum bands for unlicensed wireless connectivity will ensure that [its] members have access to improved broadband infrastructure," enabling them to create applications that benefit all Americans.[5]

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of the Midwest Food Products Association at 1, ET Docket No. 20-36 (filed May 4, 2020) ("MFPA Comments"); Comments of National Association of Broadcasters at 1, 8, ET Docket No. 20-36 (filed May 4, 2020) ("NAB Comments"); Comments of National Rural Education Association at 1, ET Docket No. 20-36 (filed May 4, 2020) ("NREA Comments"); Comments of National Public Safety Telecommunications Council at 1, 11, ET Docket No. 20-36 (filed May 4, 2020) ("NPSTC Comments"); Comments of Pennsylvania Farm Bureau at 1, ET Docket No. 20-36 (filed May 4, 2020) ("PA Farm Bureau Comments"); Comments of Public Interest Spectrum Coalition at 1, ET Docket No. 20-36 (filed May 4, 2020) ("PISC Comments"); Comments of RADWIN LTD. at 1-2, ET Docket No. 20-36 (filed May 4, 2020) ("RADWIN Comments"); Comments of RED Technologies at 1, ET Docket No. 20-36 (filed May 1, 2020) ("RED Comments"); Comments of RTO Wireless, LLC at 1, ET Docket No. 20-36 (filed May 1, 2020) ("RTO Comments"); Comments of Sennheiser Electronic Corporation at 2, 11, ET Docket No. 20-36 (filed May 4, 2020) ("Sennheiser Comments"); Comments of Wireless Internet Service Providers Association at 5, ET Docket No. 20-36 (filed May 4, 2020) ("WISPA Comments").

3 CAN Joint Comments at 1.

4 Cal.net Comments at 1.

5 App Association Comments at 3-4.

Other commenters describe how the updates to the TVWS rules will strengthen both education and economies in rural areas. The National Rural Education Association explains that many of its students are "outside the reach of existing broadband networks, but better TVWS rules could change that."[6] Farmers "depend on broadband for the viability of their operations," thus, the Pennsylvania Farm Bureau Federation "strongly support[s]" the NPRM because it would "reduce the digital divide and provide an affordable solution for farmers and rural communities to access broadband services."[7] The American Farm Bureau Federation describes how access to "health care, government services, and educational and business opportunities," in rural communities can only be realized through broadband services and high-speed connections, thus, "[i]t is critical that the Commission embrace an all-of-the-above approach to expand broadband services in rural and unserved areas."[8]

The record also demonstrates that the proposed rule changes will accelerate the pace of TVWS deployments and significantly improve the ability of TVWS technology to narrow the digital divide. The Broadband Connects America Coalition explains that "[d]eployments relying on unlicensed spectrum in the unlicensed TVWS channels in dozens of states across the nation demonstrate enormous potential to extend broadband connectivity in rural, remote and hard-to-serve areas."[9] And the Public Interest Spectrum Coalition ("PISC") provides several examples of how TVWS deployments are already being used to expand broadband to otherwise unserved areas, including to 18 schools and 200 households in two of the most underserved counties in

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6 NREA Comments at 1.

7 PA Farm Bureau Comments at 1.

8 American Farm Bureau Comments at 1.

9 BCA Coalition Comments at 8.

Virginia, and 3,000 rural and unserved households in rural Maryland.[10] Recent progress by the Microsoft Airband Initiative to connect additional homes and communities further highlights the unique potential for TVWS technology to connect the unconnected. The Airband Initiative has now helped provide 1.2 million people with access to broadband in rural, previously unserved areas of the United States through its partnerships with local service providers, many of which seek to leverage TVWS technology to extend connectivity in areas with low population densities that are not cost-effective to reach with other technologies.[11]

At the same time, TVWS deployments have been small-scale so far, in large part because of regulatory uncertainty and unfavorable regulations that artificially limit access to TVWS spectrum. To build on the success of existing small-scale TVWS deployments and enable providers to connect even more communities as described by commenters, the Commission should adopt the focused rule changes proposed in the NPRM and allow increased power levels in frequencies closer to broadcast channels.

- Increasing power limits for fixed TVWS devices in less-congested areas will improve cost-to-coverage ratios, allowing providers to serve more locations from a single tower.
- Increasing the height above average terrain ("HAAT") limit will enable deployments unnecessarily precluded by the current HAAT limit, thereby increasing coverage areas, particularly in mountainous and hilly areas.
- Permitting geofenced operations on mobile platforms will enable broadband connectivity in settings where it is otherwise difficult to deliver—on school buses, for agricultural operations, and in industrial facilities.

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[10] PISC Comments at 8-9.

[11] Brad Smith, *COVID-19 Has Only Intensified the Broadband Gap*, Microsoft Blog (May 21, 2020), https://blogs.microsoft.com/on-the-issues/2020/05/21/broadband-gap-covid-19-airband/.

- Permitting narrowband operations will allow Internet of Things ("IoT") applications to use the unique propagation characteristics of 600 MHz spectrum, powering high-demand applications in agriculture, mining, manufacturing, and other settings.

- Permitting increased power levels for fixed TVWS devices on frequencies closer to broadcast channels, using a terrain-based model where appropriate, will open up additional channels for TVWS operations and make networks viable in a much wider range of scenarios.

Importantly, the record is clear that the Commission can implement these rule changes without causing harmful interference to licensed services. Based on the strong support in the record, the Commission should therefore move forward with a Report and Order as soon as possible.

I. COMMENTERS SUPPORT THE COMMISSION'S PROPOSAL TO ENABLE IMPROVED BROADBAND COVERAGE BY INCREASING POWER LIMITS IN LESS-CONGESTED AREAS.

The Commission should adopt its proposal to increase the radiated power limit for fixed TVWS operations in less-congested areas from 10 to 16 watts EIRP. The Commission correctly concludes that adopting a 16-watt radiated power limit in less-congested areas for fixed white space devices ("WSDs") will permit TVWS operations "to reach users at greater distances, thus enabling improved broadband coverage," and will "enable signals to better penetrate foliage, buildings, and other obstacles, thus providing improved coverage."[12]

A majority of commenters support this proposal.[13] For example, the Broadband Connects America Coalition explains that "[p]ermitting fixed WSDs to operate at a maximum 16 Watts EIRP in less congested areas is a modest change that allows TVWS operators to cover more

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[12] *TVWS NPRM* ¶ 12.

[13] *See* App Association Comments at 8; Adaptrum Comments at 2; American Farm Bureau Comments at 1; ARK Comments at 5; BCA Coalition Comments at 3, 11-12; Cal.net Comments at 1; Taxpayers Coalition Comments at 1; CAN Joint Comments at 1; DNG Comments at 1; DSA Comments at 5-6; MFPA Comments at 1; NREA Comments at 1; PISC Comments at 13; RED Comments at 2; RTO Comments at 1.

customers with a given amount of investment, a critical factor in the availability and affordability of rural broadband."[14] Adaptrum, a TVWS equipment maker, also explains that "[t]he ability to operate at increased power levels up to 16W enables networks to maximize the coverage and capacity they can deliver," and, where a channel is authorized by the white spaces database ("WSDB") but has a high noise floor due to external factors, "the ability to operate at a higher power level provides an opportunity to achieve reasonable coverage distances and throughputs."[15]

In implementing this proposal, the Commission should consider how new rules will facilitate operations for WSDs using multiple streams and multiple-input-multiple-output ("MIMO") technology. Adaptrum notes that across the WSD ecosystem, devices increasingly support MIMO techniques to increase data capacity and data rates.[16] Using MIMO technology, "transmissions from two or more radio transmit chains are coded to constructively send multiple data streams across the same radio channel," and "[t]wo or more receive chains are used to receive and decode the individual data streams."[17] As Microsoft noted, the Commission can facilitate MIMO operations by treating each antenna element separately for purposes of power level measurement for WSDs with multiple streams.[18]

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[14] BCA Coalition Comments at 12.

[15] Adaptrum Comments at 2.

[16] *Id.*

[17] *Id.*

[18] *See* Comments of Microsoft at 15, ET Docket No. 20-36 (filed May 4, 2020) ("Microsoft Comments").

II. THE RECORD SUPPORTS THE COMMISSION'S PROPOSED NEW HAAT LIMIT, WHICH WILL FACILITATE BROADBAND COVERAGE IN ADDITIONAL COMMUNITIES.

A broad range of commenters support increasing the HAAT limit from 250 meters to 500 meters.[19] RADWIN explains that "this change, which will increase the reach of white space base stations, will allow WISPs to serve additional customers without siting additional base stations and towers," and will, in many instances, mean "the difference between WISPs providing service to additional customers or foregoing the opportunity to do so."[20] As RED Technologies explains, this change will permit "a greater range of available locations for White Space Devices (WSDs), particularly in mountainous areas."[21] The Public Interest Spectrum Coalition points out that "[i]ncreasing the HAAT to 500 meters would particularly help rural communities situated in valleys or at the base of mountains, where the transmitter could be installed somewhere above the community on a natural feature," because, especially in these communities, "it is likely that the cost of deploying fixed broadband is far more expensive for both providers and consumers."[22] Importantly, the record supports adopting an increased HAAT limit in all areas, rather than limiting such an increase to only less-congested areas.[23]

The extension of the existing separation distance framework to account for increased HAAT limits will, as commenters note, ensure that incumbent services are protected from

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19 *See* App Association Comments at 9; Adaptrum Comments at 3; ARK Comments at 5; BCA Coalition Comments at 12; Cal.net Comments at 1; CAN Joint Comments at 1; DNG Comments at 1; DSA Comments at 9; MFPA Comments at 1; PISC Comments at 13; RADWIN Comments at 3; RED Comments at 2; RTO Comments at 1; WISPA Comments at 7.

20 RADWIN Comments at 3.

21 RED Comments at 2.

22 PISC Comments at 13-14.

23 App Association Comments at 9; BCA Coalition Comments at 3, 12; DSA Comments at 9; PISC Comments at 14.

harmful interference. As the Dynamic Spectrum Alliance ("DSA") notes, "[t]he separation distance for a fixed WSD operating at 40 dBm EIRP (and above) and a HAAT approaching 500 meters is more than 50 km beyond the broadcaster's protected contour."[24]

The National Public Safety Telecommunications Council suggests that the Commission should make adjustments to the separation distances proposed in the NPRM for Private Land Mobile Radio Service/Commercial Mobile Radio Service ("PLMRS/CMRS") operations if it allows TVWS devices with HAAT values over 250 meters to operate in less-congested areas.[25] The Commission's framework for protecting PLMRS/CMRS uses the same criteria, specified in its rules, to protect land mobile operations from low power TV, TV translator, TV boosters, Class A TV, and WSDs operations.[26] These rules provide that "[t]he low power TV or TV translator station field strength is calculated from the proposed effective radiated power (ERP) and the antenna height above average terrain (HAAT) in pertinent directions."[27] Microsoft's understanding is that the rule assumes the maximum possible HAAT value, even if the actual HAAT value is considerably less. If the Commission adopts the increased HAAT limit in all areas—rather than limiting the increase to less-congested areas—and chooses to adjust the PLMRS/CMRS separation distances, it should adjust those distances using a stepped increase,

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24 DSA Comments at 9.

25 *See* NPSTC Comments at 6.

26 *See Unlicensed Operation in the TV Broadcast Bands; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd. 16807, ¶¶ 190, 193 (2008) ("*TVWS 2008 R&O, M&O*"); *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Guard Band, 600 MHz Bands and Duplex Gap,* Report & Order, 30 FCC Rcd. 9551, ¶ 59 (2015) ("*2015 TVWS R&O*"); 47 C.F.R. § 74.709 (describing the criteria for land mobile station protection).

27 47 C.F.R. § 74.709(d). The field strength is calculated using the FCC (F(50,10) curves. *Id.* § 74.709(d)(1).

rather than assuming that all WSDs are operating at 500 meters HAAT and have omnidirectional antennas. A blanket increase in PLMRS/CMRS separation distances that does not account for actual WSD HAAT values would needlessly render large areas off-limits for TVWS operations on the affected channels.

Sennheiser Electronic Corporation ("Sennheiser") contends that the Commission should adopt larger separation distances than proposed in the NPRM in situations where TVWS devices operate at higher HAATs and power levels to protect licensed wireless microphones.[28] However, Sennheiser's proposed distances are substantially over-protective. Further, this argument is based on an attempt to re-litigate the existing 1-km separation distance for TVWS operations between 4 watts and 10 watts EIRP, which the NPRM correctly uses as a basis to calculate distances for higher power or HAAT.[29]

The Commission conservatively proposes to increase the existing 1-km licensed wireless microphone separation distance to 1.3 km for fixed TVWS devices operating at power levels between 10 watts and 16 watts.[30] The change in signal propagation distance using a free space propagation model is proportional to the square root of the change in power level, so an increase in maximum power by a factor of 1.6 (from 10 watts to 16 watts) increases the propagation distance by a factor of 1.25, yielding a new separation distance of 1.3 km for power levels greater than 10 watts.[31] Sennheiser, however, argues that the Commission should increase the existing separation distance by a factor of 1.6.[32] This is because Sennheiser contends that the

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[28] *See* Sennheiser Comments at 6-7 (proposing a new set of required separation distances).

[29] Sennheiser Comments at 6.

[30] *TVWS NPRM* ¶ 34.

[31] *Id.* ¶ 34 n.57.

[32] Sennheiser Comments at 7.

existing 1-km separation distance for 10-watt TVWS operations should have been larger to protect licensed wireless microphones. But it does not identify any instances of harmful interference that have occurred under the existing rules. Further, the FCC rules apply the 1-km separation distance uniformly regardless of whether the fixed WSD operates at 40 milliwatts or 10 watts EIRP, which means that the 1-km distance is vastly overprotective for TVWS operations in many cases.[33] In comparison, the separation distance for a 100 milliwatt Mode II personal/portable device is 400 meters.

The existing 1-km separation distance protects wireless microphones today—and a 1.3-km separation distance will protect microphones under the FCC's proposed new rules. In fact, it is more conservative than needed, as the Commission calculated the distance using the assumption of free space propagation,[34] despite the fact that in the vast majority of cases there will be clutter and terrain variations. Although the record supports the use of an updated, terrain-based model, as discussed in additional detail in Section V,[35] the use of a free-space model here certainly produces separation distances that provide more than adequate protection.

Finally, the record confirms that the Commission should reconsider its above ground level ("AGL") height limit in addition to its proposed HAAT improvement. The Commission seeks comment on whether it should "make any changes to the antenna height above ground limit," noting that the AGL height limit may in some cases "preclude white space device operators from taking advantage of the higher HAAT limit we are proposing, or even the current 250-meter limit."[36] The Dynamic Spectrum Alliance notes that the Commission could eliminate

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33 *See* 47 C.F.R. § 15.712(f).

34 *TVWS NPRM* ¶ 34.

35 *See, e.g.,* DSA Comments at 6-7.

36 *TVWS NPRM* ¶¶ 25, 26.

the AGL height limit and rely solely on HAAT, an approach that "will still protect broadcasters."[37] The Wireless Internet Service Providers Association ("WISPA") likewise recommends that to promote continued growth of the WSD ecosystem, the Commission should "eliminate the height above ground level ("AGL") limit."[38] This approach would permit deployments located in a valley where the HAAT value would be negative, and therefore, would offer robust protection for incumbents, but the AGL would otherwise limit deployment.[39] Because interference protection calculations are performed, or could be performed, using HAAT values, "this renders the separate AGL metric unnecessary."[40]

III. COMMENTERS SUPPORT PERMITTING GEOFENCED OPERATIONS BY ADAPTING FIXED DEVICE RULES.

Many commenters support the Commission's proposal to allow higher-power operations on mobile, geofenced platforms in order to enable important new TVWS use cases.[41] Geofenced mobile TVWS operations will facilitate innovation in agriculture and extractive industries and will provide additional connectivity for rural communities. "Adopting this policy," the Public Interest Spectrum Coalition notes, "has the significant potential to help bridge the Homework Gap, particularly during the COVID-19 pandemic where schools and local governments are seeking novel solutions such as Wi-Fi-enabled buses and leveraging TVWS to connect students

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37 DSA Comments at 13.

38 WISPA Comments at 3.

39 *See* DSA Comments at 13.

40 PISC Comments at 15; *see also* WISPA Comments at 8.

41 *See* App Association Comments at 9; BCA Coalition Comments at 14; CAN Joint Comments at 1; CTA Comments at 2; DNG Comments at 1; DSA Comments at 15; MFPA Comments at 1; PISC Comments at 15; RADWIN Comments at 4; RED Comments at 4-5; RTO Comments at 1; Sennheiser Comments at 8; NPSTC Comments at 8.

who do not have broadband access and cannot participate in remote learning."[42] The geofencing rules could be particularly useful because they would allow for connectivity on buses, "allowing students to study on the way to or from school[,] and also by being parked in strategic locations for use as a Wi-Fi hotspot for students without adequate internet access at home."[43] As Commissioner Rosenworcel explained recently, with more than 50 million students in the U.S. out of school who have been told they have to connect online, the FCC should "double down on the solutions that will make sure that every student everywhere is connected."[44]

To achieve these goals, however, the Commission should modify its proposal. The NPRM proposes to allow geofenced mobile operations through the Mode II personal/portable rules. It would be more straightforward and effective to either (1) adopt rules creating a new class of "mobile white space devices" or (2) authorize fixed WSDs to operate on mobile platforms using a geofence, as suggested in Microsoft's Petition.[45] Relying on the Mode II rules is problematic because, as RED Technologies explains, classifying the "movable platform" use case under the Mode II personal/portable device rules would require a substantial number of complicated changes to those rules, including to the separation distances in 47 C.F.R. § 15.712, "which are computed on the assumption that the maximum power is 100mW, and that HAAT

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42 PISC Comments at 16.

43 *Id.* at 17.

44 *See* Elijah Labby, *Current Telework Methods Not Sufficient, Says FCC Commissioner Jessica Rosenworcel*, BroadbandBreakfast (May 19, 2020), http://broadbandbreakfast.com/2020/05/current-telework-methods-not-sufficient-says-fcc-commissioner-jessica-rosenworcel/ (quoting Commissioner Rosenworcel's remarks at an App Association webinar on COVID-19 and the digital divide).

45 *See TVWS NPRM* ¶ 41 (asking whether, if it permits use of detachable antennas, it should create "a new class of white space devices, such as mobile white space devices"); Petition for Rulemaking of Microsoft Corporation at 24-25, ET Docket No. 14-165, RM-11840 (filed May 3, 2019).

may be safely discounted when compared to a fixed device."[46] RED Technologies explains that the geofenced use case would be better categorized as a fixed device on a movable platform, or as a "new device class with technical requirements and separation distances derived from fixed devices."[47] Creating rules for geofenced mobile operations based on the current fixed device rules will also better enable database operators to accommodate this new functionality because fixed devices are already broadly deployed and database providers have gained database implementation experience with fixed devices. Microsoft therefore agrees with RED Technologies that because "the interference protection rules for fixed devices are already tailored to higher-power usage, the use-case can be enabled with only minimal changes to the rules and with minimal burden to a WSDB administrator."[48] Importantly, such rules would also reduce burdens on WSD technology providers, because the certification process for WSDs would be more straightforward under a version of the fixed device rules—all without risking harmful interference to incumbents. Additionally, as explained in Microsoft's opening comments, the fixed device rules already include antenna gain provisions that will facilitate the proposed geofenced operations. The personal/portable device rules, by contrast, require omni-directional, non-detachable antennas with 0 dBi gain, which would prevent geofenced devices from being able to successfully close the links for the envisioned use cases.[49]

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46 RED Comments at 5.

47 *Id.*

48 *See* RED Comments at 5; *see also* Microsoft Comments at 23 (explaining that a new "mobile white space device" rule "could be straightforward and reference the fixed device rules for power levels, antennas, and RF exposure, and include the new geolocation rule the Commission has proposed in Section 15.711(c)(3) of the rules").

49 *See* Microsoft Comments at 22.

Additionally, PISC recommends that the Commission should allow channels of operation and power levels to vary across the geofenced areas.[50] We agree. The Commission should adopt "rules that would allow WSDBs to calculate a geofence of available white space channels throughout a pre-defined area, or a pre-planned route," and should make clear that "the list of available channels can differ across the geofence."[51] Doing so would allow for uninterrupted broadband connectivity when the device moves over larger areas, even where switching channels or varying power levels is necessary.

While many commenters support the Commission's proposal, a handful of parties raise questions about how the proposal will protect incumbent services. Shure Incorporated ("Shure"), for example, argues that the FCC should categorically limit geofenced operations to 4 watts EIRP, and that even at 4 watts, geofenced TVWS operations "would pose an unacceptable risk of harmful interference."[52] Shure's concern may misapprehend the proposed rules. Under whatever framework the Commission adopts, geofenced operations would be permitted *only* for locations, channels, and power levels at which the WSDB determines TVWS operations will not cause harmful interference to licensed services. This means that a WSDB will only allow a power level over 4 watts, for example, in a location where the entire geofenced area is far enough from licensed services that this power level would maintain conservative interference protection to licensed services. The proposed new rules would not create blanket permission to operate at the specified power limit in all locations. Additionally, geofenced devices will adhere to the required recheck intervals and shutoff distances to ensure that they do not exceed permitted power levels

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50 *See* PISC Comments at 4.

51 PISC Comments at 18.

52 Comments of Shure Incorporated at 6-8, ET Docket No. 20-36 (filed May 4, 2020) ("Shure Comments").

and areas of operation.[53] Because the WSDB will perform the power-limiting function where it is necessary, there is no reason for the rules to set a 4-watt limit that applies in all scenarios.

Based on the same misapprehension, Shure also argues that the Commission should limit geofenced operations to less-congested areas.[54] But this limit would provide no additional interference protection benefit and would therefore needlessly limit the use of the band for geofenced operations. As explained above, the WSDB will only permit geofenced operations in areas and at power levels where they will not cause harmful interference to incumbents, regardless of whether those areas are defined as less congested or not. Because the WSDB will perform the geographic limiting function, there is no need for the rules to set a blanket limitation on areas of operation. Shure also notes that the Commission declined—nearly ten years ago—to create an additional class of vehicle-mounted devices at power levels higher than those then currently authorized for personal/portable devices.[55] But at that time, the Commission did not consider the more comprehensive and protective geofencing proposal it has now proposed.[56] And even then, the Commission expressly noted the possibility that it would consider authorizing such operations in the future, noting that it would "re-visit the issue of higher power levels [for

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53 *See TVWS NPRM* ¶ 40 (explaining that geofenced operations will be subject to location re-check requirements and shutoff requirements within certain distances of the geofenced boundary in order to protect licensees from harmful interference).

54 *See* Shure Comments at 3; *see TVWS NPRM* ¶ 39 (proposing to limit geofenced operations to less-congested areas).

55 *See* Shure Comments at 6-7.

56 *Unlicensed Operation in the TV Broadcast Bands and Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, 25 FCC Rcd. 18661, 18693-4 (2010) ("*Unlicensed Operation in the TV Broadcast Bands 2010 Order*"); *See also Unlicensed Operations in the TV Broadcast Bands*, Petition for Reconsideration and Clarification of Motorola, Inc. at 16, ET Docket No. 04-186 (filed Mar. 19, 2009) (asking the Commission to permit mobile devices at higher power levels "wirelessly tethered" to a fixed WSD, not using a geofencing approach with location re-checks, shutoff distances, and pre-cleared areas).

TVWS devices] . . . at some point in the future as may be appropriate."[57] Finally, if a wireless microphone operator makes a new wireless microphone reservation within the geofenced area, our expectation is that the geofence would be required to adjust accordingly for the duration of the reservation.

Similarly, the WSDB pre-clearance control function for geofenced mobile operations also addresses other commenters' concerns about protecting incumbent operations from harmful interference. ONE Media 3.0, LLC ("ONE Media") expresses concern about protection for single frequency network ("SFN") broadcast operations.[58] In fact, the WSDB currently protects SFN operations within a broadcaster's protected contour[59] (but should not extend protection outside that contour), and would not allow geofenced TVWS devices to operate if it would cause harmful interference inside the protected contour.[60] Additionally, the National Public Safety Telecommunications Council notes that the rules must protect licensed PLMRS/CMRS services, and suggests making a separate table of separation distances for these services.[61] But these

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57 *Unlicensed Operation in the TV Broadcast Bands 2010 Order* at 18694.

58 *See* Comments of ONE Media 3.0, LLC at 4, ET Docket No. 20-36 (filed May 4, 2020) ("ONE Media Comments") (noting that "[i]n an environment with increased SFN deployments delivering mobile services," mobile geofenced operations could create harmful interference).

59 *See* White Space Database Administrator Group, *Channel Calculations for White Spaces Guidelines* at 17-18 (Aug. 12, 2014), https://ecfsapi.fcc.gov/file/7521805564.pdf.

60 *See TVWS NPRM* at App. A, Proposed Rules, § 15.711(c) (geofenced operations would "load channel availability information" for multiple locations); 47 C.F.R. § 15.713(b), (c)(1) (specifying that all television stations, including "television translator and booster stations" are included in the WSDB, but that "[t]elevision translator, low power TV and Class A station receive sites within the protected contour of the station being received are not eligible for registration in the database"); *see also* Comments of Microsoft at 3, GN Docket No. 16-142 (filed Nov. 12, 2019).

61 *See* NPSTC Comments at 9 (requesting that the Commission add "separation tables to the rules relative to mobile platform operations in geofenced areas").

services already would be protected under the Commission's proposal using the WSDB, making a separate table unnecessary.[62]

IV. THE RECORD SUPPORTS THE COMMISSION'S PROPOSAL TO FACILITATE NARROWBAND TVWS IOT OPERATIONS.

A wide range of commenters, including service providers, equipment makers, and public interest groups, support the Commission's proposal to better facilitate narrowband IoT operations to support an array of agricultural and industrial applications.[63] RED Technologies notes that the Commission's proposal to create a new class of narrowband WSDs will "enable large-scale environmental and agricultural monitoring in a wide range of rural environments" because of the excellent propagation characteristics of TVWS spectrum in areas with foliage and other line-of-sight obstacles.[64] The App Association explains that its members would benefit from the ability to use TVWS frequencies for IoT to provide "more accurate results about the overall health of the livestock" through "connected enabled ear tags that transmit small data bursts at set intervals."[65] And the Broadband Connects America Coalition explains that "[u]pdating the rules to facilitate narrowband applications will be particularly beneficial to farms, ranches, utilities[,] and remote infrastructure . . . sensing, monitoring and other applications."[66]

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62 *See* 47 C.F.R § 15.713(b)(1)(vi-vii) (specifying that PLMRS and CMRS stations are included in the WSDB).

63 App Association Comments at 11; BCA Coalition Comments at 16; Taxpayers Coalition Comments at 1; CAN Joint Comments at 1; CTA Comments at 4; DNG Comments at 1; DSA Comments at 18-20; MFPA Comments at 1; NPSTC Comments at 10-11; PISC Comments at 20; RED Comments at 8; RTO Comments at 1.

64 RED Comments at 8.

65 App Association Comments at 11.

66 BCA Coalition Comments at 16.

The record demonstrates that the Commission can enable this new class of WSDs "while providing existing licensees the same level of protection from harmful interference."[67] The new rules would limit "total transmitted power in a six-megahertz channel to no higher than the existing limits" for an existing 4-watt EIRP WSD and even where all 55 narrowband channels in a 6-MHz range were occupied simultaneously by narrowband WSDs operating at maximum power, "the maximum 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 four watts EIRP."[68]

Shure and Sennheiser argue that the Commission should limit narrowband operations to less-congested areas.[69] This additional regulation is unnecessary to protect licensees and would unnecessarily preclude narrowband operations in areas where they would otherwise be useful. Microsoft anticipates that the greatest demand for narrowband TVWS technology will be in less densely populated areas, but IoT technologies will benefit urban and suburban communities as well. And there is no reason to impose an *ex ante* prohibition on narrowband TVWS operations in all suburban and urban areas. As Sennheiser recognizes, licensed wireless operators can "register for interference protection from WSDs in the database system."[70] The WSDB will equally protect wireless microphones in all areas of the country. Shure and Sennheiser have not identified any characteristic of narrowband WSD operations in urban and suburban areas that renders them more likely to cause harmful interference than in less-congested areas.[71] There may

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67 CTA Comments at 4.

68 *TVWS NPRM* ¶ 47; *see* Microsoft Comments at 26-27.

69 Sennheiser Comments at 9-10; Shure Comments at 8-10.

70 Sennheiser Comments at 11.

71 *See id*; Shure Comments at 8-10.

be more microphones in more populated areas, but the combination of both geographic and spectral separation will more than adequately protect registered licensed microphones from harmful interference. Three contiguous vacant 6-MHz channels would be required for a single fixed narrowband WSD channel to operate within the center of the 6-MHz channel, a 250-kHz guard band would be required at the top and bottom of the 6-MHz channel in which the narrowband channel operates, and a 1-km separation distance would be required for fixed narrowband TVWS devices and licensed wireless microphones on the same 6-MHz channel.

To the extent that Shure and Sennheiser seek interference protection for *un*licensed wireless microphones, they seek greater protection than the Commission's rules allow. All unlicensed operations authorized under Part 15 of the Commission's rules—wireless microphones and TVWS devices alike—have shared access to the band. Neither are entitled to protection from harmful interference from licensed users or other unlicensed users.[72]

Nonetheless, however, the proposed characteristics and regulatory limitations of narrowband IoT devices will minimize the risk of harmful interference, even to wireless microphones that operate on an unlicensed basis without any entitlement to interference protection. First, because each 6-MHz channel will contain 55 different 100-kHz channels,[73] the probability that an unlicensed digital wireless microphone operating with a 200-kHz bandwidth or an analog wireless microphone with a 25 kHz bandwidth, for example, will overlap with a narrowband WSD is extremely low. In the unlikely event that overlap does occur, it is very likely that other channels will be available, and the wireless microphone operator could address any interference issues by changing frequency. Second, most wireless microphones operate indoors,

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[72] *See* 47 C.F.R. § 15.5.

[73] *See TVWS NPRM* ¶ 47.

whereas narrowband WSDs will predominantly operate outdoors, adding an additional level of physical separation and interference protection in the majority of interactions.

Shure also argues that the Commission should impose the emissions mask required for wireless microphones on narrowband IoT devices.[74] But they fail to demonstrate that the protections already proposed by the FCC to protect licensed wireless microphones will not be sufficient, or why it would be appropriate to apply an emissions mask designed for wireless microphones on a completely different technology with a different operating bandwidth. In fact, the Commission's proposed rules will provide licensed wireless microphone operators with at least as much protection from interference by narrowband TVWS devices as they enjoy from broadband TVWS devices. Most significantly, licensed wireless microphone registrations prevent TVWS operations at that location anywhere within their reserved 6-MHz block. In addition, for wireless microphones operating at the edge of a 6-MHz channel, the proposed rules would require narrowband operations to comply with the same emissions limit that applies to existing broadband TVWS devices: -42.8 dBm at 100 kHz beyond the edge of the applicable 6-MHz channel. In adopting this limit for broadband operations, the Commission already concluded that this limit is sufficient to prevent harmful interference to adjacent-channel wireless microphones.[75] Shure and Sennheiser offer no reason why the Commission should reach a different conclusion here. In fact, in addition to applying the same mask at the edge of a 6-MHz channel, the proposal would also require narrowband IoT devices to observe 250 kHz internal guard bands within each of these channels.[76]

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[74] Shure Comments at 9.

[75] *See TVWS NPRM* ¶ 46.

[76] *TVWS NPRM* ¶ 47.

The FCC's proposal would also require narrowband IoT devices to meet the Commission's existing spurious emissions rules for unlicensed devices, and as a result, Shure's contention that the wireless microphone mask is needed to address spurious emissions issues is incorrect in this context.[77] Shure also contends that the FCC must "properly account for intermodulation issues."[78] For both of these issues, it appears that Shure seeks more protection for *unlicensed* wireless microphones than the rules provide. These issues will not arise for licensed wireless microphones, which will never operate co-channel with narrowband TVWS operations because of registration and protection through the WSDB.

Finally, although they are not entitled to interference protection and therefore are not permitted to register in the database, the protections outlined above with respect to potential co-channel operations between TVWS devices and unlicensed wireless microphones will also minimize the chances of any adjacent-channel interference between unlicensed operations. The odds of an unlicensed wireless microphone and a narrowband TVWS device operating in close physical proximity and on adjacent narrowband channels is small, given the large number of narrowband channels, and any interference could almost certainly be corrected by the unlicensed microphone operator. Thus, although it would not be appropriate under the Commission's rules to grant one category of unlicensed devices priority over another—the Commission's rules

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77 *See* 47 C.F.R. §15.209(f) ("If measurements above the tenth harmonic are so required, the radiated emissions above the tenth harmonic shall comply with the general radiated emission limits applicable to the incorporated digital device, as shown in § 15.109 and as based on the frequency of the emission being measured, or, except for emissions contained in the restricted frequency bands shown in § 15.205, the limit on spurious emissions specified for the intentional radiator, whichever is the higher limit."); 47 C.F.R. §15.205(a), (d)(10); *Cf.* Shure Comments at 9 (contending that the Commission must adopt rules that address spurious emissions and intermodulation issues for narrowband IoT devices).

78 Shure Comments at 9.

clearly provide that no unlicensed device can claim interference protection from other operations[79]—there is no reason to expect that unlicensed wireless microphones would be significantly affected by narrowband TVWS operations.

V. THE COMMISSION SHOULD AUTHORIZE HIGHER-POWER FIXED TVWS OPERATIONS IN LESS-CONGESTED AREAS ON CHANNELS CLOSER IN FREQUENCY TO BROADCAST CHANNELS.

Rural providers, technology companies, and public interest organizations agree that the Commission can expand broadband availability by authorizing higher-power fixed TVWS operations closer in frequency to broadcasters—while still protecting licensees from harmful interference.[80]

The Wireless Internet Service Providers Association explains that the Commission should revisit the issue of higher power TVWS operations on adjacent channels because it will allow service providers to access more contiguous spectrum, and combine more non-contiguous channels to increase capacity.[81] WISPA notes that "[i]n some cases, the additional spectrum may be the difference between investing in TV white space equipment and deploying service or forgoing the opportunity altogether."[82] Adaptrum explains that it "supports approaches that will allow increased operation in first adjacent channels," because a significant portion of channels are currently unavailable due to adjacent channel limitations.[83] And the Broadband Connects

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79 *See* 47 C.F.R. § 15.5.

80 *See* App Association Comments at 12; Adaptrum Comments at 3; BCA Coalition Comments at 13; Cal.net Comments at 1; CAN Joint Comments at 1; DNG Comments at 1; DSA Comments at 22; PISC Comments at 18; RED Comments at 8; RTO Comments at 1; WISPA Comments at 9-10.

81 WISPA Comments at 9.

82 *Id.*

83 Adaptrum Comments at 3.

America Coalition asks the Commission to revise its current rules under which "a contiguous block of three vacant channels is required to operate at a power sufficient to provide fixed broadband connectivity, thereby foreclosing opportunities to use TVWS technology to bring broadband to unserved and underserved communities."[84]

Commenters further explain that an appropriate terrain-based model, such as the Longley-Rice/Irregular Terrain Model ("ITM"), will allow the Commission to identify locations where higher-power WSD operation will not cause harmful interference to incumbents.[85] The FCC's current model, however, uses "standardized and static contours calculated using a very conservative FCC propagation model that is in practice both unrealistic and overly protective."[86] The Dynamic Spectrum Alliance explains that a terrain-based model, by contrast, will provide "a greater degree of accuracy for both the incident DTV power and fixed WSD power received at a location."[87] Accordingly, "the Commission should authorize use of the Longley-Rice Irregular Terrain Model (ITM) methodology," which the Public Interest Spectrum Coalition explains, "has now been authorized by the Commission to coordinate spectrum sharing in other bands," such as the CBRS band at 3.5 GHz.[88] Additionally, commenters note that, only two months ago, in the 6 GHz proceeding, the Commission authorized the use of a terrain-based model combined with a

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84 BCA Coalition Comments at 14.

85 *See* Adaptrum Comments at 3; BCA Coalition Comments at 9-11; DSA Comments at 19; PISC Comments at 11-12; WISPA Comments at 4-6.

86 BCA Coalition Comments at 9.

87 DSA Comments at 22.

88 PISC Comments at 12.

model specific to distances under 1 km to enable the frequency coordination database to effectively protect incumbent fixed microwave services.[89]

A small number of commenters raise general objections to the use of the Longley-Rice model and the authorization of higher power levels on channels closer to broadcast operations. But no party supports these positions with testing or real-world analysis indicating that increased power levels combined with appropriate protections would cause harmful interference to broadcasting operations.

We appreciate the willingness of the National Association of Broadcasters ("NAB") to engage with TVWS supporters on an engineering basis. Here, NAB contends that for "the Longley-Rice model, the nature of high HAAT operations leads to a potential for out-of-range conditions (error codes)," and that using such a model would create issues regarding how to choose the correct terrain data, sampling strategy, and other input parameters.[90] But these are questions of implementation which we can address by working together, and the Commission has readily addressed similar concerns in every other band where it has authorized sharing using well accepted terrain-aware propagation models. There is no reason the Commission cannot or should not address these issues in the TVWS sharing context, when it has done so in other bands

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[89] *See* BCA Coalition Comments at 11; DSA Comments at 21; WIPSA Comments at 5; *see also Unlicensed Use of the 6 GHz Band and Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Report and Order and Further Notice of Proposed Rulemaking, FCC No. 20-51, ET Docket No. 18-295, GN Docket No. 17-183, ¶¶ 63-66 (rel. Apr. 24, 2020) ("*6 GHz R&O*") (adopting the ITM model for distances over 1 km, and the WINNER-II model for distances between 30 m and 1 km).

[90] NAB Comments at 7.

and even between other services in the TV bands.[91] The FCC's expert engineering staff, based on information provided on the record in this proceeding, is well-positioned to make decisions regarding the technical inputs necessary to guarantee robust interference protection just as it has done to promote efficient use of spectrum in other bands.

In addition, ONE Media submits an analysis that it asserts shows TVWS "co-channel usage provides unacceptable interference protection in many adjacent channel allocations."[92] For example, it concludes that a 40 milliwatt EIRP personal/portable device operating on a first adjacent channel would cause harmful interference to a DTV tuner receiving a weak signal over 5 km away.[93] That a device operating at that low a power could disrupt a distant receiver is inconsistent with the Commission's 2008 analysis that determined a 40 milliwatt personal portable device could operate on a first adjacent channel without causing harmful interference to broadcasters—and inconsistent with lab and field testing that we describe below.[94]

Unfortunately, ONE Media does not provide sufficient detail or explanation of its assumptions, the propagation model it applied, or assumed losses, so that the Commission can assess its claim. Without this information it would be capricious to rely on ONE Media's assertion. Additionally, while the FCC used a conservative D/U ratio of -33 dB in its analysis of

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91 On the question of error codes specifically, there is no reason to expect that Longley-Rice error codes will present significant problems in areas where terrain data is available, receiver and transmitter heights are within the range for which the model is valid (an extremely broad 0.5 to 3000 meters), and other input parameters are well defined. And even if the model does generate an error code at a given location, the Commission has many options for addressing this eventuality. For example, it could use a value interpolated between nearby points for which no error code was produced, fill in a value derived from a conservative alternate model, or other techniques.

92 ONE Media Comments at 8.

93 *Id.* at 10-11. Additionally, based on the -5 dBi antenna gain, we believe this example concerns a DTV tuner integrated or plugged into a mobile device.

94 *See TVWS 2008 R&O, M&O*, ¶ 176.

potential interference caused by TVWS devices, ONE Media appears to have used the 1998 DTV planning factors and did not specify whether the frequency of the first adjacent channel was above or below that of the broadcast channel. The FCC's planning factors on first adjacent channel are -26 dB (above) and -28 dB (below) the broadcast channel. ONE Media's Comments highlight the need for the Commission to update the planning factor for ATSC 1.0 receivers and measure the D/U ratio for ATSC 3.0 receivers at different modulation levels resulting from interactions between DTV transmissions and TVWS signals.

Microsoft submitted both laboratory and field testing, by contrast, which demonstrates that (1) the ATSC 1.0 TV receivers with integral displays that we tested have better adjacent channel selectivity than previously assumed by the FCC; (2) these same ATSC 1.0 receivers have even better adjacent channel selectivity if the undesired signal is offset by 3 MHz from the edge of the broadcast channel; (3) ATSC 3.0 "Next Gen" receivers will offer superior adjacent channel selectivity compared to ATSC 1.0 receivers, depending on the modulation rate; and (4) the Commission can authorize higher-power operation on frequencies closer to the edge of broadcast channels without causing harmful interference to broadcast services.[95] As ARK Multicasting, Microsoft's partner in conducting the adjacent-channel analysis, points out, the testing included "both today's ubiquitous ATSC 1.0 digital broadcast standard and the new ATSC 3.0 standard," and "conclusively demonstrated that there is no detectable interference

[95] *See* Microsoft Comments at 28-39, App. A, DEKRA Certification and Testing, Inc., *TVWS-DTV Coexistence on the First Adjacent Channel, Laboratory Measurements Test Report* (May 3, 2020), App. B DEKRA Certification and Testing, Inc., *TVWS-DTV Coexistence on the First Adjacent Channel, Field Measurements Test Report* (May 3, 2020).

either to or from ATSC 3.0 licensed television broadcast signals from TVWS devices" operating on the first-adjacent channel.[96]

The Microsoft studies demonstrate that the Commission can authorize increased power for fixed TVWS operations on channels closer to broadcast operations and significantly increase TVWS channel availability while continuing to provide conservative interference protection to broadcast operations.

Based on our laboratory and field tests, Microsoft offers three proposals for allowing higher power WSD operations closer in frequency to broadcast television stations in less-congested areas. The Commission should permit WSDs to operate: (1) downlink only on the first adjacent channel at up to 34 dBm EIRP, bonded to, or aggregated with, a bi-directional TVWS channel, within an annular (i.e., donut-shaped) coverage area defined by the WSDB; (2) uplink and downlink on a channel that is offset by 3 MHz from the broadcast channel within the annular coverage area; or (3) uplink and downlink at up to 36 dBm EIRP in any 500-meter by 500-meter cells identified by the WSDB as permissible, using a terrain-based model within the proposed coverage area.

To arrive at these proposals, our laboratory testing program first measured television receiver sensitivity at threshold and at the D/U ratios on the co-channel, first adjacent channel, and a channel with a 3-MHz offset to the broadcast channel.[97] Based on the lab results, the proposals we explain here use a DTV receiver sensitivity of -84.5 dBm, a co-channel D/U ratio

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96 ARK Comments at 4.

97 *See* Microsoft Comments at App. A, DEKRA Certification and Testing, Inc., *TVWS-DTV Coexistence on the First Adjacent Channel, Laboratory Measurements Test Report* (May 3, 2020).

of 15 dB,[98] a first adjacent channel D/U ratio of -43.5 dB, and a 3-MHz offset channel D/U ratio of -49 dB.[99]

We present these three proposals as a way to lay a foundation for engineering discussions between the Commission, broadcasters, and broadband providers on how to make more effective use of otherwise vacant first-adjacent channels without causing harmful interference to licensees.

Proposal One: Downlink TVWS operations only on the first adjacent channel at up to 34 dBm EIRP, bonded to or aggregated with a bi-directional TVWS channel, within an annular coverage area defined by the WSDB.

Restricting TVWS operations on a first-adjacent channel to downlink transmissions from a TVWS base station avoids the most significant challenge of adjacent-channel operations: the potential interference between a TVWS device in a user's home to her neighbor's DTV receiver, which could be only a short distance away. While the prohibition on adjacent-channel uplink operations would continue to impose significant constraints on TVWS deployments, it would allow providers to increase bandwidth and alleviate congestion on the side of the link with by far the greater demand: the downlink into users' homes.

As an example of determining the conditions under which this could occur, we calculated the separation distances necessary to achieve both the required co-channel D/U ratio and adjacent-channel D/U ratio, given the out-of-band emissions ("OOBE") from a TVWS device in the adjacent channel, based on Microsoft's field tests.

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[98] The co-channel D/U ratio was determined using Section 73.616 of the Commission's rules. *See* 47 C.F.R. § 73.616(d)(1)(i) (providing that, for DTV station interference protection, the D/U ratio for co-channel stations is 15 dB). Based on the test points in Grapeland, Texas, which all received a moderate desired signal, this analysis uses a 15 dB co-channel D/U ratio throughout. We recognize, however, that at the edge of the noise-limited service area, where the signal-to-noise ratio is 16 dB, the co-channel D/U ratio would be 23 dB.

[99] The average change in D/U on the 3-MHz offset channel was -5.7 dB, which was rounded to -5.5 dB.

Co-channel Selectivity: The following parameters were used to determine the maximum received power level, in band, at the DTV receiver: a co-channel D/U ratio of 15 dB, a DTV receiver selectivity value of -84 dBm, a maximum undesired WSD power at the DTV receiver of -99 dBm, and a TVWS power (adjacent emissions, radiated) of -38.8 dBm.[100] We next adjusted the TVWS radiated power by the DTV receiver gain (10 dBi) and the typical loss measured in our Grapeland, TX field tests (-21 dB), which includes polarization mismatch and other losses beyond path loss, using a center frequency of 599 MHz. Finally, to determine the minimum separation distance between a TVWS base station ("B/S") and a DTV receiver, we calculated the distance at which the radiated TVWS power level, minus the applicable propagation loss and other factors listed above, equals the maximum undesired co-channel signal of -99 dBm. This results in a minimum separation distance, considering only interference from TVWS OOBE, of 28 meters (slant distance).[101] When the TVWS base station's antenna gain pattern and TVWS base station's height above ground level are taken into account, the horizontal distance from the TVWS base station where harmful interference could occur is very close to the tower. Any rooftop DTV antenna situated at 9-10 meters above ground level would be in the shadow of the TVWS transmitter.[102]

Adjacent Channel Selectivity: We separately considered the allowable power in the first-adjacent channel, applying the measured D/U ratio required to avoid interference from adjacent-

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[100] *See* 47 C.F.R. 15.709(b)(1)(iii). The conducted adjacent channel limit of -42.8 dBm/100 kHz was converted to a radiated adjacent emissions limit per 100 kHz to reflect the 34 dBm EIRP of the 6Harmonics radio, and then converted to -21 dBm/6 MHz.

[101] This calculation assumed free-space propagation conditions.

[102] The co-channel D/U ratio can increase to 23 dB for very weak signals. However, this is addressed by our proposal to limit TVWS operations to areas within an adjacent-channel broadcaster's city-grade contour, increasing the minimum received DTV signal strength.

channel operations. This was performed separately from the co-channel OOBE analysis above because evidence suggests that, under certain circumstances, blocking interference can also be a factor in adjacent-channel interference to DTV receivers.

We repeated the co-channel analysis explained above, with two important differences:

1. Instead of the co-channel D/U ratio, we used the required D/U ratio derived from our measurements of DTV receiver performance for adjacent-channel operations: -43.5 dB. This change resulted in a significantly increased maximum undesired signal power of -41 dBm, as compared to the FCC's 2008 analysis.[103]
2. Instead of TVWS out-of-band emissions, we assumed in-band TVWS power levels of 34 dBm EIRP.

Our assumptions were as follows: a D/U ratio of -43.5 dB, a DTV receiver sensitivity of -84.5 dBm, a maximum undesired signal power of -41 dBm, a DTV receiver antenna gain of 10 dBi, and other measured losses of -21 dB. Like the analysis for the co-channel selectivity, we then calculated the minimum separation distance at which the received TVWS power level, subject to the losses and other assumptions above, would not exceed the maximum undesired co-channel signal of -41 dBm.

As predicted, although the required D/U ratio was far lower than in the co-channel analysis, the conducted TVWS power level was significantly higher. Accordingly, the minimum separation distance was also higher (63 meters, slant distance). While higher than the 28 meter slant distance found above, in less congested areas where TVWS base stations are commonly

[103] *See TVWS 2008 R&O, M&O*, ¶ 171 n.237 (assuming a D/U ratio of -33 dB and a maximum undesired TVWS signal on the adjacent TV channel of - 51 dBm).

installed tens of meters above ground level, taking the antenna pattern into account, and the typical separation between rural homes, Microsoft believes the proposal is workable.

However, for an added conservative margin, we propose only to allow adjacent-channel operations under this approach within a broadcaster's city grade contour. This reduces the minimum separation distance by increasing the value of "D" in the calculations above, replacing the minimum DTV sensitivity with the substantially higher DTV field strength at the city grade contour.[104]

Finally, under the ATSC A/74 recommended standard, DTV receivers' required D/U ratios are 13 dB higher for a strong desired DTV signal than for a moderate desired signal.[105] Although we did not study this phenomenon in our testing, this can readily be addressed by requiring adjacent-channel TVWS devices under this proposal to be a minimum distance away from a DTV transmitter, but still within the city-grade contour, resulting in an annular, or donut-shaped, area of operation.

Proposal Two: Uplink and downlink TVWS operations on a channel that is offset by 3 MHz from the broadcast channel within the annular coverage area.

Another strategy for allowing TVWS operations in spectrum adjacent to broadcast licensees would be to allow operations within an annular zone of operations, as detailed below, but with 3 MHz spectral separation from the broadcast signal.[106] This approach takes advantage

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[104] This also addresses the potentially higher required D/U ratio where the received DTV signal is very weak.

[105] *See* Advanced Television Systems Comm., Inc., *ATSC Recommended Practice: Receiver Performance Guidelines*, Document A/74:2010 at 15, Tbl. 5.2 (Apr. 7, 2010), https://www.atsc.org/wp-content/uploads/2015/03/Receiver-Performance-Guidelines-1.pdf.

[106] The Commission proposed such an approach in 2014 but declined to adopt corresponding rule changes because analysis based on the existing D/U ratio indicated that the separation

of the lower required D/U ratio for DTV receivers with respect to undesired signals 3 MHz away, rather than immediately adjacent, to enable uplink and downlink operations. Because the D/U ratio of the DTV receiver operating on a 3-MHz offset from the TVWS channel is an average of 5.5 dB below that of the D/U ratio of a DTV receiver operating on the first-adjacent to a TVWS channel, we are confident that the TVWS downlink will not lead to harmful interference. As explained above in proposal one, downlink operations would not result in harmful interference to broadcast services even in the absence of the 3-MHz offset.

In this case, the analysis focuses on the case of potential uplink interference from a TVWS device in a consumer's home to a nearby DTV receiver. During the field testing in Grapeland, Texas, we demonstrated that using a 33 dBm EIRP TVWS customer premises equipment did not cause harmful interference to the ATSC 1.0 DTV receiver tested at a 16 meter separation.[107] The DTV antenna was placed in the path between the TVWS base station and TVWS customer premise equipment at the same height as the TVWS customer premise equipment antenna. The Commission has concluded that the appropriate assumed distance between homes in this context is 16 meters. In the course of our field measurements, we found

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distances would be too great to allow TVWS operation and because no parties submitted evidence supporting the feasibility of TVWS operations at increased powers with a 3-MHz offset. *See 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*, Notice of Proposed Rulemaking, 29 FCC Rcd. 12248, ¶ 37 (2014); *2015 TVWS R&O* ¶ 37. However, the Commission explained that it would revisit the issue in the future if "new studies and information become available . . . showing that such operation is possible without causing interference to TV reception." *2015 TVWS R&O* ¶ 37.

[107] *See* Microsoft Comments at App. B, DEKRA Certification and Testing, Inc., *TVWS-DTV Coexistence on the First Adjacent Channel, Field Measurements Test Report,* at 31-32 (May 3, 2020).

that the typical distance between rural homes is far greater—on the order of tens of meters. However, we use the Commission's 16-meter value to ensure a conservative result.

In conducting this analysis, we repeated a version of the methodology described above. One important difference is that in the analysis of the co-channel selectivity, with the 3-MHz offset, the undesired radiated TVWS signal leaking into the DTV receiver combines both (1) the undesired signal emanating from the radiated adjacent channel leakage from the TVWS CPE in the first 3 MHz of the DTV channel and (2) emissions under Section 209 of the Commission's Part 15 rules in the second 3-MHz portion of the DTV channel.[108] However, because the necessary minimum distance is known—16 meters—we solve for the desired DTV signal level to determine the maximum distance from the DTV transmitter where a TVWS device can operate without risking harmful interference.

At these close distances, path loss and antenna pattern misalignment between DTV and WSD CPE antennas are major sources of loss. Another major factor identified in our field testing is polarization mismatch loss between TVWS devices and DTV receivers. Most DTV transmissions are horizontally polarized, with only a small percentage of stations transmitting using circular polarization. Single input, single output WSD transmissions are vertically polarized.[109] Under these conditions, cross polarization loss can be very significant if the

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[108] *See* 47 C.F.R.§15.209(a) (providing that the emissions from an intentional radiator operating between 216 and 960 MHz shall not exceed 200 microvolts per meter at 3 meters). This converts to 46.02 dBuV per meter or -49.21 dBm.

[109] There are some recently certified MIMO WSDs that use both vertical and horizontal polarization.

antennas are close to perfectly aligned.[110] Given the short separation distance, the propagation model should assume free-space path loss.

In this case, we again find that the potential coverage area will be a donut-shaped area, with the minimum desired signal representing the outer contour of the area, determined by the values used for the miscellaneous losses. Similarly, we find that also requiring a minimum separation from the DTV transmitter is required to address cases where the received desired signal is very strong, resulting in a higher required D/U ratio.

Proposal Three: Uplink and downlink TVWS operations at up to 36 dBm EIRP in any 500-meter by 500-meter cells identified by the WSDB as permissible using a terrain-based model within the proposed coverage area.

The third proposed method is the simplest. The WSDB could use a terrain-based model (that includes clutter) to calculate the maximum WSD power on either the first adjacent channel or with a 3-MHz offset in each 500-meter by 500-meter cell within the coverage area where a WISP seeks to operate. Under this approach, for each cell, the database would calculate the maximum received WSD power level as well as the minimum received DTV signal, potentially blending these values with the values computed for adjacent cells to create weighted averages. This weighted averaging would address any issues relating to sampling of terrain data within the cell, or other rare anomalies. The WSDB could then determine whether the calculated D/U ratio for the first adjacent channel or channel with a 3-MHz offset using the terrain-based model is lower than the required D/U ratio identified in Microsoft's testing. If it passes, WSD operations on the first adjacent channel or channel with a 3-MHz offset could be authorized within the cell.

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[110] *See* DSA Comments at 26-27; *Directivity and polarization discrimination of antennas in the reception of television broadcasting*, ITU-R BT.419-3 (06/90) (June 1990), https://www.itu.int/dms_pubrec/itu-r/rec/bt/R-REC-BT.419-3-199006-I!!PDF-E.pdf.

This approach has the advantage of producing more accurate predicted signal levels, preventing harmful interference while enabling TVWS operations in areas where an approach based on separation distances may not identify as available. However, it has the disadvantage of potentially producing permitted zones of operation where the maximum EIRP level in adjacent cells can vary, potentially complicating network planning efforts. This set of calculations would be calculated across the coverage area of each TVWS device a WISP seeks to operate, taking into account the terrain- and clutter-dependent propagation conditions relative to each device's location.

VI. THE COMMISSION SHOULD DECLINE TO ADDRESS ADDITIONAL ISSUES OUTSIDE THE SCOPE OF THE NPRM.

Finally, some commenters ask the Commission to use this proceeding to address broadcast licensing windows, wireless microphone eligibility, and the operation of the WSDB. These topics are outside the scope of the NPRM and are better addressed through a different mechanism. The Commission need not consider them in the context of this NPRM.

One commenter, for example, suggests that the FCC "open an unqualified new filing window for LPTV and TV translators."[111] Such a filing window is outside the scope of the Commission's NPRM and unrelated to any aspect of the Commission's proposal.

Other commenters assert that the Commission should expand the eligibility of licensed wireless microphones under Part 74 of the Commission's rules to encompass microphone users who currently operate wireless microphones on an unlicensed basis.[112] This is also outside the

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[111] Comments of the National Translator Association at 3-4, ET Docket No. 20-36 (filed May 4, 2020).

[112] *See* Comments of Edgar C. Riehle, P.E. at 3, ET Docket No. 20-36 (filed May 4, 2020); Sennheiser Comments at 3; Shure Comments at 17-18.

scope of this proceeding. The Commission should not consider it here. In fact, in other proceedings, the FCC already has made substantial accommodations for wireless microphones within the 600 MHz bands, made spectrum available for licensed and unlicensed operations in other bands, and sought comment on the eligibility issue in a separate notice.[113]

Finally, in a delay tactic, CP Communications and the wireless microphone interests argue that the Commission should postpone expanding broadband access and instead address a set of specific registration issues with the TVWS database.[114] These commenters do not assert that the WSDB has failed to prevent harmful interference to licensed services. In fact, one commenter specifically notes the "lack of reported instances of interference to date."[115] The NPRM requests comment on how particular rule changes would be implemented using the WSDB,[116] but this proceeding is the wrong venue for addressing individual WSDB functions or the "trajectory" of a database system that is successfully performing its interference protection mission.[117]

CONCLUSION

The record developed in response to the Commission's NPRM demonstrates wide support for the FCC's proposed rule changes. These focused changes would result in immediate

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[113] *Promoting Spectrum Access for Wireless Microphone Operations*, Order on Reconsideration and Further Notice of Proposed Rulemaking, 32 FCC Rcd. 6077, ¶¶ 77-93 (2017); Comments of Microsoft Corporation at 3-5, GN Docket No. 14-166, ET Docket No. 14-165, GN Docket No. 12-268 (filed Oct. 2, 2017).

[114] CP Comments at 4; *see also* Sennheiser Comments at 3-4; Shure Comments at 18-19.

[115] Sennheiser Comments at 4.

[116] *See TVWS NPRM* ¶¶ 21, 36, 42, 49, 52.

[117] *See* Shure Comments at 18.

and significant improvements to TVWS providers' ability to expand broadband to people in new locations. The Commission should quickly move forward with a Report and Order.

Respectfully submitted,

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