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, and	ET Docket No. 14-165
Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	GN Docket No. 12-268

REPLY COMMENTS OF MICROSOFT CORPORATION

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I. INTRODUCTION AND SUMMARY.

In 2014, the Federal Communications Commission ("FCC" or "Commission") issued an order that permitted unlicensed white space device ("WSD") operations in both the post-auction 600 MHz and broadcast bands. The Commission followed this decision with a Notice of Proposed Rulemaking to establish technical rules that would permit WSD operations in a manner that would advance the FCC's goal of expanding wireless broadband across the country ("*Part 15 NPRM*" or "*NPRM*"). The record in response to this *NPRM* strongly supports the Commission's core proposals.

In particular, and as discussed in further detail below, the majority of commenters favor allowing WSDs to operate in the duplex gap, guard bands of 9 and 11 MHz, and on Channel 37 at operating powers between 40 and 100 mW. Most commenters also support the rule changes proposed by the Commission to improve the operating environment for WSDs, including expanding the spectrum available for WSDs and allowing additional flexibility with respect to operating power, antenna height, and geolocation accuracy in certain circumstances.

A minority of commenters opposes the Commission's proposals, but these parties provide little in the way of new support for their positions. For example, CTIA – The Wireless Association ("CTIA") and Qualcomm Incorporated ("Qualcomm") have both submitted test reports purporting to show that WSDs operating in the guard bands and duplex gap at the power levels proposed by the Commission would cause harmful interference to adjacent LTE operations. But these supposedly new test results rely on many of the same problematic assumptions that rendered previous technical analyses submitted by LTE proponents inaccurate. The tests themselves also appear designed to achieve a particular outcome and do not reflect real-world operating conditions.

Similarly, GE Healthcare ("GEHC") has submitted test results that it claims demonstrate that WSDs operating on Channel 37 according to the parameters proposed in the *Part 15 NPRM* would cause harmful interference to Wireless Medical Telemetry Service ("WMTS") operations. But GEHC's test design also departs from real-world operating conditions in several respects, which renders the testing unreliable for purposes of the Commission's analysis.

Finally, wireless microphone interests merely recycle the same arguments that they have already raised previously in the incentive auction proceeding. Wireless microphone proponents self-servingly encourage the Commission to restrict the spectrum available for WSD use in order to allow spectrum warehousing by inefficient wireless microphone operations, leaving spectrum to lie fallow in the vast majority of the country for the vast majority of the time. They also urge the Commission to allow wireless microphones to operate under permissive technical rules that threaten harmful interference to incumbents and undermine the potential for efficient, shared use of the 600 MHz band. Furthermore, wireless microphone interests oppose many of the Commission's proposed technical rule changes for WSD operation in the TV bands without providing any technical support for their position that such rule changes may cause harmful interference to licensed wireless microphone users.

Microsoft Corporation ("Microsoft") respectfully requests that the Commission reject unfounded allegations and faulty test results and instead adopt its core proposed Part 15 rules. Specifically, the Commission should:

- Allow fixed and personal/portable WSDs to operate in the duplex gap and 9 and 11 MHz guard bands at power levels up to 100 mW;
- Allow fixed and personal/portable WSDs to operate on Channel 37 subject to reasonable exclusion zones to protect incumbents;
- Allow WSDs to operate on Channels 36 and 38 subject to the proposed adjacent-channel emission limits and proposed WMTS adjacent-channel separation distances;

- Adopt technical rules for wireless microphone operations in the guard bands and duplex gap that comply with Spectrum Act requirements, foster shared use of spectrum, improve spectral efficiency, and adequately compensate database providers; and

- Adopt the revisions to the WSD technical rules discussed herein to ensure adequate spectrum resources for WSDs, facilitate the deployment of rural broadband networks, and encourage the development of robust WSD operations in the 600 MHz band.

Adopting these proposals will foster the development of a vibrant WSD ecosystem in the 600 MHz band, protect licensed operations, and substantially increase spectral efficiency.

II. THE RECORD SUPPORTS ALLOWING WSDS TO OPERATE AT POWER LEVELS UP TO 100 MW IN THE DUPLEX GAP AND GUARD BANDS OF 9 AND 11 MHZ.

The record demonstrates that WSD innovators, manufacturers, and network operators need access to three or more 40 mW, 6 MHz channels in every market to support a personal/portable WSD ecosystem in the post-auction 600 MHz and broadcast television bands.[1] The duplex gap, in particular, is crucial to providing the required three channels, because it will exist in every market. Guard bands of sufficient size also have the potential to contribute to the provision of three channels, but the FCC's band plan makes it clear that such guard bands will not exist in all auction scenarios. Critically, however, the Commission must adopt suitable technical rules for the duplex gap and guard bands to ensure that these frequencies support commercially viable options for manufacturers and network operators. Merely permitting unlicensed operations in these channels is not enough to build a WSD ecosystem—the FCC's technical rules must make investment economically and technically viable.

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[1] Comments of Google Inc. at 51 ("Google Comments"); Comments of Microsoft Corporation at 2 ("Microsoft Comments"); Letter from Paul Margie, Counsel to Broadcom Corp., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 (filed Sept. 25, 2014). Unless otherwise noted, all comment citations herein are to comments filed on February 4, 2015 in ET Docket No. 14-165 and GN Docket No. 12-268.

The record in this proceeding strongly supports the Commission's proposals to allow WSDs to operate in the duplex gap and guard bands at powers up to (or even exceeding) 100 mW.[2] In particular, analyses submitted by Broadcom and Google are consistent with Microsoft's analysis, and show that the FCC's proposals will both protect licensed operations and permit investment in WSD technologies.[3] Qualcomm and CTIA, representing a minority of commenters, have submitted tests that they state demonstrate that WSD operation is not feasible in the guard bands and duplex gap at the power levels proposed in the *Part 15 NPRM*. However, these studies are unreliable and do not change the legitimacy of the FCC's analysis shown in the *NPRM*, or the analyses conducted by Broadcom, Google, Microsoft, and others. Qualcomm and CTIA simply rehash the same positions found in these parties' past filings (and the technical assertions that the FCC discounted prior to issuing the *Part 15 NPRM*), and continue to rely on many of the same inaccurate assumptions that undermined previous LTE analyses in this proceeding. Qualcomm and CTIA's testing parameters further undermine the legitimacy of their results, as they appear not to reflect real-world operating conditions. The FCC should therefore give little weight to the test results submitted by Qualcomm and CTIA and allow WSD operations of up to 100 mW in the duplex gap and guard bands of 9 and 11 MHz.

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[2] Comments of Adaptrum, Inc., at 6 ("Adaptrum Comments"); Comments of the Dynamic Spectrum Alliance at 8-9 ("DSA Comments"); Google Comments at 4; Microsoft Comments at 5, 14; Comments of Motorola Solutions, Inc., at 8-9 ("Motorola Solutions Comments"); Comments of WhiteSpace Alliance at 20-22 ("WhiteSpace Alliance Comments"); Comments of Wi-Fi Alliance at 24-26 ("Wi-Fi Alliance Comments").

[3] Comments of Broadcom Corporation at 4-20 ("Broadcom Comments"); Google Comments at 4-16.

A. The Tests Submitted by Qualcomm and CTIA Suffer from Many of the Same Deficient Assumptions that Plagued Qualcomm's Initial Analysis.

Qualcomm and CTIA both submit test reports purporting to show that WSD use of the guard bands and duplex gap would be all but impossible without causing harmful interference to LTE. However, these tests fail to correct the infirmities that rendered Qualcomm's initial analysis incorrect. Repeating flawed analyses does not make them more legitimate. As the Commission has noted, "[t]here are numerous ways to conduct interference analyses and each depends on a number of assumptions, such as filter characteristics, the propagation model and miscellaneous losses (e.g., body loss, polarization mismatch, etc.)."[4] Qualcomm and CTIA's tests rely on a number of odd assumptions about propagation loss and LTE/WSD separation, all of which appear designed to ensure a negative result. Their assumptions are also inconsistent with one another, providing the Commission with no reliable basis to justify departing from the Commission's own assumptions as set forth in the *Part 15 NPRM*.

First, Qualcomm assumes no body loss at either the receiver or the transmitter,[5] even though the Commission, Broadcom, and Google agree with Microsoft that it is reasonable to account for a certain amount of LTE and WSD body loss.[6] Google believes that the appropriate

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4 *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 37and Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap; Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, ET Docket No. 14-165, GN Docket No. 12-268, Notice of Proposed Rulemaking, FCC 14-144, 29 FCC Rcd. 12,248, 12,274 ¶ 82 (2014) ("*Part 15 NPRM*").

5 Comments of Qualcomm Incorporated at 10 ("Qualcomm Comments") (assuming only free space propagation losses over 1 m).

6 *Part 15 NPRM* at 12,274 ¶ 84; Broadcom Comments at 4-5 (assuming 3 dB body loss for the LTE handset and an additional 3 dB loss for a client WSD); Google Comments at 6-9.

real-world assumption for LTE body loss is 6 dB—double that which Broadcom assumed—and that unlicensed device body loss would result in an additional 3 dB of loss.[7] In the Commission's interference analysis set forth in the *H Block Order*, the Commission assumed both head and body loss at a separation distance of 2 m when evaluating mobile-to-mobile interference.[8] Moreover, even CTIA factors in 3 dB of body loss each for transmitters and receivers, assuming that the user equipment will be held in the hand.[9] Qualcomm provides no adequate rationale as to why the Commission should depart from its *H Block Order* or the rational body loss assumptions by other commenters—including other LTE proponents.

Qualcomm compounds this error by inappropriately assuming 0 dB of shadowing loss and 0 dB of polarization mismatch loss,[10] while CTIA assumes only 3 dB of loss for antenna polarization mismatch "and other losses."[11] These LTE proponents therefore underestimate loss by at least 3 to 6 dB.[12]

Although CTIA agrees with the Commission, Broadcom, and Google that it is appropriate to factor in a certain amount of body loss and antenna polarization mismatch, it inexplicably fails to account for loss due to negative LTE antenna gain. Broadcom, Google, and even Qualcomm agree that it is appropriate to account for a negative LTE antenna gain of at least

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7 Google Comments at 6.

8 *Service Rules for Advanced Wireless Services H Block—Implementing Section 6401 of the Middle Class Tax Relief and Job Creation Act of 2012 Related to the 1915-1920 MHz and 1995-2000 MHz Bands*, Report and Order, FCC 13-88, 28 FCC Rcd. 9483, 9536-37 ¶ 142, 9538-39 ¶¶ 146-47 (2013) ("*H Block Order*").

9 Comments of CTIA – The Wireless Association at 9 ("CTIA Comments").

10 *See, e.g.*, Qualcomm Comments at 10.

11 CTIA Comments at 10.

12 *See* Broadcom Comments at 26 (assuming polarization mismatch loss of 3 dB and shadowing loss of 3 dB); Google Comments at 6 (same).

6 dB.[13] CTIA therefore underestimates loss by a further 6 dB. The Commission should rely on the reasonable loss assumptions of the majority of commenters and reject the inconsistent loss assumptions proposed by Qualcomm and CTIA.

Both Qualcomm and CTIA also inappropriately assume only 1 m separation distance between LTE and WSDs.[14] In contrast, Broadcom, Google, and Microsoft conservatively assumed 2 to 3 m separation between LTE and WSDs,[15] consistent with ample Commission precedent.[16] Qualcomm and CTIA's inappropriate separation distance assumption results in an underestimation of path loss by at least 6 dB (the difference between path loss at 1 m and path loss at 2 m separation). Compared to the Commission's 7 m separation distance assumption, Qualcomm and CTIA have underestimated path loss by 16.9 dB. The Commission should reject the unjustified separation distance assumption relied upon by CTIA and Qualcomm. Broadcom's assumptions—supported by Google and Microsoft[17]—along with Commission precedent, support a more reasonable separation distance of 2 to 3 m and assumptions for

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13 Broadcom Comments at 5; Google Comments at 6; Qualcomm Comments at 10.

14 Qualcomm Comments at 3; CTIA Comments at 10.

15 Broadcom Comments at 5; *see also* Google Comments at 7-8; Microsoft Comments at 6, 9.

16 *See H Block Order* at 9536-37 ¶ 142 ("[W]e believe that a 1 meter separation distance represents an overly conservative value and that it is a more realistic scenario to assume that the devices at issue are likely to be at least 2 meters apart."); *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, Including Third Generation Wireless Systems*, Sixth Report and Order, Third Memorandum Opinion and Order, Fifth Memorandum Opinion and Order, FCC 04-219, 19 FCC Rcd. 20,720, 20,734 ¶ 25 (2004); *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands*, Report and Order and Order of Proposed Modification, FCC 12-151, 27 FCC Rcd. 16,102, 16,137-39 ¶¶ 84-86, 16,158-59 ¶¶ 142, 144 (2012).

17 Google Comments at 7-8; *see also* Microsoft Comments at 6, 8.

propagation loss that account for body loss, shadowing, polarization mismatch, and negative LTE antenna gain.

B. The Tests Submitted by Qualcomm and CTIA Are Inconsistent and Do Not Identify Tested Handsets.

The bench tests performed by Qualcomm and CTIA purport to show that WSDs would cause harmful interference to LTE if the FCC authorizes them to operate in the guard bands and duplex gap. But in addition to the inaccurate assumptions discussed above, the tests themselves suffer from a variety of infirmities that render the results unreliable.

Qualcomm bench-tested six LTE handsets and ultimately concluded, based on its test results, that blocking from a WSD occurred at -42 dBm with a 5 MHz separation from mobile downlink, which it states would result in an interference radius of 18 m (rather than 7 m) at the proposed 16 dBm (40 mW) EIRP level for WSDs.[18] According to Qualcomm's results, blocking from a WSD operating at 3 MHz separation from LTE downlink occurred at -47 dBm, which Qualcomm states would result in an interference radius of 29 m, assuming WSD operations of 16 dBm (40 mW).[19] These results are irrelevant because Qualcomm used unreasonable testing parameters that appear designed to achieve its desired conclusion and that bear no resemblance to real-world operating conditions.

First, Qualcomm states only that it tested six "commercially-available LTE devices."[20] It does not disclose which devices it used, or even represent that the relevant devices are marketed or sold in the United States. Moreover, without disclosure of the specific devices tested, neither Microsoft nor the Commission can determine whether such devices are reasonable proxies for

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[18] Qualcomm Comments at 8-10.

[19] *Id.* at 11.

[20] *Id.* at 8, 10.

future devices that manufacturers would build for the 600 MHz band, or whether they might be outdated devices that no longer represent industry best practices. This is important because, as the Commission has recognized, "[g]iven that there is some time prior to networks being deployed," it is reasonable to "expect manufacturers to improve filter technology and designs to ensure a minimum potential for harmful interference."[21] A test of six unspecified devices should hold little weight, especially when compared to Broadcom's testing and analysis, which demonstrated that WSD operations of 100 mW or more at a separation distance of 4 MHz would not cause blocking to three popular and current LTE handsets—the iPhone 5s, Samsung Galaxy 4, and the Samsung Galaxy Note.[22]

Second, Qualcomm set the desired LTE signal strength to only 1 dB above the device's reference sensitivity.[23] In other words, Qualcomm tested the impact of a WSD signal on LTE reception capability when the LTE signal purportedly interfered with was barely detectable even in the absence of any WSD transmission. Setting the desired signal strength so low is like asking whether a person can hear a pin drop in the middle of a rock concert in a packed stadium. REFSENS+1 is such a faint desired signal that 3GPP specifications do not impose *any* performance requirements in such circumstances.[24] Such a testing parameter virtually guarantees the result.

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21 *Part 15 NPRM* at 12,275 ¶ 85.

22 *See* Broadcom Comments at 13 n.20.

23 Qualcomm Comments at 9, Appendix at Table A-1.

24 *See generally* 3rd Generation Partnership Project (3GPP), Technical Specification Group Radio Access Network, Evolved Universal Terrestrial Radio Access (E-UTRA), User Equipment (UE) radio transmission and reception (Release 12) (3GPP 36.101 V12.6.0, Dec. 2014).

Guaranteeing the result must be what Qualcomm had in mind when it picked REFSENS+1 for the purposes of its test, as there is no other explanation for why Qualcomm would depart from its previous assumptions. In its prior blocking analysis, Qualcomm had assumed REFSENS+6, a more reasonable choice,[25] consistent with both Broadcom's assumption[26] and the LTE standard for receiver blocking (which is based on a desired signal level 6 dB above the receiver's reference sensitivity).[27] Qualcomm has now dramatically changed gears and inappropriately selected REFSENS+1, an unreasonable testing parameter that greatly undermines its results. Qualcomm should have specified the measurement uncertainty associated with attempting to measure REFSENS+1, whether the measurement uncertainty is considered high, and whether such a measurement is typically used during conformance or performance testing by the wireless industry.

CTIA's testing parameters also bear little resemblance to real-world operating conditions. CTIA focuses primarily on out-of-band emissions ("OOBE") and concludes that an extremely stringent OOBE limit of -89 dBm/100 kHz is necessary to prevent harmful interference to LTE from WSDs operating in the duplex gap and guard bands.[28] CTIA's proposed OOBE limit is a whopping ***32 dB more stringent*** than that proposed in the *NPRM*.[29] To arrive at this result,

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[25] Letter from John W. Kuzin, Senior Director, Government Affairs – Regulatory, Qualcomm Incorporated, to Marlene H. Dortch, Secretary, FCC, at Attachment at 24, GN Docket No. 12-268 (filed May 2, 2013).

[26] Broadcom Comments at 13 n.19.

[27] *H Block Order* at 9527 ¶ 114, n.374 (citing 3rd Generation Partnership Project (3GPP), Technical Specification Group Radio Access Network, Evolved Universal Terrestrial Radio Access (E-UTRA), Base Station (BS) radio transmission and reception (Release 11), 75 (Requirement 7.6.1.1) (3GPP 36.104 V10.7.0, July 2012)).

[28] CTIA Comments at 13.

[29] *Part 15 NPRM* at 12,321 (Appendix A – Proposed Rules).

CTIA—like Qualcomm—used unreasonable testing parameters. It also did not disclose which devices it tested.

CTIA's testing purports to demonstrate that LTE devices can only tolerate in-band interference of -127 dBm/100 kHz before receivers suffer 1 dB of desensitization, or -121 dBm/100 kHz before receivers suffer 3 dB desensitization.[30] CTIA provides no adequate explanation for how its tests arrived at such a low tolerance for co-channel noise. Analyses submitted by both Broadcom ***and Qualcomm*** in this proceeding indicate that LTE devices are able to tolerate co-channel noise of up to -98.5 dBm[31]—a number based on 3GPP reference sensitivity levels. As Broadcom pointed out in its comments on the *Part 15 NPRM*, even this value is a "substantially more demanding" co-channel interference threshold than the -95.5 dBm that the Commission has previously assumed.[32] It is also more conservative than what Google deems to be an appropriate real-world assumption for the LTE in-band interference level (also -95.5 dBm).[33] One possible explanation for CTIA's very low interference tolerance results is that CTIA tested atypical handsets that perform far worse than Broadcom or even Qualcomm predicted, and would therefore be poor proxies for future devices that manufacturers will design for the 600 MHz band. But CTIA failed to reveal which handsets it tested, so Microsoft cannot

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30 CTIA Comments at 13, Appendix at 82.

31 *See* Broadcom Comments at 8 & n.14 (citing Reply Comments of Qualcomm Incorporated, GN Docket No. 12-268 (filed Mar. 12, 2013) and Letter from Paul Margie, Counsel to Google Inc. and Broadcom Corp., to Marlene H. Dortch, Secretary, FCC, Broadcom Corp. WiFi-LTE Interference Analysis at 3, GN Docket No. 12-268 (filed Jan. 30, 2014)).

32 *Id.* at 8 (citing *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, FCC 14-50, 29 FCC Rcd. 6567, 6990, Appendix C ¶ 57 (2014) ("*Incentive Auction Order*")).

33 Google Comments at 7.

determine if this is the reason for the enormous disparity between CTIA's results and those of Qualcomm and Broadcom.

Significantly, CTIA designed its tests to measure the levels at which 1 dB and 3 dB degradation of the LTE handsets' sensitivity occurs, and relied primarily on the 1 dB results. "A 1 dB desensitization level is defined as the level of interference at which the effective noise floor of the system will rise by 1 dB, that is, the receiver sensitivity will be reduced by 1 dB."[34] However, as the Commission has previously found, a 1 dB desensitization level "is too restrictive for modern cellular systems," which "are designed to perform in a strong interference environment, much of which is often self-generated, coming from other network elements (*e.g.*, other nearby base stations in the same or adjacent bands)."[35] As a practical matter, most handsets can easily tolerate 1 dB of desensitization. Indeed, simply holding most handsets naturally can result in between 0.8 dB and 19.8 dB of attenuation.[36] Putting a handset in a case can result in between 3.2 dB and 9.0 dB of attenuation.[37] Even holding a handset on your open palm can result in up to 9.2 dB of attenuation, depending upon the handset.[38] It was therefore inappropriate for CTIA to use such a low 1 dB desensitization threshold for its tests.

Finally, CTIA tested ten unidentified "commercial Band 12 LTE devices," but failed to identify the handsets.[39] Without knowing the identity of the handsets, the Commission cannot

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34 *H Block Order* at 9537 ¶ 144.

35 *Id.* at 9537 ¶¶ 144-45.

36 Brian Klug, *HTC Thunderbolt Review: The First Verizon 4G LTE Smartphone*, AnandTech, Apr. 27, 2011, *available at* http://www.anandtech.com/show/4240/htc-thunderbolt-review-first-verizon-4g-lte-smartphone/3 (last visited Feb. 18, 2015).

37 *Id.*

38 *Id.*

39 CTIA Comments at 8.

determine if these devices provide the FCC with representative results, and other parties cannot properly analyze CTIA's assertions. Notably, CTIA faults the Commission for relying on Broadcom's handset tests.[40] But Broadcom clearly identified which models it tested, and used only popular handsets sold widely in the United States today. This test showed that real-world devices typically perform 10 dB better than the requirements of the 3GPP specification for adjacent-channel selectivity. And yet CTIA argues that the Commission should rely on CTIA's own tests of unidentified handsets to impose an unreasonably stringent OOBE limit. This is yet another reason for the Commission to reject CTIA's test results as unreliable.

Finally, the tests submitted by CTIA and Qualcomm did not take into account the overlapping duplexers required for pass bands of 30 MHz and greater. The Commission recognized in the *Incentive Auction Order* that current SAW filter technology can accommodate a 600 MHz pass band up to 25 MHz.[41] As wireless carriers noted in their comments, however, two overlapping filters would be required to achieve a 30 or 35 MHz pass band,[42] as is contemplated for the 700 MHz band under the Asia Pacific Telecommunity band plan (implemented by 3GPP as Band 28). Neither CTIA nor Qualcomm simulated the use of dual overlapping duplexers in their respective duplex gap tests, rendering the tests incomplete for some of the most likely incentive auction scenarios. Moreover, tests using two overlapping

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40 *Id.* at 29.

41 *Incentive Auction Order* at 6971, Appendix C ¶ 15.

42 *See id.* (citing Reply Comments of T-Mobile USA, Inc., at 20-23, Exh. A at 20-21, GN Docket No. 12-268 (filed Mar. 12, 2013); Letter from Kathleen Ham, Vice President, Federal Regulatory, T-Mobile USA, Inc., and Kathleen Grillo, Senior Vice President, Verizon, to Ruth Milkman, Chief, Wireless Telecommunications Bureau and Gary Epstein, Chief, Incentive Auction Task Force, FCC, at Attachment, GN Docket No. 12-268 (filed Sept. 16, 2013)).

duplexers could show a relative increase in the threshold for harmful interference within the duplex gap.[43]

III. THE RECORD SUPPORTS ALLOWING WSDS TO OPERATE ON CHANNEL 37 SUBJECT TO EXCLUSION ZONES ONLY AS LARGE AS NECESSARY TO PROTECT INCUMBENTS AND ALLOWING WSD OPERATIONS ON ADJACENT CHANNELS SUBJECT TO REASONABLE EMISSION LIMITS.

The record also supports allowing WSDs to operate on Channel 37 subject to reasonably sized exclusion zones that are only as large as necessary to protect incumbents.[44] Google "agrees with the Commission's goal of enabling unlicensed operations in channel 37," but requests that the Commission "align its separation distances with real-world conditions."[45] Broadcom also "supports the Commission's proposal to permit TVWS operations in channel 37," but notes "that the Commission's proposed separation distances for TVWS devices operating in channel 37 are far larger than necessary."[46] Similarly, Motorola Solutions states that WSDs should be allowed in Channel 37, "as long as they meet minimum separation distances from WMTS and RAS users," which should be limited to a maximum of the radio horizon for RAS and should not extend to entire urban areas to protect WMTS users.[47] "Wi-Fi Alliance supports the FCC's technical proposals with regard to unlicensed operations on channel 37, with the exception of the proposed methodology for calculating minimum separation distances," which should account for

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43 *See* Reply Comments of Samsung Electronics America, Inc. and Samsung Telecommunications America, LLC, GN Docket No. 12-268, at 4 (filed June 28, 2013).

44 Adaptrum Comments at 6; DSA Comments at 10-11; Google Comments at 18-20; Microsoft Comments at 19; Motorola Solutions Comments at 10; Wi-Fi Alliance Comments at 28; WhiteSpace Alliance Comments at 22; Comments of the Wireless Internet Service Providers Association at 6 ("WISPA Comments").

45 Google Comments at 19.

46 Broadcom Comments at 21.

47 Motorola Solutions Comments at 10.

building penetration and urban clutter losses and antenna height.[48] Dynamic Spectrum Alliance ("DSA") states that "[t]he Commission can and should allow unlicensed devices to operate in channel 37 while protecting existing users of the channel,"[49] while WhiteSpace Alliance "strongly supports the use of white space Mode II, Mode I and Fixed devices up to an EIRP of 4 watts on Channel 37."[50] The record also strongly supports allowing all types of WSDs—fixed and Mode I and Mode II personal/portable WSDs—to operate in Channel 37[51] and in adjacent Channels 36 and 38.[52]

GEHC, however, repeats its previous argument that the FCC should severely restrict use of Channel 37, and should adopt extremely large exclusion zones. But GEHC bases its assertions about the need for such exclusion zones on study results that depend on a series of inappropriate assumptions. These errors render the study's results unreliable.

The National Academy of Sciences' Committee on Radio Frequencies ("NAS"), on the other hand, should be recognized for its more reasonable and productive approach. It proposes a step in the right direction with Very Long Baseline Array ("VLBA") separation distances using modeling that accounts for the terrain at each site. This proposal could be further adjusted to permit additional WSD operations while still protecting radio astronomy ("RAS") incumbents. Several other proposals offered by NAS, the National Radio Astronomy Observatory ("NRAO"),

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48 Wi-Fi Alliance Comments at 28, 30-31.

49 DSA Comments at 10.

50 WhiteSpace Alliance Comments at 22.

51 DSA Comments at 10-12; Google Comments at 31-35; Microsoft Comments at 26-28; Motorola Solutions Comments at 10; Comments of Spectrum Bridge, Inc., at 10, ET Docket No. 14-165 (filed Feb. 2, 2015) ("Spectrum Bridge Comments"); WhiteSpace Alliance Comments at 22; Wi-Fi Alliance Comments at 28.

52 Google Comments at 36-37; Microsoft Comments at 29-33; Motorola Solutions Comments at 10-11; WhiteSpace Alliance Comments at 23; Wi-Fi Alliance Comments at 33-34.

and WMTS Coalition, however—including proposals to exclude WSDs from Channel 37 in all rural areas and to adopt large separation distances rather than adjacent-channel emission limits for WSD operations on adjacent Channels 36 and 38—are not necessary to protect RAS incumbents and would needlessly foreclose consumer broadband access.

A. The Commission Should Use Models that Approximate Real-World Path Loss in Calculating WMTS Separation Distances.

Broadcom's comments demonstrate that fixed and Mode I and Mode II personal/portable WSDs can operate on Channel 37 at smaller separation distances than the Commission has proposed without causing harmful interference to WMTS operations.[53] Broadcom uses the WINNER + Urban Micro propagation model to show that for personal/personal WSDs operating at 40 mW EIRP, a co-channel separation distance of less than the 300 m proposed by the Commission[54] is appropriate to protect a WMTS receiver along the perimeter of the facility.[55] The use of the WINNER + model for calculating exclusion zones will provide sufficient protection for WMTS while allowing efficient, opportunistic use of WSDs in more locations. If the Commission continues to use its proposed TM-91-1 propagation model, it should adopt the smallest of its separation distances (300 m) for all WSD operations.

Microsoft believes that the WINNER + channel model is the appropriate model in this context. WINNER + builds on the WINNER I and WINNER II channel models. WINNER I creates an IEEE 802.11n channel model that covers the following propagation scenarios: indoor, typical urban micro-cell, typical urban macro-cell, suburban macro-cell, rural macro-cell, and stationary feeder link. WINNER II expanded the propagation scenarios covered to include:

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53 *See* Microsoft Comments at 20-22.

54 *Part 15 NPRM* at 12,282 ¶ 112.

55 *See* Broadcom Comments at 24.

indoor-to-outdoor, outdoor-to-indoor, bad urban micro-cell, bad urban macro-cell, and moving network scenario. WINNER + extends these models from 2 to 6 GHz down to 450 MHz. The WINNER + Urban Micro propagation model is used to model the propagation between antennas at rooftop levels and outdoor devices at ground level. This is analogous to the real-world operating environment for WMTS systems, many of which are likely to be located above ground level in multi-floor medical facilities, as well as for WSDs, many of which will operate at ground level. Using WINNER +, Broadcom determined that the co-channel separation distance required between a WSD and a WMTS receiver located at the perimeter of a medical facility is 65 m. Broadcom then adds a safety margin to that number to arrive at a proposed separation distance of 200 m.[56] Microsoft has examined Broadcom's analysis and agrees with its conclusion that a separation distance of 200 m is sufficient to prevent harmful interference to WMTS operations.

The *Part 15 NPRM* relies on the TM-91-1 model instead of WINNER +. A paper entitled "Propagation in Suburban Areas at Distances less than Ten Miles" presented the TM-91-1 model.[57] This model predicts median field strength levels within ten miles of a transmitter, taking into consideration frequency, distance, transmitting and receiving antenna heights, and building penetration losses. Test data in the original paper validate the model for a receiving antenna up to 27 feet above ground level and for distances between transmitting and receiving antennas of between 300 feet (91 m) and 2300 feet (700 m).[58] While the authors make clear that

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[56] *Id.* at 24-25.

[57] William Daniel and Harry Wong, *Propagation in Suburban Areas at Distances less than Ten Miles*, Federal Communications Commission Office of Engineering and Technology, FCC/OET TM 91-1, Jan. 25, 1991, *available at* http://transition.fcc.gov/oet/info/documents/technical/tm91-1.pdf.

[58] *Id.* at 4-5.

"[s]trictly speaking" the applicable range of field strength equations is 1 mile (1.6 km), they state that the model "can be assumed to be approximately valid for distances up to 10 miles."[59] Additionally, the authors conclude that "the upper limit on antenna height is 300 feet or until the free space field strength is reached."[60]

Microsoft believes that the FCC should use the WINNER + Urban Micro model rather than the TM-91-1 model for calculating the co-channel separation distances for personal/portable WSDs operating at 40 mW and at 100 mW. However, if the FCC does use the TM-91-1 model, it should use the smallest of the calculated separation distances (300 m) for all personal/portable WSD operations of 40 mW and 100 mW, which Broadcom's analysis demonstrates is feasible while still protecting WMTS.

For proposed separation distances of greater than 1 km in the table in paragraph 112 of the *Part 15 NPRM*, Microsoft supports the use of a terrain-based model like Longley-Rice.[61] The Longley-Rice model predicts long-term median transmission loss over irregular terrain relative to free-space transmission loss. The model was originally designed for path lengths between 1 km and 2000 km, and while a number of improvements have been made over the intervening years, it may not be valid for short distances. However, it would be appropriate for

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59 *Id.* at 6.

60 *Id.*

61 A.G. Longley and P.L. Rice, *Prediction of Tropospheric Radio Transmission Loss Over Irregular Terrain: A Computer Method*, ESSA Tech. Report ERL 79-ITS 67, July 1968, *available at* http://www.dtic.mil/cgi-bin/GetTRDoc?AD=AD0676874; G.A. Hufford, A.G. Longley, and W.A. Kissick, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, NTIA Report 82-100, Apr. 1982, *available at* http://www.ntia.doc.gov/files/ntia/publications/ntia_82-100_20121129145031_555510.pdf.

the FCC to apply Longley-Rice in calculating separation distances of greater than 1 km, beyond the strictly applicable range of the TM-91-1 model.

B. GEHC's Testing Inappropriately Used Test Transmitters with Weak Signals that Do Not Reflect Real-World WMTS Device Operations.

GEHC submitted a report regarding testing it conducted using WSDs and test WMTS transmitters at Inova Mount Vernon Hospital in Virginia ("Inova").[62] GEHC's filing purports to show that WSDs will interfere with WMTS systems when operating at the power levels, separation distances, and antenna heights proposed by the Commission.[63] The FCC should not rely on the analysis GEHC draws from this test because it depends on inappropriate assumptions.

Importantly, GEHC's results depend on received power levels for WMTS test signals that are substantially weaker than those of the actual WMTS transmitters in use at Inova. But GEHC fails to explain this discrepancy. The spectrum analyzer figures from GEHC's test report show that the received signal strength for a majority of ***live*** WMTS transmitters reached between approximately -33 dBm and -50 dBm.[64] However, the received signal strength for the GEHC ***test*** transmitters ranged only from -56.52 dBm to -46.43 dBm,[65] far weaker than the received signal strength of the actual transmitters. Notably, GEHC only reports the received signal level for one of the three WMTS antenna fields.[66] The received power at the other two WMTS antenna fields could therefore be higher than the received power depicted in Figure 9 for Antenna Field B. The difference in the received power between GEHC's test transmitters and

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62 Comments of GE Healthcare at 25 ("GEHC Comments").

63 *Id.* at 26.

64 *Id.* at Appendix A at 4-5 (see figs. 1-3).

65 *Id.* at Appendix A at 11.

66 *Id.*

the actual WMTS transmitters in operation would more than compensate for the reductions in power of between 3 dB and 9 dB that GEHC claims are necessary to avoid interference.[67]

GEHC also admits that it intentionally placed all of its test transmitters at line-of-sight or partial line-of-sight locations, even if actual Inova transmitters were not in line-of-sight locations.[68] While some percentage of WSDs could operate within line-of-sight of WMTS facilities, a test that places all transmitters in these positions will not produce reliable results. As Microsoft, Google, and Broadcom all noted in their comments in this proceeding, WMTS analysis must account for that fact that non-line-of-sight situations will be extremely common, and, in fact, many WMTS deployments will be located in urban areas where buildings, foliage, and other clutter will act to attenuate most WSD signals.[69] The Commission cannot base its rules for WSD operation upon a study that completely ignores non-line-of-sight situations.

Where WSDs do operate within line-of-sight of WMTS facilities, a TV white space ("TVWS") database can make appropriate adjustments to available channels and operating power to ensure that WSDs do not cause harmful interference to WMTS licensees. Indeed, GEHC itself has proposed a more nuanced approach to the calculation of WMTS separation distances that would account for whether a WSD is within line-of-sight of a WMTS facility and apply an appropriate model for propagation loss.[70] As GEHC notes, a more nuanced approach "offers the benefit of yielding separation distances that can vary according to the situation and change over time," both providing adequate protection for WMTS operators and maximum

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67 *See id.* at Appendix A at 12.

68 *Id.* at 26.

69 Broadcom Comments at 23-24; Google Comments at 21-22; *see also* Microsoft Comments at 20-21.

70 GEHC Comments at 27-28.

spectrum availability and flexibility for WSDs.[71] Even GEHC's own tests show that at some line-of-sight locations at separation distances only slightly greater than 300 m, a WSD did not cause harmful interference to WMTS.[72] This test result suggests that it will be possible to reduce the separation distance for non-line-of-sight WSDs while still providing adequate protection for WMTS.

Using such an approach for calculating separation distances would enable both fixed and personal/portable WSDs to operate in Channel 37 while protecting WMTS. GEHC argues that only fixed WSDs should be allowed to operate on Channel 37, questioning the security and reliability of databases[73] (despite the fact that the Commission has ruled that they are secure and reliable in previous orders). Contrary to GEHC's claims, the Commission now has several years of experience with database operations and fixed devices that demonstrate that database technology works.

Databases will provide protection in the context of personal/portable devices in the same manner as they do for fixed devices. As Microsoft noted in its comments, incumbent operations on Channel 37 will be protected from operations of Mode I personal/portable WSDs in the same way they are protected from fixed and Mode II personal/portable WSDs.[74] Although a Mode I device does not have geolocation capabilities, it must communicate with a fixed or Mode II personal/portable device in order to obtain a list of available channels from the database. Without database approval through communications with fixed or Mode II WSDs, Mode I WSDs are not able to operate because it will appear to the devices that there are no channels available in

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71 *Id.*

72 *Id.* at Appendix A at 12 (see Table 4).

73 *Id.* at 28-30.

74 Microsoft Comments at 26-28.

the area. Personal/portable WSDs pose no greater threat to Channel 37 incumbents than fixed WSDs. The Commission should therefore allow the operation of all three types of devices in Channel 37.

Curiously, GEHC also placed three of its four WMTS test transmitters on the top two floors of Inova—two transmitters on the sixth floor (the top floor at Inova), one transmitter on the fifth floor, and only one transmitter on the first floor.[75] There is no indication of why GEHC chose such a distribution, whether this is consistent with the actual distribution at Inova, or if it reflects a real-world environment. If this distribution is not shown to be realistic, it further undermines the legitimacy of the results, because testing transmitters that are placed to maximize line-of-sight to TVWS will show unrealistically low propagation losses.

C. The Testing Conducted by Comsearch Does Not Accurately Represent Real-World Propagation Loss.

In addition to the GEHC tests discussed, above, GEHC also attaches to its comments a study by Comsearch on path loss between WSDs located at various distances from Inova—but all within line-of-sight of the hospital—and WMTS transmitters. Comsearch concluded that "path loss values could be measured that were between 0.2dB and 9.85 dB of calculated free space loss."[76] However, the results of Comsearch's path loss tests, like GEHC's tests discussed above, do not represent real-world operating conditions. The Commission should not rely upon these highly distorted results in estimating the likely path loss between WSDs and WMTS transmitters.

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[75] GEHC Comments at Appendix A at 6-7.

[76] *Id.* at Appendix B at 4.

Comsearch placed victim WMTS test transmitters in exterior rooms or hallways on the fifth and sixth floors of the hospital right next to large windows.[77] As Google has pointed out in its comments, many hospital facilities are built using dense, industrial-grade supplies that typically result in greater signal attenuation than most buildings.[78] Placing all the WMTS antennas next to windows likely resulted in a serious underestimation of the impact of building loss. This error is likely compounded by the fact that the WMTS antennas are shown in pictures to be located on a cart, presumably pointed in the direction of the specific WSD test site and aligned to maximize the received signal.[79] In actual WMTS deployments, however, Microsoft understands that WMTS distributed antennas are built into hospital walls and ceilings, likely resulting in a different antenna gain than the Comsearch test transmitters on carts. A test set-up that uses directional antennas on carts pointed out of hospital windows directly at WSDs does not accurately represent how WSDs and WMTS transmitters are likely to operate in the real world. Such a test set-up significantly underestimates the likely path loss and signal attenuation.

Moreover, rather than performing the tests using the conducted power of a commercially available fixed TVWS radio with an omnidirectional antenna, Comsearch created a scaled-down microwave beam produced by a signal generator and amplified by a directional log-periodic antenna.[80] This resulted in underestimating path loss in two important ways. *First*, Microsoft would have expected Comsearch to use filters in front of the simulated WSD antenna to account for body loss and polarization mismatch. Failing to use such filters renders the simulated WSD

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77 *Id.* at Appendix B at 28, 40, 52, 62, 70, 81, 92, 103, 114.

78 Google Comments at 21.

79 GEHC Comments at Appendix B at 28, 40, 52, 62, 70, 81, 92, 103, 114.

80 *Id.* at Appendix B at 9, 13.

transmission only a loose representation of actual WSD operations and underestimates propagation loss.

Second, Comsearch also used a focused beam antenna which likely further underestimated path loss. The 10 dBi Kathrein Scala Division CL-1469B[81] directional UHF-TV log-periodic antenna's azimuth and elevation patterns indicate a focused beam not typical of portable-use antennas. Comsearch simulated a 40 mW EIRP WSD scaled to 100 kHz by reducing the conducted power emitted from a signal generator connected over a cable to that directional log-linear antenna. While the power emitted by the log-linear antenna is equivalent to that emitted by the isotropic WSD device at the point of transmission, the focusing effect of the antenna makes the two spread out differently as the distance increases from the antenna. A log-linear antenna with line-of-sight to the WMTS receiver will produce a narrower beam that spreads less than the beam produced by an omnidirectional antenna. Depending on the radius of the WSD simulated beam to the radius of the first Fresnel zone, and the presence and location of any obstructions, the path loss along the line-of-sight path may appear more "free-space"-like than using a model with clutter.[82] The narrow beam width likely resulted in further underestimating the real-world path loss, as a focused beam would miss the attenuating effect of trees and other ground clutter, even in line-of-sight environments, due to Fresnel zone obstruction.

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81 *See* Kathrein Scala Division CL-1469B Data Sheet, *available at* http://www.kathrein-scala.com/catalog/CL-1469B.pdf.

82 The key parameters to calculate the radius of the first Fresnel zone are frequency (610.2 MHz) and distance. The maximum radius of the first Fresnel zone is half the distance between the transmit and receive antennas. If the radius of the transmitted beam is unobstructed within 60 percent of the first Fresnel zone radius, then the path loss approaches that of free space.

D. The Commission Should Reject Calls to Establish Exclusion Zones for RAS that Are Larger than Necessary to Protect RAS Operations.

NAS's proposal to establish separation distances that are specific to each VLBA facility is reasonable, and the FCC should adopt it with an adjustment to permit WSD operation in areas where there is no threat to VLBA operations.[83] To calculate the specific separation distances it proposes, NAS used the Longley-Rice Irregular Terrain Model.[84] Microsoft supports the use of terrain-based modeling in calculating separation distances for Channel 37 incumbents, and welcomes NAS's proposal to reduce the separation distances proposed in the *NPRM* by calculating facility-specific exclusion zones. NAS's proposal could be further improved by adopting the bearing-dependent exclusion zone calculation method proposed by Google.[85] Google's proposed method not only takes into account variations in the terrain, but also accounts for terrain variations in each direction and allows the database to adjust spectrum availability and operating power for WSDs accordingly.[86] The Commission should adopt terrain-based modeling as proposed by both NAS and Google, but should allow the database to account for bearing when calculating separation distances.

NAS also proposes, however, to prohibit WSD operations in all rural areas and in areas where more than 10 percent of the TV channels are unused for broadcast services.[87] This proposal is extreme and unnecessary to protect RAS operations. It would unnecessarily limit the

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83 Comments of the National Academy of Sciences' Committee on Radio Frequencies at 7-8, ET Docket No. 14-165 ("NAS Comments").

84 *Id.* at 8.

85 Google Comments at 29-30, Appendix C, Declaration of Andrew W. Clegg, Ph.D., at 4-6 ¶¶ 8-9.

86 *Id.*

87 NAS Comments at 6-7.

spectrum available for WSDs in the vast majority of the country where there is no risk of causing harmful interference to RAS operations. Banning consumer broadband using WSDs in every rural community in the nation is not necessary to prevent harmful interference to the small number of geographically limited RAS incumbents. The Commission can easily protect these incumbents using rational database-enforced exclusion zones based on the incumbent facility's location.

A nationwide ban on rural operations would be particularly damaging because WSDs have real promise for improving rural broadband availability. NAS's proposal would therefore undermine the Commission's goal of expanding broadband access in rural areas using TVWSs. The FCC recognized in the *Part 15 NPRM* the importance of expanding the spectrum available for WSDs and adopting technical rules that would facilitate the provision of broadband service in rural areas.[88] The Commission should not prevent WSDs from providing much-needed broadband service in rural areas by adopting a blanket prohibition on their use.

E. The FCC Should Reject Calls to Apply Overly Stringent Separation Distances on Channels 36 and 38 Rather than Adjacent-Channel OOBE Limits.

NRAO and WMTS Coalition both argue that the Commission should adopt large separation distances for WSDs operating on Channels 36 and 38—adjacent to Channel 37 incumbent RAS and WMTS operations—rather than rely primarily on adjacent-channel OOBE limits as proposed in the *NPRM*.[89] WMTS Coalition calls for the Commission to apply the same separation distances and power limits in Channels 36 and 38 that it applies in Channel 37, rather than adopting the much smaller adjacent-channel WMTS separation distances proposed in the

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[88] *See Part 15 NPRM* at 12,255-58 ¶¶ 22-32, 12,261-64 ¶¶ 44-53.

[89] *Id.* at 12,286 ¶ 128.

NPRM, combined with an adjacent-channel emissions limit.[90] NRAO proposes separation distances of between 16 and 100 km between adjacent-channel WSD operations and single-dish radio astronomy observatories.[91] NRAO's proposed distances are not based on propagation models, but have been reverse-engineered from OOBE limits "inferred from the difference between proposed adjacent band operations at 2.4 km separation (the present default for TVWS) and the distances for in-band operation."[92]

Neither WMTS nor RAS interests have demonstrated that such large separation distances are necessary to protect their systems from adjacent-channel WSD operations. In the absence of a solid technical analysis showing that such separation distances are required, the Commission should adopt its proposal in the *NPRM* to use small separation distances to protect WMTS licensees, combined with adjacent-channel emission limits to protect all Channel 37 incumbents. If the Commission were to rely on separation distances to protect RAS from adjacent-channel WSD operations, it should use bearing-dependent, terrain-based modeling to calculate the relevant distances, as proposed by Google, not the reverse-engineered calculations proposed by NRAO.

Importantly, the large adjacent-channel separation distances proposed by WMTS Coalition, if required to protect WMTS from adjacent-channel WSD operations, would also preclude several of the Commission's proposed band plans. In several of the Commission's band plans, a television broadcaster (presumably operating at 1 MW) would operate on Channels

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90 Initial Comments of the WMTS Coalition at 25-27 ("WMTS Coalition Comments"); *see also Part 15 NPRM* at 12,282-83 ¶ 112, 12,286 ¶ 128.

91 Comments of the National Radio Astronomy Observatory at 3-4 ("NRAO Comments") (filed Nov. 24, 2014).

92 *Id.* at 3-4.

36 and 38, immediately adjacent to Channel 37 WMTS operations.[93] Specifically, in scenarios where 42, 48, 60, 72, 78, or 84 MHz of spectrum is recovered, a television broadcaster would operate immediately adjacent to Channel 37.[94] Although WMTS Coalition acknowledges that some WMTS transmitters operate immediately adjacent to TV broadcast operations today, it argues that only these existing systems employ filtering necessary to reject signals from adjacent-channel TV licensees.[95] Other WMTS systems "typically are not capable of such filtering."[96]

If WMTS Coalition is correct that the separation distances proposed for WSD use on Channel 37 itself are also necessary for adjacent-channel WSD operation, this would also mean that the adjacent channels could not be used for high-powered TV broadcasters except in locations where such broadcasters already operate. This, in turn, would render six out of the Commission's eleven proposed band plan scenarios untenable because they rely on allowing TV broadcasters to operate in Channels 36 and 38. The Commission should therefore reject WMTS Coalition's proposal to apply the Channel 37 WSD separation distances to Channels 36 and 38.

IV. THE PROPOSALS BY WIRELESS MICROPHONES RELATING TO USE OF THE GUARD BANDS, DUPLEX GAP, AND OTHER SHARED 600 MHZ SPECTRUM WOULD RESULT IN INEFFICIENT SPECTRUM USE AND INCREASE INTERFERENCE RISK TO INCUMBENTS.

The FCC should reject calls by wireless microphone interests for higher power microphone operations in the guard bands and duplex gap, as well as arguments that unlicensed wireless microphones should not be required to access the database or bear their share of the

93 *See Incentive Auction Order* at 7017-18, Appendix C ¶¶ 116-19.

94 *Id.*

95 WMTS Coalition Comments at 26 n.46.

96 *Id.*

costs for database use. Also, in the wake of the Commission's extraordinary expansion of eligibility for Part 74 licenses, it should reject calls to allow certain classes of unlicensed wireless microphone operators to continue to make reservations in the databases.

Wireless microphone interests state that the 20 mW power limit proposed in the *NPRM*[97] is too low to facilitate wireless microphone operation in the guard bands and duplex gap.[98] But as the Commission has noted, many wireless microphones operate at power levels between 10 and 20 mW today.[99] Wireless microphone interests argue that the Commission should instead allow 50 mW wireless microphone operations in the guard bands and duplex gap,[100] 10 mW more power than the 40 mW the Commission proposes to authorize for WSDs.

Wireless microphone interests do not adequately address the Commission's concern that because multiple wireless microphones may operate on one 6 MHz channel, the Commission's power limit for wireless microphone operations must account for the aggregate power and greater interference risk of multiple wireless microphones.[101] There are no analyses on the record studying whether allowing 50 mW wireless microphone operations adjacent to LTE would result in harmful interference to licensees.

Wireless microphone proponents assert that higher powers are necessary in order to prevent interference to wireless microphone operations.[102] However, wireless microphone

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97 *Part 15 NPRM* at 12,296 ¶ 160.

98 *See, e.g.*, Comments of Audio-Technica U.S., Inc., at 10 ("Audio-Technica Comments"); Comments of Sennheiser Electronic Corporation at 15, 17-18 ("Sennheiser Comments"); Comments of Shure Incorporated at 19 ("Shure Comments").

99 *Part 15 NPRM* at 12,296 ¶ 160.

100 Sennheiser Comments at 15, 17-18; Shure Comments at 19-20.

101 *Part 15 NPRM* at 12,296 ¶ 160.

102 Audio-Technica Comments at 10; Shure Comments at 19-20.

interests' own comments undermine this assertion. Wireless microphone proponents argue that they can operate with as little as 100 kHz separation from LTE licensees.[103] This suggests that interference from adjacent licensees is not as great a concern for wireless microphone operations as some have argued in comments seeking higher authorized power limits.

Wireless microphone proponents also argue that unlicensed wireless microphones operating in guard band and duplex gap spectrum should not be required to access the database.[104] For the reasons already set forth by Microsoft[105] and a variety of other commenters in this proceeding,[106] the FCC should reject this argument. The Spectrum Act clearly requires all unlicensed users of the guard bands and duplex gap to rely on a database. And, as a practical matter, wireless microphones will need this capability in order to provide adequate protection for incumbent operations.

The Commission should also reject calls by wireless microphone interests to exempt wireless microphones from paying database fees. Audio-Technica, Sennheiser, and Shure all argue that the wireless microphones should not be required to pay database fees.[107] However, they provide no compelling explanation as to why such users should not be required to pay a fee just like WSD users that rely on database access to protect incumbent operations. In Microsoft's view, not only unlicensed wireless microphone users but licensed wireless microphone users that

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[103] Sennheiser Comments at 14-15; Shure Comments at 15-16.

[104] Audio-Technical Comments at 11-12; Comments of CP Communications LLC at 4; Sennheiser Comments at 15-17; Shure Comments at 16-19.

[105] Microsoft Comments at 36-38.

[106] Comments of Mobile Future at 6-7; Wi-Fi Alliance Comments at 38-39.

[107] Audio-Technica Comments at 12-13; Sennheiser Comments at 20; Shure Comments at 32-33.

are able to register for database protection (particularly licensed wireless microphones used for Electronic News Gathering ("ENG") operations) should also be required to pay a fee for database access. The Commission has proposed to increase the database re-check requirement to twenty minutes—imposing significant costs on TVWS network operators and database providers—largely to protect occasional and geographically limited wireless microphone use for ENG operations.[108] It is therefore only reasonable that these entities, wireless microphone users that derive economic benefit from the protections the database affords and who have paid nothing for their access to the band, should also be required to contribute to the cost of operating the databases.

Many wireless microphone proponents argue that the Commission should continue to allow certain classes of unlicensed wireless microphone users to register for protection in the database, including those operating fewer than the fifty wireless microphones necessary to qualify for a Part 74 license.[109] But wireless microphones cannot have their cake and eat it too. The Commission permitted an extraordinary (and generous, in light of previously illegal behavior) expansion of eligibility for Part 74 "to include professional sound companies and the owners and operators of large venues that routinely use 50 or more wireless microphones."[110] In expanding eligibility, the Commission sought to recognize the needs of wireless microphone operators at large venues that use many microphones and require database protection with the needs of 600 MHz WSDs that also need spectrum on which to operate—even though this would

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[108] *Part 15 NPRM* at 12,306 ¶ 190.

[109] *See, e.g.*, Sennheiser Comments at 19-20; Shure Comments at 30-32; Comments of the Performing Arts Wireless Microphone Working Group at 2.

[110] *Part 15 NPRM* at 12,305 ¶ 186.

deny access to spectrum for wireless broadband consumers. The Commission settled on fifty wireless microphones as the cut-off for database protection, concluding that this number struck the right balance between stakeholders.[111] The Commission should not undo that careful balance now by allowing venues with smaller numbers of microphones that are not eligible for Part 74 licenses to nevertheless register for database protection, and thereby deny even more broadband consumers access to spectrum. This would also exacerbate the risk that consumers will be shut out from vacant TV channels by overly broad wireless microphone reservations that do not protect active wireless microphone operations, but instead are merely efforts by squatters permanently to preserve open channels, resulting in inefficient spectrum warehousing.

V. THE RECORD SUPPORTS THE ADOPTION OF TVWS RULE CHANGES THAT WILL FOSTER THE WIDESPREAD DEVELOPMENT OF 600 MHZ WSD OPERATIONS.

The record in this proceeding supports the adoption of the FCC's proposals to change the TVWS rules in ways that will expand the TV band spectrum available for WSDs and give WSD manufacturers and network operators increased flexibility. The only opponents to such rule changes provide absolutely no technical support for their view that the proposed changes would result in harmful interference to TV broadcasters or wireless microphone operations.

Among other changes, the FCC has proposed (1) to expand the spectrum available for WSD use below Channel 21;[112] (2) to allow fixed WSDs to operate where there are two vacant

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[111] *Revisions to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band*; *Public Interest Spectrum Coalition, Petition for Rulemaking Regarding Low Power Auxiliary Stations, Including Wireless Microphones, and the Digital Television Transition*; *Amendment of Parts 15, 74 and 90 of the Commission's Rules Regarding Low Power Auxiliary Stations, Including Wireless Microphones*, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, Second Report and Order, FCC 14-62, 29 FCC Rcd. 6103, 6107 ¶¶ 8-9 (2014).

[112] *Part 15 NPRM* at 12,257-58 ¶¶ 30-31.

TV channels instead of three;[113] (3) to allow higher power WSD operations and higher antenna heights in rural areas;[114] and (4) to relax the ±50 m geolocation accuracy requirement, provided that WSDs provide equivalent protection for incumbent operations.[115]

The majority of commenters favors these rule changes to foster the development of robust WSD operations in the TV bands, particularly in rural areas in order to support the provision of broadband Internet connectivity. For instance, DSA, Google, Microsoft, Spectrum Bridge, Wi-Fi Alliance, and xG Technology all support the FCC's proposal to allow personal/portable WSD operations on at least some of the vacant TV channels below Channel 21.[116] Audio-Technica, Sennheiser, and Shure, however, oppose these proposals on the grounds that such operations may cause harmful interference to licensed wireless microphone operations.[117]

Similarly, Adaptrum, Google, Microsoft, Motorola Solutions, Wi-Fi Alliance, WhiteSpace Alliance, the Wireless Internet Service Providers Association, and xG Technology support allowing fixed WSDs to operate where there are two vacant TV channels instead of

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[113] *Id.* at 12,259-60 ¶ 37.

[114] *Id.* at 12,262-64 ¶¶ 46-50.

[115] *Id.* at 12,271-72 ¶¶ 76-77.

[116] DSA Comments at 2-4; Google Comments at 37-39; Microsoft Comments at 40-41; Spectrum Bridge Comments at 3; Wi-Fi Alliance Comments at 9-11; Comments of xG Technology, Inc., at 6 (filed Feb. 6, 2015) ("xG Technology Comments").

[117] Audio-Technica Comments at 16-17; Sennheiser Comments at 10; Shure Comments at 23-25.

three,[118] while only the National Association of Broadcasters and Shure oppose that proposal.[119] Wireless microphone interests, including Audio-Technica, Sennheiser, and Shure, oppose allowing higher power WSD operations with higher antenna heights in rural areas,[120] while the majority of other commenters supports the proposal.[121]

Furthermore, DSA, Google, Microsoft, Motorola Solutions, Spectrum Bridge, and Wi-Fi Alliance support relaxing the geolocation requirement on the condition that WSDs continue to provide the same protection for licensees.[122] Only Sennheiser opposes this proposal.[123]

The opponents of these helpful and reasonable proposals—wireless microphone interests and broadcasters—provide no technical support to substantiate their claims that these rule changes would cause harmful interference to broadcasters or licensed wireless microphone operations. In the absence of such support, it appears that wireless microphone interests simply seek to exclude WSDs in order to have exclusive access to more spectrum rather than sharing

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[118] Google Comments at 43-44; Microsoft Comments at 45-46; Motorola Solutions Comments at 5; Wi-Fi Alliance Comments at 13-14; WhiteSpace Alliance Comments at 10; WISPA Comments at 8; xG Technology Comments at 6.

[119] Comments of the National Association of Broadcasters at 8-11; Shure Comments at 26-27.

[120] Audio-Technica Comments at 15; Sennheiser Comments at 11; *see also* Shure Comments at 28-29.

[121] Adaptrum Comments at 4-5; DSA Comments at 6-7; Google Comments at 46; Microsoft Comments at 46-47; Motorola Solutions Comments at 5-7; Wi-Fi Alliance Comments at 15-16; WhiteSpace Alliance Comments at 12-14; WISPA Comments at 13-16; xG Technology Comments at 7.

[122] DSA Comments at 12-13; Google Comments at 39-43; Microsoft Comments at 41-43; Motorola Solutions Comments at 4; Spectrum Bridge Comments at 6; Wi-Fi Alliance Comments at 23-24.

[123] Sennheiser Comments at 11.

it.[124] The FCC should reject such unsupported and self-serving arguments. This is particularly true when experience with WSD operations up to this point demonstrates that WSDs can provide adequate protection for licensed wireless microphone operations and broadcasters using the databases. Adjusting the technical rules as proposed to allow a greater variety of WSD operations, even those at higher power or antenna limits, will not increase the risk of harmful interference to licensees.

VI. CONCLUSION.

For the foregoing reasons, Microsoft respectfully requests that the Commission (1) allow fixed and personal/portable WSDs to operate in the duplex gap and 9 and 11 MHz guard bands at power levels up to 100 mW; (2) allow fixed and personal/portable WSDs to operate on Channel 37 subject to reasonable terrain-based separation distances to protect incumbents; (3) allow WSDs to operate on Channels 36 and 38 subject to the proposed adjacent-channel emission limits and WMTS adjacent-channel separation distances; (4) adopt technical rules for wireless microphone operations in the guard bands and duplex gap that comply with Spectrum Act requirements, foster shared use of spectrum, and adequately compensate database providers; and (5) adopt the revisions to the WSD technical rules discussed herein to ensure adequate spectrum resources for WSDs, facilitate the deployment of rural broadband networks, and encourage the development of a vibrant ecosystem of WSD operations in the 600 MHz band.

[124] *See, e.g.*, Sennheiser Comments at 10 (opposing the Commission's proposal to allow personal/portable white space devices to operate on channels 14-20 on the grounds that this would reduce the spectrum available for wireless microphones).

Respectfully submitted,

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