

**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 GOOGLE INC.

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I. Introduction and Summary

The record shows that the Commission's proposals for technical rules governing Part 15 devices in the 600 MHz band generally strike the right balance. These proposals would allow low-power unlicensed operations in the duplex gap, guard bands, and channel 37. They protect incumbents not only through strict power restrictions, but also through spectral separation and database systems that govern unlicensed devices in geographic areas where they otherwise might cause harmful interference to licensees. As outlined in our initial comments, Google generally supports the Commission's proposals. We also suggest certain improvements to further open the band to innovative unlicensed operations without impinging on licensees' rights.

Many other commenters agree with Google that the FCC's interference-protection proposals effectively protect (and sometimes overprotect) licensees. Specifically, the technical analyses of Broadcom, Microsoft, and Google support the FCC's tentative conclusions that it can permit 40 mW unlicensed operations in the duplex gap, 9-MHz-or-larger guard bands, and channel 37 without causing harmful interference to licensees. Furthermore, these analyses show that the FCC can permit fixed, Mode 1, and Mode 2 TV white space device ("WSD") operations in each of these spectral locations.

Qualcomm, CTIA, and GE Healthcare ("GEHC"), however, continue to argue that even low-power unlicensed operations will cause harmful interference to licensees. As in prior rounds of briefing, these parties attempt to support their positions with analyses that depend on faulty assumptions and unrealistic test designs. As shown below:

- Qualcomm's latest study addressing interference to LTE includes many of the same flaws found in its earlier submissions, including a failure to account for many sources of attenuation, use of an inappropriate separation distance, dependence on unrealistic testing conditions, and use of an inappropriate benchmark for determining harmful interference.

- CTIA, like Qualcomm, fails to account for relevant sources of attenuation, proposes an inappropriate separation distance, tests receiver performance using flawed test conditions, and references an incorrect benchmark for determining harmful interference.
- GEHC tested interference using unrepresentative test signals at a site with an atypically low noise floor, and failed to account for non-line-of-sight scenarios.

These unreliable analyses cannot support the drastic changes to the Commission's proposals that Qualcomm, CTIA, and GEHC seek. Reductions in maximum power, draconian out-of-band emissions masks, and huge exclusion zones are not necessary to protect licensees and would strangle unlicensed operations in the 600 MHz band.

Wireless microphone manufacturers call on the Commission to remove various restrictions on microphone operations without examining the potential for interference to LTE, while piling restrictions—and costs—onto users of unlicensed WSDs. They do so without submitting a technical study supporting these assertions. Consistent with the record evidence, the Commission should adopt its own proposals to permit unlicensed devices in rural areas to operate at higher power levels and antenna heights, permit unlicensed devices to operate on channels below 21, and require unlicensed wireless microphones to use a database to determine their permissible channels of operation. It should reject the wireless microphone industry's unsubstantiated request to increase power limits imposed on wireless microphones and to prohibit unlicensed operations in areas with fewer than three vacant channels.

If the Commission establishes reasonable technical rules that protect licensees against legitimate threats of harmful interference while avoiding unnecessary over-protection, it will produce a 600 MHz band where LTE, WMTS, radio astronomy, wireless microphones, and unlicensed networks can all thrive.

II. The Record Demonstrates that Unlicensed White Space Devices Can Operate in the Duplex Gap and Guard Bands at 40 mW without Causing Harmful Interference

The majority of commenters agree with the Commission's proposal to permit 40 mW WSD operations in the duplex gap and in 9-MHz-or-larger guard bands.¹ Of particular note, the new study described in Broadcom's comments deepens its previous technical work and further demonstrates that unlicensed WSDs can coexist alongside LTE in both the duplex gap and guard bands under the Commission's proposed operating parameters. In fact, Broadcom's analysis indicates that the Commission could authorize unlicensed operations at significantly higher powers, and with less spectral separation between unlicensed devices and LTE downlink operations, than the NPRM suggests.² However, in Google's view, even Broadcom's analysis incorporates assumptions that substantially underestimate real-world filter performance and the impact of several sources of propagation loss.³

Qualcomm and CTIA have submitted analyses that they maintain demonstrate that unlicensed use of these bands will cause harmful interference to LTE operations unless the

¹ See Comments of Adaptrum, Inc. at 6, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("Adaptrum Comments"); Comments of the Dynamic Spectrum Alliance at 8-9, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("DSA Comments"); Google Comments at 4; Comments of Microsoft Corporation, at 5, 14, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("Microsoft Comments"); Comments of Motorola Solutions, Inc. at 8-9, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("Motorola Comments"); Comments of WhiteSpace Alliance at 20-22, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("WhiteSpace Alliance Comments"); Comments of Wi-Fi Alliance at 24-26, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("Wi-Fi Alliance Comments").

² Comments of Broadcom Corporation at 17-20, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("Broadcom Comments").

³ Compare Comments of Google Inc. at 6-16, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("Google Comments") with Broadcom Comments at 4-5, 12.

Commission adopts extreme and impractical technical restrictions. But—in marked contrast to Broadcom’s cautious engineering approach—these analyses rely on results-oriented assumptions the Commission rightly rejected in the NPRM.⁴ As explained below, the Qualcomm and CTIA analyses are inconsistent with each other, and those parties do not even agree on the cause of the interference they assert low-power unlicensed operations would introduce.⁵ Moreover, the Qualcomm and CTIA filings attempt to move the Commission’s interference goalposts. In asserting that a mere 1 dB reduction in receiver sensitivity represents harmful interference to LTE, Qualcomm and CTIA assume desired signals so faint that they likely would be undetectable in the real world.

A. Qualcomm’s Blocking Interference Results Are Incorrect

Qualcomm contends that the potential for blocking interference will make unlicensed operations in the duplex gap and guard bands virtually impossible. But both CTIA and Broadcom’s analyses sharply disagree with this conclusion.⁶ Qualcomm’s results are a product

⁴ 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, and 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*, Notice of Proposed Rulemaking, FCC 14-144, 29 FCC Rcd. 12,248, ¶ 84, (2014) (“NPRM”).

⁵ Compare Comments of Qualcomm Incorporated at 10-11, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) (concluding that unlicensed devices can operate at a power of only -9.0 dBm before the onset of blocking interference) (“Qualcomm Comments”) with Comments of CTIA – The Wireless Association at 20-22, Appendix B at 76, ET Docket No. 14-165, GN Docket Nos. 12-268 and 14-166 (filed Feb. 4, 2015) (concluding that an unlicensed white-space device could operate at 20.1 dBm before an LTE device suffered even 1 dB of desense interference, at a separation distance of only 1 meter) (“CTIA Comments”).

⁶ Compare Qualcomm Comments at 10-11 with Broadcom Comments at 17-20; CTIA Comments at 20-22, Appendix B at 76.

of incomplete propagation assumptions and a testing methodology seemingly designed to find “interference.”

While Qualcomm conducted empirical tests of LTE handset performance, the results of these tests played a minimal role in Qualcomm’s overall analysis. Specifically, Qualcomm’s tests measured only the power level that an LTE handset could tolerate in an adjacent band, at the LTE antenna connector.⁷ The critical relationship between these measured power levels and the corresponding transmit power of an unlicensed device is a function of assumptions about the propagation environment between the LTE and unlicensed device. Qualcomm’s assumptions here repeat its old mistakes,⁸ presenting a badly distorted picture of the true risk of harmful interference.

First, Qualcomm assumes that an LTE handset and unlicensed WSD will be separated by only 1 meter. The Commission has considered and rejected this unrealistic assumption in both the NPRM’s preliminary analysis and in prior proceedings. Instead, it has used a separation distance assumption of at least 2 meters between handsets.⁹ With this assumption alone, Qualcomm overestimates the potential for interference by at least 6 dB.

⁷ See Qualcomm Comments at 10-11, Appendix A at 1-2.

⁸ See Reply Comments of Qualcomm Incorporated on Public Notice to Supplement the Record on the 600 MHz Band Plan at 6, GN Docket No. 12-268 (May 28, 2013) (“May 2013 Qualcomm Reply Comments”).

⁹ See, e.g., *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 (2013) (“*H Block Order*”); *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

Qualcomm also fails to account for other typical sources of attenuation. Conspicuously absent from Qualcomm's analysis are any body loss (at either the transmitter or receiver), shadowing loss due to the likely presence of obstructions, or polarization mismatch loss.¹⁰ According to Broadcom's analysis, these would account for another 12 dB of attenuation,¹¹ or, according to Google's analysis, another 15 dB.¹² CTIA agrees that a reasonable set of propagation assumptions would include a total of 9 dB of attenuation from body loss at the handset and receiver, as well as antenna polarization mismatch. It is difficult to imagine the propagation environment that Qualcomm's assumptions describe: The devices are neither held in a user's hand and thus subject to body loss, nor rested on a table and thus subject to shadowing loss. Less plausible still, the devices' antennas are perfectly aligned so that there is zero loss due to polarization mismatch. Through these omissions (which by Google's calculation leave out 15 dB of attenuation) and Qualcomm's inappropriately small assumption for separation distances between devices (which leave out another 6 dB of attenuation), Qualcomm overestimates the potential for interference by at least 21 dB.

Qualcomm adds several additional dB to its assumptions to account for variability in "power supply voltage, operating temperature, and manufacturing process."¹³ Qualcomm assumes 3 dB of "production variation,"¹⁴ but provides no support for this assumption and fails to explain why this impact is not already captured in the variability inherent in its measurement

Order of Proposed Modification, FCC 12-151, 27 FCC Rcd. 16,102, 16,137-39, 16,158-59, ¶¶ 84-86, 142, 144 (2012).

¹⁰ Qualcomm Comments at 10.

¹¹ Broadcom Comments at 4-5.

¹² Google Comments at 6-7.

¹³ Qualcomm Comments at 13.

¹⁴ *Id.* at 10.

of six different phones. These factors, combined with the corrections to Qualcomm’s propagation assumptions described above, indicate that Qualcomm’s calculations likely underestimate the maximum safe operating power of unlicensed WSDs by at least 24 dB. Correcting for these erroneous assumptions increases Qualcomm’s calculated -9 dBm power limit to 15 dBm.

QUALCOMM’S ASSUMPTIONS V.
REAL-WORLD PROPAGATION ENVIRONMENT

	Qualcomm’s Assumptions (dB)	Broadcom’s Assumptions (dB)	Appropriate Real-World Assumptions (dB)
LTE Body Loss	0	3	6
Unlicensed Body Loss	0	3	3
Shadowing	0	3	3
Polarization Mismatch	0	3	3
LTE Antenna Gain	-6	-6	-6
Free-Space Propagation Loss	29	35	35
Additional “Variation”	-3	Included	Included
TOTAL ASSUMED LOSS	32	53	56

There are additional problems with Qualcomm’s analysis, moreover. In keeping with 3GPP standards,¹⁵ Qualcomm’s prior blocking analyses attempted to predict the onset of blocking interference when the desired LTE downlink signal was 6 dB stronger than the handset’s reference sensitivity (“REFSENS+6”).¹⁶ Consistent with its own work, Qualcomm did

¹⁵ See 3GPP TS 36.101 V12.6.0 § 7.6.1.1(2014-12).

¹⁶ Letter from John W. Kuzin, Senior Director, Government Affairs – Regulatory, Qualcomm Corporation, to Marlene H. Dortch, Secretary, Federal Communications Commission, Attachment at 24, GN Docket No. 12-268 (filed May 2, 2013).

not disagree with Broadcom’s choice of REFSENS+6 as a blocking standard.¹⁷ Yet, without explanation, Qualcomm abandons this standard in its latest analysis. Qualcomm now assumes that the desired signal is a mere 1 dB above the device’s reference sensitivity, (“REFSENS+1”)¹⁸—a desired signal so faint that 3GPP imposes no performance requirements at all under these circumstances.¹⁹ This is why the Commission has previously concluded that a 1 dB desensitization level is an inappropriate standard for evaluating the potential for interference with LTE 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).”²⁰

With its odd test parameters and other skewed assumptions, Qualcomm’s analysis says little about the conditions under which unlicensed devices will be able to operate in guard bands and the duplex gap. On the other hand, Broadcom’s more careful, transparent, and, in Google’s view, overly conservative analysis—along with the widespread confirmation of 40 mW operations evidenced by comments on the record²¹—strongly supports adoption of the FCC’s proposal.

¹⁷ See Letter from Dean R. Brenner, Senior Vice President, Government Affairs, Qualcomm Corporation, to Marlene H. Dortch, Secretary, Federal Communications Commission, at 2 GN Docket No. 12-268 (filed Aug. 5, 2014); Letter from John W. Kuzin, Senior Director, Government Affairs – Regulatory, Qualcomm Corporation, to Marlene H. Dortch, Secretary, Federal Communications Commission, Attachment at 24, GN Docket No. 12-268 (filed May 2, 2013).

¹⁸ Qualcomm Comments at 9, Appendix at A-2.

¹⁹ See generally, 3GPP TS 36.101 V12.6.0 (2014-12).

²⁰ *H Block Order* at 9537 ¶ 144.

²¹ See *supra* n. 1.

B. *CTIA's Out-of-Band Emissions Results Are Unreliable*

CTIA argues that unlicensed devices can operate alongside LTE downlink in the guard bands and duplex gap only if they are subject to a draconian out-of-band emissions mask.²² Like Qualcomm's submission, CTIA's analysis measures the strength of an unlicensed white-space signal at the LTE handset's antenna connector.²³ Thus, like Qualcomm, CTIA did not actually measure the relationship between unlicensed transmit power and the onset of interference, but rather derived power limits from its measurements at the antenna connector and a variety of assumptions.

As with Qualcomm's submission, CTIA's analysis inappropriately assumes, without explanation, that the unlicensed WSD and LTE handset will be separated by only 1 meter.²⁴ CTIA's remaining propagation assumptions, however, are inconsistent with Qualcomm's. While Qualcomm assumed that propagation of an unlicensed signal would be attenuated by the LTE antenna, but not by body loss or polarization mismatch, CTIA assumes that propagation would be subject to body loss as well as polarization mismatch loss, but not antenna loss.²⁵

Like Qualcomm, CTIA fails to acknowledge the likely presence of obstructions, causing it to omit shadowing loss.²⁶ And while CTIA included body loss at the LTE receiver, it assumed that this would account for only 3 dB of loss. Body loss of 6 dB is a more appropriate

²² CTIA Comments at 11-22.

²³ *Id.*, Appendix B at 4.

²⁴ *Id.* at 10.

²⁵ *Id.* at 9-10.

²⁶ *Id.*; Qualcomm Comments at 10.

assumption.²⁷ The combined effect of these missing and incorrect assumptions is that CTIA underestimates the applicable unlicensed power limit by at least 18 dB.

CTIA’S ASSUMPTIONS V.
REAL-WORLD PROPAGATION ENVIRONMENT

	CTIA’s Assumptions (dB)	Broadcom’s Assumptions (dB)	Appropriate Real-World Assumptions (dB)
LTE Body Loss	3	3	6
Unlicensed Body Loss	3	3	3
Shadowing	0	3	3
Polarization Mismatch	3	3	3
LTE Antenna Gain	0	-6	-6
Free-Space Propagation Loss	29	35	35
Additional “Variation”	0	Included	Included
TOTAL ASSUMED LOSS	38	53	56

In addition, the parameters of CTIA’s test render its measured results highly misleading. According to CTIA’s test results summary, the devices it tested experienced 1 dB of desensitization when the interfering co-channel signal was an average of only -127 dBm/100 kHz, and 3 dB of desensitization with an interfering co-channel signal power of -121 dBm/100 kHz. Integrated across the 4.5 MHz LTE channel, these limits translate into -110.5 dBm and -104.5 dBm, respectively. These results are far below the -98.5 dBm co-channel interference

²⁷ See Google Comments at 9; see also *Advanced Wireless Service Interference Tests Results and Analysis*, Federal Communications Commission Office of Engineering and Technology, WT Docket Nos. 07-195 and 04-356 ¶ 7 n. 17 (rel. Oct. 10, 2008) (reviewing literature supporting body loss assumptions of 9-15 dB).

threshold that both Broadcom and Qualcomm cited, based on 3GPP-imposed reference sensitivity requirements.²⁸ They are even farther below the -95.5 dBm interference threshold that the Commission has endorsed.²⁹

A likely explanation for the discrepancy is that CTIA's "[OOBE] tests were performed with LTE [devices under test] operating at 0 dBm power level."³⁰ This would mean that, under the conditions of CTIA's test, the LTE receiver would exhibit a sensitivity far in excess of its real-world performance, due to the substantial lack of any interference from its own LTE uplink signal. In the real world, and especially under the conditions CTIA sought to simulate at the outer edge of an LTE cell, any LTE handset would be transmitting at a power far higher than 0 dB, substantially desensitizing the LTE receive antenna.

Thus, while CTIA concludes that the LTE handsets it tested experienced 1 or 3 dB of desensitization with extremely weak interfering signals, this desensitization was relative to an unrealistically low reference sensitivity. Had the handsets been transmitting at realistic power levels, the devices would have exhibited a substantially higher reference sensitivity and, thus, would have required significantly more in-band power to be desensitized by an interfering signal. Put more simply, the desensitization measured in CTIA's tests has no real-world impact because a real LTE handset would never have been able to receive a desired signal at those power levels in the first place.

²⁸ See May 2013 Qualcomm Reply Comments; Letter from Paul Margie, Counsel, Google Inc. and Broadcom Corp., to Marlene H. Dortch, Secretary, Federal Communications Commission, *Broadcom Corp. WiFi-LTE Interference Analysis* at 3, GN Docket No. 12-268 (filed Jan. 30, 2014).

²⁹ *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).

³⁰ See CTIA Comments, Appendix A at 4.

CTIA also discloses no information about the handsets it tested other than that they are “commercially available.”³¹ The Commission cannot ascertain whether the handsets were appropriate for this test without further disclosure. Broadcom, by contrast, identified the handsets used in its tests.³²

Finally, CTIA’s use of co-channel additive white Gaussian noise to simulate out-of-band emissions from an unlicensed device likely caused it to overestimate the impact of out-of-band emissions. This is because the additive white Gaussian noise used in CTIA’s tests was received at a constant power across the LTE band. Real out-of-band emissions would diminish in power—perhaps drastically—across the width of the 4.5 MHz band at larger spectral separations from the unlicensed channel.³³ CTIA’s “flat” modeling of power across the band thus over-represents the actual amount of energy appearing in-band to the LTE radio.

CTIA’s test procedures and assumptions thus are flawed and, like Qualcomm’s, produce an unreliable interference analysis on which the Commission should not rely.

III. Unlicensed Devices Can Safely Operate in Channel 37

As Google and Broadcom have demonstrated, both fixed and personal/portable unlicensed devices may safely operate in channel 37 and adjacent channels so long as they

³¹ *Id.* at 8.

³² *See* Letter from Broadcom Corp., to Marlene H. Dortch, Secretary, Federal Communications Commission, at slide 8, GN Docket No. 12-268 (filed July 22, 2014).

³³ *See* Broadcom Comments at 7.

observe appropriate separation distances from wireless medical telemetry service (WMTS) and radio astronomy service (RAS) sites.³⁴ The record reflects widespread support for this position.³⁵

GEHC, which sells equipment to channel 37 incumbents, has submitted a contrarian study that purports to show that unlicensed devices will cause interference to WMTS systems at the power levels and separation distances that the Commission has proposed. GEHC's study does not analyze the impact of WSDs on an actual WMTS implementation. Instead, GEHC studied mock WMTS "victim transmitters" that it placed in a hospital that also contained a real WMTS system. The decision to test WMTS equipment that was not in actual use is understandable from the perspective of avoiding any impact on normal hospital operations. But in analyzing results, it is important to recognize that the reported siting, operational behavior, and interference do not necessarily reflect a real-world environment. Rather, GEHC's study contains design features that render it unreliable.

GEHC's test involved placing a handful of WMTS transmitters at a few locations at the test site and determining whether various simulated unlicensed transmitters interfered with the WMTS antenna system's reception of those signals. GEHC states that each test WMTS transmitter was placed so that its transmitting signal would be received at a power at least 10 dB above a predetermined receive sensitivity level, by one of the three antenna fields in operation at

³⁴ Google Comments at 20-22; Broadcom Comments at 22-26.

³⁵ Adaptrum Comments at 6; DSA Comments at 10; Google Comments at 18-20; Microsoft Comments at 19; Motorola Comments at 10; Wi-Fi Alliance Comments at 28; WhiteSpace Alliance Comments at 22; Comments of the Wireless Internet Service Providers Association at 6, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("WISPA Comments").

the site.³⁶ Notably, GEHC does not state the power level at which WMTS signals are *normally* received by the antenna system.

Examination of GEHC's test reports suggests that, in fact, received power levels are typically significantly higher than those from the transmitters used in GEHC's test. GEHC depicts the received power of its four test transmitters by one antenna field in Appendix A, Figure 9, of its comment. This figure indicates that the four test signals are received at power levels of -56.52 dBm, -52.51 dBm, -46.43 dBm, and -49.44 dBm.³⁷ Meanwhile, Figures 1-3 appear to illustrate the signals received by the three antenna fields of actual, operational WMTS transmitters. While GEHC does not provide markers to indicate the precise received power levels, virtually every transmitter appears to be received by at least one antenna field at a power of at least -50 dBm and, in many cases, more than -40 dBm. Moreover, because GEHC's report includes only the power levels at which the test signals are received by a single antenna field, it is impossible to confirm that the depiction of antenna field B in Figure 9 is representative of the signals received by the other antenna fields operational at the site.

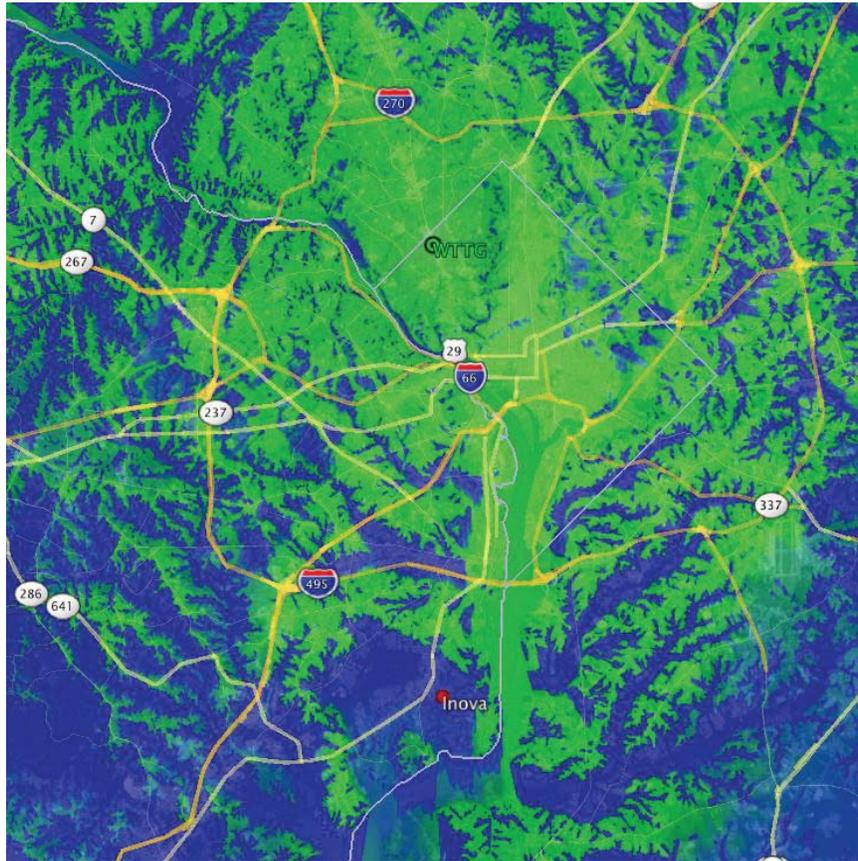
GEHC's results also depend on the prevailing noise floor at a given WMTS test site. By choosing a test site a substantial distance from any adjacent-channel television broadcaster, GEHC was likely able to detect "interference" from signals that would never have been noticeable at WMTS sites operating on channel 37 in noisier environments. This is important in determining the true interference sensitivity of WMTS operations. As the figure below illustrates, many WMTS sites operate in environments that are substantially noisier than the test site chosen by GEHC. To adapt to these noisier environments, WMTS transmitters must be

³⁶ See Comments of GE Healthcare, Appendix A at 5, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) ("GE Healthcare Comments").

³⁷ *Id.*, Appendix A at 11.

capable of transmitting at higher powers than the transmitters used in GEHC's test. GEHC does not explain why this simple remediation technique would not also eliminate the alleged interference threat from unlicensed devices, even in environments with unusually low noise floors, at little-to-no cost.

CHANNEL 37 NOISE FLOOR LEVELS IN THE WASHINGTON, D.C., AREA



Effect on the channel 37 noise-floor in the Washington, D.C., area due to adjacent-channel television broadcaster. Blue represents areas shielded from this source of noise. The Inova Mount Vernon WMTS site is represented by the red dot.

Even under its atypical test conditions, GEHC detected interference only when there was line-of-sight or partial-line-of-sight between the WMTS site and a mast-mounted unlicensed

transmitter.³⁸ This provides further support for Google’s proposal to account for site-specific line-of-sight information in generating separation distances from WMTS sites, in order to maximize spectrum utilization and provide optimal protection for WMTS.³⁹

In fact, GEHC appears to propose a similar approach: It suggests that the Commission should consider “a more nuanced approach to separation distances . . . that can vary according to the situation and change over time.”⁴⁰ GEHC and Google agree that “[s]uch an approach is particularly well-suited in this case because WMTS systems occupy Channel 37 throughout the country and in many urban areas where non-LOS may be present.”⁴¹ This is especially important because densely occupied areas where obstructions are common are precisely the same areas where spectrum is likely to be most scarce and, accordingly, where additional unlicensed spectrum will be most valuable to consumers. Google has provided a detailed and workable proposal for implementing such a system,⁴² and urges the Commission to consider this approach to maximizing the utility of channel 37. Certainly the FCC should not rely on a study that considers only line-of-sight situations in setting exclusion zones for all situations. This would vastly overprotect WMTS licensees and unnecessarily deny consumers access to unlicensed spectrum in many areas throughout the country—especially in cities where unlicensed 600 MHz channels will be most scarce.

³⁸ *See id.* at 26.

³⁹ *See* Google Comments at 22-25.

⁴⁰ GE Healthcare Comments at 27.

⁴¹ *Id.* at 28.

⁴² Google Comments at 22-25.

Google, moreover, strongly disagrees with GEHC's suggestion that unlicensed operations on channel 37 be limited to fixed devices only.⁴³ GEHC speculates that unlicensed personal/portable devices might malfunction and operate on channel 37 in too-close proximity to a WMTS site. But there is nothing to support this speculation. Tellingly, GEHC has not cited a single example from the several years of unlicensed white space operation thus far.

Similarly, GEHC raises the specter of a hacker compromising the geolocation system of an unlicensed device, but provides no explanation of how this could be accomplished—particularly in light of the security requirements for WSDs mandated by the Commission's existing white space rules.⁴⁴ GEHC also fails to explain why this would be a likely vector for attack, or why such a hack would not be possible using an LTE device or a higher-power fixed device operating in geographic proximity of a WMTS site but on a different channel.

IV. The Commission Should Reject Unsupported Proposals to Limit Unlicensed Operations

In addition to the technical reports discussed above, some commenters have proposed restrictions on unlicensed operations without providing substantive analysis or any policy support beyond the parties' desire to have clean spectrum for themselves. The Commission should reject these proposals.

⁴³ GE Healthcare Comments at 28-30.

⁴⁴ See 47 C.F.R. § 15.711(b)(3)(vi).

A. The Commission Should Permit Unlicensed Operations in Communities that Licensees Choose Not to Serve

CTIA, Qualcomm, and the Telecommunications Industry Association oppose the Commission's sensible proposal to allow unlicensed devices to operate in the parts of a license area where a licensee does not offer service.⁴⁵ These parties contend that merely registering the outer perimeter of their coverage area, as proposed by the Commission, is an impermissible burden and inconsistent with the Spectrum Act.⁴⁶

None of these parties are able to cite a single provision of the Spectrum Act that supports their position. Rather, their arguments revolve around the assertion that "600 MHz mobile licensees will have purchased exclusive spectrum rights via an auction to use all of the licensed spectrum within a service area without having to share those rights with unlicensed users."⁴⁷ True, mobile licensees will have purchased rights under "licenses for the use of the spectrum."⁴⁸ But those licenses grant only the rights that the Commission chooses to convey. It is, in fact, routine for the Commission to impose limitations and conditions on spectrum licensees, and to permit Part 15 operation in licensed bands.⁴⁹ There is no provision of the Spectrum Act that requires that licenses sold in the forward auction be entirely free of conditions, let alone in areas where the licensee is making no use of the spectrum. And, to be clear, the only "restriction" that

⁴⁵ See Qualcomm Comments at 19-20; CTIA Comments at 36-40; Telecommunications Industry Association Comments at 16-18, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015).

⁴⁶ Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6407(e) (codified at 47 USC §1452), 126 Stat. 156 (2012) ("Spectrum Act").

⁴⁷ Qualcomm Comments at 19-20.

⁴⁸ Spectrum Act § 6403(c)(1)(A).

⁴⁹ See, e.g., 47 C.F.R. § 27.14 (imposing build-out requirements on certain AWS and WCS licensees).

the Commission proposes here is the requirement that a licensee must perform the simple task of registering the outer perimeter of the area where it has chosen to deploy base stations so the FCC can ensure that unlicensed devices only operate where there are no licensed operations. This is a small price for unlocking unlicensed use of fallow spectrum in communities throughout the United States. In addition, because the Commission’s proposal would allow unlicensed operations only outside of licensed operators’ chosen coverage areas, this approach does not limit licensed deployments, presents no risk of harmful interference to LTE, and will not reduce the amount of spectrum available to be licensed in the forward auction.

The Telecommunications Industry Association questions whether the overlapping polygons produced by this process will prove cumbersome for database operators to process. As a database operator, Google can assure the Commission that this concern is unfounded. Indeed, databases already must determine for several channels simultaneously whether a given unlicensed device is within one or more potentially overlapping polygons.⁵⁰ Adding more polygons to the database will impose virtually no additional burden on database operators.

B. The Commission Should Protect RAS by Adopting Bearing-Specific Separation Distances

The National Academy of Sciences’ Committee on Radio Frequencies (“CORF”) argues that the Commission can and should adopt reduced separation distances tailored to each individual VLBA site, using the Longley-Rice propagation model.⁵¹ Google agrees that this would be a step in the right direction. CORF, however, would impose a single, fixed distance for

⁵⁰ See Google Comments, Appendix B, Declaration of Andy Lee ¶ 9.

⁵¹ Comments of the National Academy of Sciences’ Committee on Radio Frequencies at 8, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) (“CORF Comments”).

each VLBA site. As we have explained, this approach would waste valuable spectrum when white space databases can just as easily enforce separation distances that vary (due to terrain blockage) depending on an unlicensed device's bearing relative to a VLBA site.⁵² It would be straightforward to implement such a rule, adding little or no complexity to white space databases. A combination of bearing-dependent separation distances and time coordination would make channel 37 available in many large population centers around the country, where its use would be precluded by constant-radius separation distances.⁵³

Google does not agree with CORF's alternate suggestion that TVWS devices be prohibited on channel 37 in all rural areas. Such an approach would yield little improvement in simplicity of implementation—it would merely replace Longley-Rice derived exclusion areas with complex polygons representing rural areas. Meanwhile, this approach would needlessly prohibit channel 37 operations in the significant majority of rural areas in the United States that are not in close proximity to a radio telescope.

Google likewise opposes the National Radio Astronomy Observatory's ("NRAO") proposed approach to establishing adjacent-band separation distances for the single-dish Green Bank and Arecibo radio telescopes.⁵⁴ While Google does not categorically oppose the imposition of such limits in lieu of an out-of-band-emissions mask, NRAO's approach to setting such limits yields inaccurate results. NRAO's calculations were derived by reverse-engineering the Commission's unnecessarily large, fixed separation distances, which do not take terrain into

⁵² See Google Comments at 26-31.

⁵³ See *id.*, Appendix C, Declaration of Andrew W. Clegg.

⁵⁴ See Comments of the National Radio Astronomy Observatory at 2-4, ET Docket No. 14-165 (filed Nov. 24, 2014).

account. A better approach, based on sound engineering practice, is to combine Longley-Rice propagation prediction, proposed out-of-band emissions limits, and established RAS protection criteria to calculate appropriate separation distances for adjacent-channel TVWS devices.⁵⁵ Given that unlicensed devices' adjacent-channel emissions will be substantially weaker than in-band emissions, these distances will be substantially smaller than the corresponding co-channel separation distances.

Google has reached out to the radio astronomy community with the goal of reconciling the differences described above, and will provide the Commission with updates on those discussions as appropriate.

C. The Commission Should Reject Unsupported Proposals by the Wireless Microphone Industry

Wireless microphone manufacturers put forward a variety of proposals at the expense of every other category of 600 MHz device. The manufacturers first contend that they should be permitted to operate at powers up to 50 mW.⁵⁶ But they do not address the fact that many wireless microphones successfully operate today at less than 20 mW,⁵⁷ and ignore the aggregate interference to LTE that may be caused by several wireless microphones operating in one channel. The Commission should reject the request for additional power because the record does

⁵⁵ *Id.*

⁵⁶ Comments of Audio-Technica U.S., Inc., at 10, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) (“Audio-Technica Comments”); Comments of Sennheiser Electronic Corporation at 15, 17-18, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) (“Sennheiser Comments”); Comments of Shure Incorporated at 19-20, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015) (“Shure Comments”).

⁵⁷ NPRM ¶ 160.

not support a finding that operations at this level are necessary for microphone operations or that they present an acceptable interference risk.

Manufacturers further argue that unlicensed wireless microphones should not be required to use the white space databases to determine their permissible channels of operation.⁵⁸ This proposal fatally ignores the Spectrum Act's mandate that "[u]nlicensed use [of the 600 MHz band] shall rely on a database or subsequent methodology."⁵⁹ Moreover, the manufacturers offer no analysis to address the obvious interference issues that their proposal of unconstrained microphone operations would present.

Finally, wireless microphone proponents disagree with various proposed technical rules for unlicensed devices. Audio-Technica opposes the Commission's proposal to allow fixed unlicensed devices to operate at higher powers in rural areas.⁶⁰ Sennheiser opposes any changes to the location accuracy requirement.⁶¹ Shure opposes unlicensed use in any area where fewer than three vacant channels are available for unlicensed use.⁶² And both Sennheiser and Shure oppose permitting unlicensed devices to use taller antennas in rural areas, as well as allowing personal/portable devices in channels below channel 21.⁶³ The wireless microphone proponents assert that their suggested changes to the NPRM's proposals are necessary to prevent harmful

⁵⁸ Audio-Technica Comments at 12; Comments of CP Communications LLC at 4, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015); Sennheiser Comments at 15-17; Shure Comments at 16-18.

⁵⁹ Spectrum Act § 6407(d).

⁶⁰ Audio-Technica Comments at 15.

⁶¹ Sennheiser Comments at 11.

⁶² Shure Comments at 26-27; *see also* Comments of the National Association of Broadcasters at 8-11, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015).

⁶³ *See* Sennheiser Comments at 11, 10; Shure Comments at 23-29.

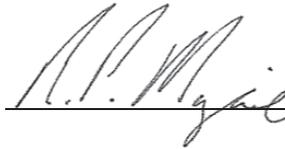
interference to wireless microphones. But their submissions contain no technical analysis to demonstrate that the Commission's proposals would expose wireless microphones to interference. Nor do they offer a policy justification for the level of protection they seek, beyond the wireless microphone industry's desire to obtain *de facto* exclusive access to 600 MHz spectrum. In the absence of such evidence, and in light of the broad policy and technical support for the Commission's proposals, the FCC should adopt the NPRM's proposed rules on these matters.⁶⁴

⁶⁴ See, e.g., Adaptrum Comments at 5,7; DSA Comments at 2, 6-7, 12; Google Comments at 37-46; Microsoft Comments at 40-46; Motorola Comments at 4-7; Comments of Spectrum Bridge, Inc., at 3-6, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 4, 2015); Wi-Fi Alliance Comments at 9-16, 13-14, 23; WhiteSpace Alliance Comments at 10-12; WISPA Comments at 13-16; Response of xG Technology, Inc., at 6-7, ET Docket No. 14-165 and GN Docket No. 12-268 (filed Feb. 6, 2015).

V. Conclusion

The record contains strong support for the Commission’s core approach to unlicensed operations, which the opposing filings fail to undermine. The Commission should permit WSD operations in the duplex gap and 9-MHz-or-larger guard bands at powers of at least 40 mW. Likewise, the record demonstrates that fixed, Mode 1, and Mode 2 personal/portable unlicensed devices can safely operate in channel 37 at the FCC-proposed separation distances from WMTS facilities and RAS sites, although an approach that allows WMTS licensees to seek tailored separation distances that take line-of-sight and terrain into account would better protect incumbents and promote more efficient use of this spectrum.⁶⁵ The Commission should reject the various proposals by the wireless microphone industry, which lack substantial technical or policy justification.

Respectfully submitted,



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⁶⁵ See Google Comments at 15-16; Broadcom Comments at 18-20.